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APPARATUS FOR TREATING MOLTEN LIGHT METAL

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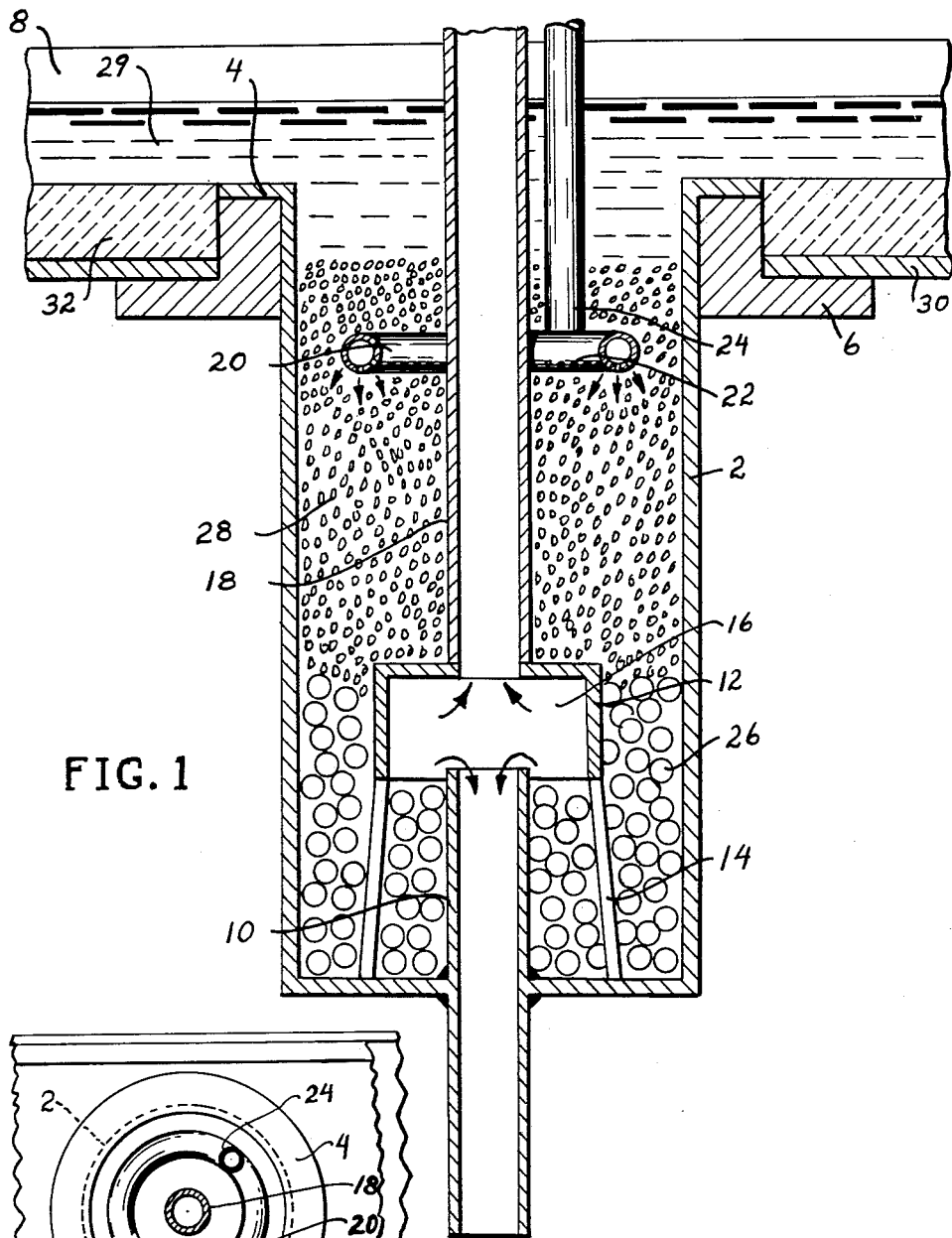


