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3,615,086

APPARATUS FOR STIRRING MOLTEN METAL

Filed June 20, 1969

2 Sheets-Sheet 1

FIG. 1.

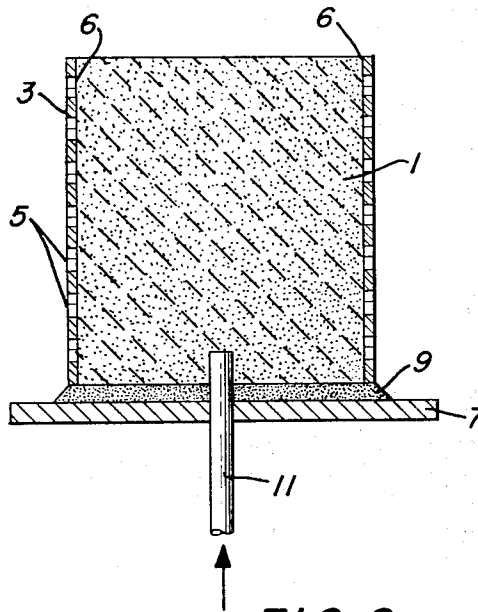
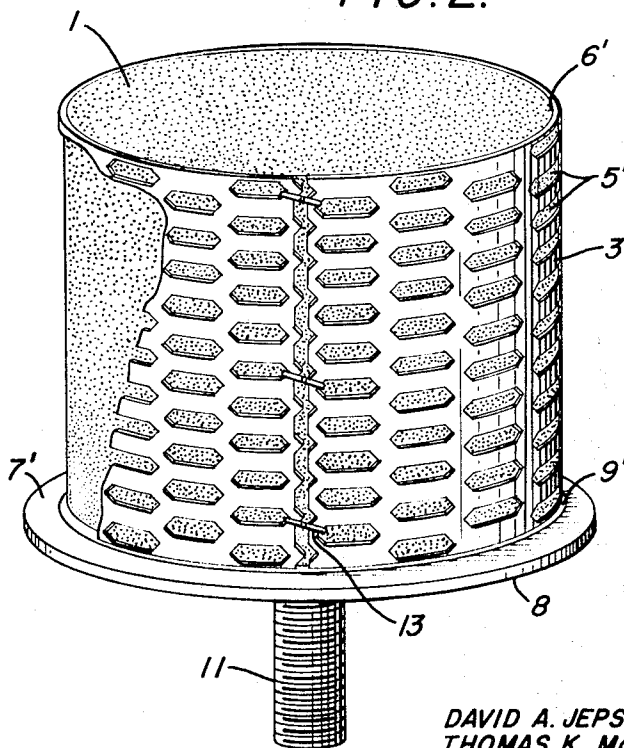


FIG. 2.



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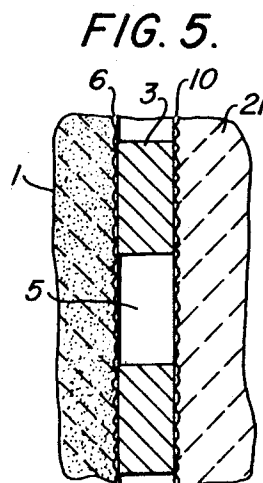
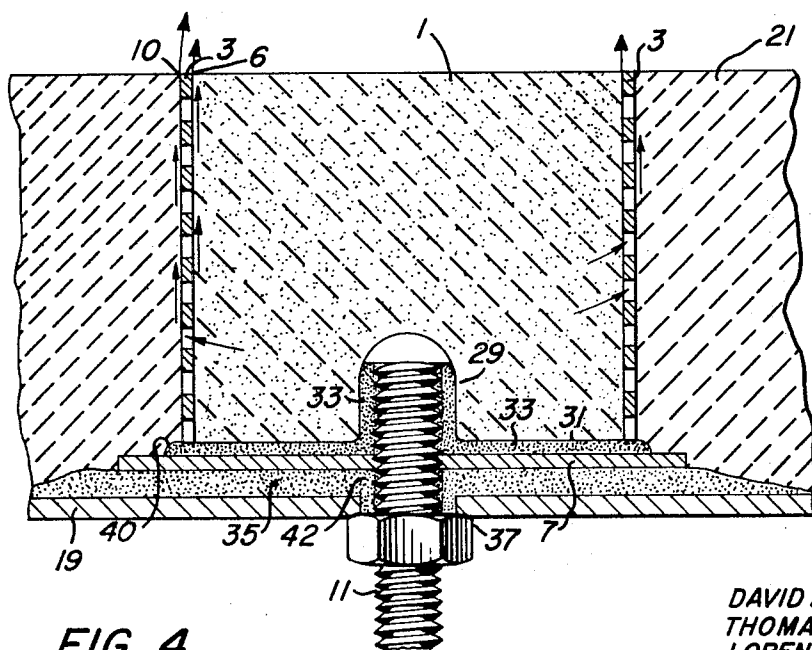