FIG. 1

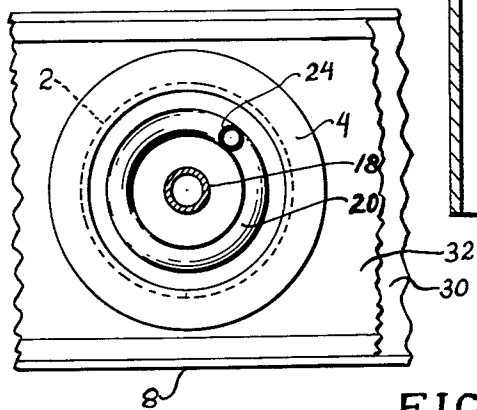


FIG. 2

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3,010,712 APPARATUS FOR TREATING MOLTEN LIGHT METAL

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4 Claims. (Cl. 266—34)

This invention relates to apparatus for the filtering and fluxing of molten light metal, and, more particularly, to apparatus wherein the fluxing gas is passed through the filter bed in co-current contact with the molten light metal.

The term "light metal," as used herein, refers to aluminum, magnesium, and to alloys thereof wherein these metals predominate.

In the melting of light metals and their transfer to other receptacles, gas is frequently entrapped or dissolved within the molten metal. This is primarily hydrogen, most of which is probably generated by the reaction with the metal of even small amounts of moisture in the surrounding environment. Also, a film generally forms on the surface of the molten metal which largely consists of the oxides of the light metal and/or its alloying constituents, and this film is broken up and dispersed within the molten metal during subsequent agitation or transfer. Upon casting of the metal article, a considerable amount of gas and oxide particles are entrapped within.

In the cast article, a large proportion of the hydrogen is usually considered to be in solution in the solid metal, i.e., it is in the monatomic state, although pockets or voids filled with molecular hydrogen have been observed. In the subsequent fabrication of wrought articles, thermal treatments are generally employed to aid in working the metal or to develop the desired strength, and it is generally considered that such heating produces diffusion of the monatomic hydrogen to any voids or discontinuities within the metal whereat association into molecular hydrogen takes place. It is also believed that the small occluded oxide particles tend to nucleate the formation of hydrogen-filled voids. Recently the problem of so-called "flakes" within the internal metal structure of wrought products has been associated with these hydrogen-filled voids.

Because of the gas pressures developed by the molecular gas, subsequent working of the metal does not effect a healing of the void or discontinuity, and heating of the article at elevated temperatures may increase such pressures to the point where the metal suffers local plastic deformation.

The problem of occluded gas have been increasingly important with the growing requirements for high-strength light metal articles. Any gas-filled void may not only constitute an area of weakness in the final article, but give rise to flakes, blisters, slivers and other defects which may cause rejection. This recognition has prompted investigations to find a method for the removal of gas from the molten light metal so as to produce a substantially gas-free article.

It has heretofore been proposed to flux molten metals with chlorine, nitrogen and inert gases to reduce the hydrogen content thereof, usually in the ladles or in the

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melting and holding furnaces. However, large quantities of gas generally remain in the cast article, and the process has been costly and time consuming.

It has also been proposed to filter molten aluminum through a bed of refractory filter medium to remove finely-divided non-metallic solids. This procedure has proven highly beneficial in this respect but has failed to reduce appreciably the gas content of the metal. Originally, increases in vacuum density of samples of the casting melt were considered as reflecting removal of gas but more recent methods of gas determination have indicated that this assumption was not completely correct and that the results were not quantitatively determinative of the gas remaining in the metal.

It is an object of this invention to provide apparatus for the simultaneous filtering and fluxing of molten light metal.

It is also an object to provide apparatus for such treatment which is employable in the casting downspout.

A further object is to provide apparatus wherein the fluxing gas is passed through the filter bed in co-current contact with the metal passing therethrough.

Other objects and advantages will be apparent from the following detailed description and the attached drawings wherein:

FIG. 1 is a vertical section of a downspout casting apparatus constructed in accordance with this invention.

FIG. 2 is a top plan view thereof in the absence of molten metal and refractory material.

In the copending application of P. D. Hess, K. J. Brondyke and N. Jarrett, Serial No. 775,628, filed November 21, 1958, a new method for the simultaneous removal of gas and finely divided solids from molten light metal has been set forth. The molten metal is passed through a bed refractory filter medium in co-current contact with a gas inert towards the molten light metal, and the inert gas is thereafter vented off the metal under a non-oxidizing atmosphere. This method is readily adaptable to use in crucibles or other apparatus in the molten metal transfer line, but, prior to this invention, it was not possible to utilize a vertical chamber or downspout of the casting apparatus.

It has now been found that this co-current method may be practiced in a vertical chamber or downspout by an apparatus consisting of a container with the metal inlet adjacent its top and an overflow discharge orifice for the metal spaced above the bottom. A hood or enclosure substantially open at its base is spaced from the discharge orifice and a vent tube is connected to the hood. Large or coarse refractory bodies are provided in the bottom of the container and extend up to at least the bottom edge outside of the enclosure and the fine refractory granules constituting the filter bed are placed thereon. The coarse bodies form a physical support and retainer for the fine refractory granules. In addition, a screen may be placed across the open base of the enclosure although this is not necessary with the large refractory bodies. The inside of the enclosure and particularly the orifice and the space above it, should be free of any refractory bodies so as to permit ready flow of metal and venting of the inert gas. A fluxing gas device is placed in the filter bed for introducing the inert gas and this may be a single or several porous or perforated diffusers.

In this apparatus, the metal flows downwardly through the refractory filter bed in co-current contact with fluxing

gas from the gas device. At the bottom of the container, the metal flows under the hood or enclosure and overflows into the discharge orifice; at the same time the gas is vented off the metal into the enclosure and out of the unit through the vent tube. The venting inert gases prevent the entry of air or moisture through the vent tube and serve to provide a non-oxidizing atmosphere in this venting zone or hood.

The gas device should be situated in the refractory bed so that the gas and molten metal flow in co-current contact through at least two inches of the filter bed. Generally, it has been found suitable to place the gas introduction means about two to three inches below the top of the filter bed.

The filter bed is composed of refractory granules 3 to 14 mesh in size, and preferably 3 to 8 mesh. To obtain the substantially complete removal of non-metallic impurities, it is necessary to pass the molten light metal through at least four inches of filter medium, and preferably eight inches or more. Greater lengths may be employed providing that the metal can be passed through the bed with sufficient rapidity.

The large refractory particles at the base of the unit are preferably $\frac{3}{4}$ to 1 inch in diameter and form a retaining bed for the finer granules of the filter bed. They also permit a rapid flow of metal in the base of the container. Alumina balls $\frac{3}{4}$ inch in diameter have proven highly satisfactory. This layer of coarse particles is considered to have little, if any, effect upon the removal of solid impurities.

The refractory utilized for the base material and for the filter bed must be a substance which is inert towards the molten light metal being treated. It must also have a higher melting point, possess high hardness and be of sufficient density to gravitationally remain in place during operation. Among such substances are chromite, corundum, forsterite, magnesia spinel, periclase, silicon carbide and zircon. Of these, alumina (synthetic corundum) is preferred. All of these materials, with the exception of forsterite and zircon, are free from silica, but in the case of the last two, the silica is chemically combined with another oxide in such a manner that it is not attacked by the molten light metal. For this reason, all of these materials are regarded as being inert towards the molten light metal.

The flow rate of metal through the bed of refractory filter medium will be determined by the head of molten metal or metal hydrostatic pressure, depth of the bed, fluxing gas flow rate and mode of preparation of the filter bed. Some improvement in filtering efficiency and metal flow rate has been noted when the filter bed is prepared by adding the refractory material to an initial body of the molten light metal in the filtering container and allow the refractory to settle gravitationally therein.

More particularly, the refractory material is washed, dried, preheated to a temperature of about 1200 to 1800° F., and preferably about 1400° F., after which it is added to the filtering container which has been provided initially with molten metal sufficient to cover the refractory material which is added thereto. The refractory is allowed to settle and may be tamped lightly.

The refractory bed may also be prepared by preheating the refractory to a temperature of 1200 to 1800° F. and adding it to the preheated dry filter container or the dry container with the refractory bed in place may be heated to the desired temperature; in either instance, the temperature of the unit should be high enough to prevent chilling of the molten metal which is subsequently introduced. The device for introducing the fluxing gas into the filter bed may be any of the well-known media, such as porous or perforated pipes and plates. In practice, porous carbon diffusers and perforated metal rings have been found highly satisfactory. Where a metal ring is perforated about its base, the total area of the perforations should

be less than the cross-sectional area of the gas entry or feed tube so as to provide uniform gas distribution.

During operation of the apparatus, it is essential that the apparatus be maintained at a temperature between about 1200 and 1600° F. to prevent freezing of the molten light metal, and also to maintain the molten metal level above the top of the refractory material to prevent cohesion of the refractory mass which is now quite wet with molten metal and impurities.

Referring now to the attached drawing, therein is illustrated apparatus in accordance with this invention. The fluxing-filtering apparatus is shown as a vertical container 2, the flanges 4 of which are carried by the collar 6 of the molten metal transfer line 8. An overflow discharge pipe 10 is provided in the base of the unit and a hood or enclosure 12, which is open at its base and is supported by the legs 14, provides a venting zone 16 about the discharge pipe 10. A gas vent tube 18 joined to the hood 12 serves to carry off the gas escaping from the metal in the venting zone and further acts as a means for removing the hood 12 for cleaning or repacking.

The fluxing gas is introduced into the unit by the fluxing gas device 20, which, as illustrated, is a metal ring provided with perforations 22 in the lower part thereof. A gas entry tube 24 supplies inert gas to the ring 20 and also serves as a means for its removal. Alternatively, gas may be introduced into the bed by several porous or perforated pipes, or the ring diffuser may be constructed of a porous material, such as porous carbon.

The unit is shown as having a layer of large diameter refractory bodies 26 at the base thereof which serve to speed the discharge of metal as well as a physical retainer for the filter bed of fine refractory granules 28 which is superposed. These large refractory bodies 26, conveniently alumina balls of about $\frac{3}{4}$ inch diameter, gravitationally remain in place and are not carried along by the metal flow, although other physical retaining means may be employed if so desired.

In the operation of the apparatus, molten metal 29 in the transfer line 8, which is illustrated herein its conventional construction of a metal trough 30 and refractory lining 32, enters the container 2 and flows downwardly through the refractory filter bed 28 in co-current contact with the flow of inert gas from the device 20. It then passes under the hood 12 and the inert gas is vented off into the vent tube 18 as the metal flows into the orifice of the overflow discharge pipe 10.

The vent tube 18 should not be too large since the pressure of inert gas passing through it should prevent air from entering the apparatus therethrough and thus maintain a protective or non-oxidizing atmosphere above the metal in the venting zone. If so desired, a negative pressure may be applied to the tube to assist in obtaining the co-current flow of inert gas and also to aid the venting of the gas.

The trough 8 may be provided with a cover to enable maintenance of an inert gas atmosphere above the surface of the metal therein. To prevent regassing or development of oxide particles by attack of moisture in the surrounding environment, the metal flowing out of the discharge 10 may flow into a mold which is provided with a protective atmosphere.

Indicative of the efficacy of the present invention are the data contained in Table 1. A device in accordance with the attached drawing and 6 inches in inside diameter was provided with a 5 inch layer of $\frac{3}{4}$ inch alumina balls, and the filter medium of alumina granules 3 to 6 mesh in size was superposed. The bed and container were heated to a temperature of about 1600° F. before the introduction of an alloy nominally consisting of aluminum, 4.4 percent copper, 0.8 percent silicon, 0.8 percent manganese, and 0.4 percent magnesium. Argon was used as the fluxing gas and was introduced through a perforated metal ring diffuser located about two inches down in the filter bed.

TABLE 1
Co-current fluxing filtration

Depth of Filter Bed	Metal Flow, Lbs./Hr.	Argon Flow, Cu. Ft./Hr.	Metal-Gas Flow Rate, Lbs./Hr./Cu. Ft./Hr.	Vacuum Density, ¹ g./cc.		Hydrogen, ² ml./100 g.		Percent Hydrogen Removed
				Before	After	Before	After	
5¼-----	5,600	20	280	2.2	2.78	.27	.12	56
5½-----	4,500	20.5	220	2.4	2.78	.22	.11	50
6-----	3,350	20	168	2.3	2.79	.17	.08	53

¹ Vacuum density tests may be made in apparatus of the type described in *Light Metals* (London), vol. 15, pages 305, 307 (Sept. 1952). The molten metal is frozen under a vacuum of 5 mm. and the density determination is made on the casting.

² Hydrogen determinations made by the "Telegas" instrument described in the *Journal of the Institute of Metals* (London), vol. 86, pp. 212-219 (1958).

The data in the preceding table indicate the efficacy of the present invention in enabling the use of the co-current method of filtering-fluxing in a casting downspout. This method is very rapid and is adaptable to use in conventional metal transfer systems. The product obtained by use of this method in the apparatus of the present invention is highly superior, both as-cast and after subsequent working operations and attendant thermal treatments.

Having thus described the invention, we claim:

1. Apparatus for the removal of gas and finely divided solid impurities from molten light metal wherein an inert fluxing gas is introduced into the metal as it enters the apparatus and is vented off at the point of discharge from the apparatus comprising an open top container, molten metal feeding means disposed adjacent to and in communication with the top of said container, an overflow orifice adjacent the bottom of said container but spaced above said bottom and pipe means associated with said orifice passing through the bottom wall of said container for discharge of the treated metal from the container, a hood enclosure over said orifice and spaced therefrom which is open at its base, a gas vent tube attached to said hood leading to the atmosphere outside the container through which fluxing gas is discharged that is separated from the molten metal at the overflow orifice, means for introducing an inert fluxing gas adjacent the top of said container and above the overflow orifice, a bed of loose refractory material inert to the light metal extending above the level where the fluxing gas is introduced, said bed being composed of two portions, a lower portion of coarse bodies extending up to at least the lower edge of the said hood enclosure and an upper portion resting upon said lower portion composed of refractory granules 3 to 14 mesh in size whereby the fluxing gas and metal being treated flow in co-current relationship to the overflow orifice.

2. Apparatus in accordance with claim 1 wherein said coarse refractory bodies and said refractory granules are composed of at least one substance selected from the group consisting of chromite, corundum, forsterite, magnesia spinel, periclase, silicon carbide and zircon.

3. Apparatus in accordance with claim 1 wherein said coarse refractory bodies are ¾ to 1 inch in size.

4. Apparatus for the removal of gas and finely divided solid impurities from molten light metal wherein an inert fluxing gas is introduced into the metal as it enters the apparatus and is vented off at the point of discharge from the apparatus comprising an open top container, molten metal feeding means disposed adjacent to and in communication with the top of said container, an overflow orifice adjacent the bottom of said container but spaced above said bottom and pipe means associated with said orifice passing through the bottom wall of the container for discharge of treated metal from the container, a hood enclosure over said orifice and spaced therefrom which is open at its base, a gas vent tube attached to said hood leading to the atmosphere outside the container through which fluxing gas is discharged that is separated from the molten metal at the overflow orifice, means for introducing an insert fluxing gas adjacent the top of said container and at least two inches above the overflow orifice, a bed of loose refractory material inert to the light metal extending above the level where the fluxing gas is introduced, said material being composed of at least one substance selected from the group consisting of chromite, corundum, forsterite, magnesia spinel, periclase, silicon carbide and zircon, said bed being composed of two portions, a lower portion consisting of refractory bodies ¾ to 1 inch in size extending up to at least the lower edge of the said hood enclosure and an upper portion resting upon said lower portion composed of refractory granules 3 to 14 mesh in size, said upper portion being at least four inches in depth, whereby the fluxing gas and metal being treated flow in co-current relationship to the overflow orifice.

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**UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION**

Patent No. 3,010,712

November 28, 1961

William Q. Judge et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 54, for "have been" read -- has become --;
line 57, after "but" insert -- may --.

Signed and sealed this 5th day of June 1962.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents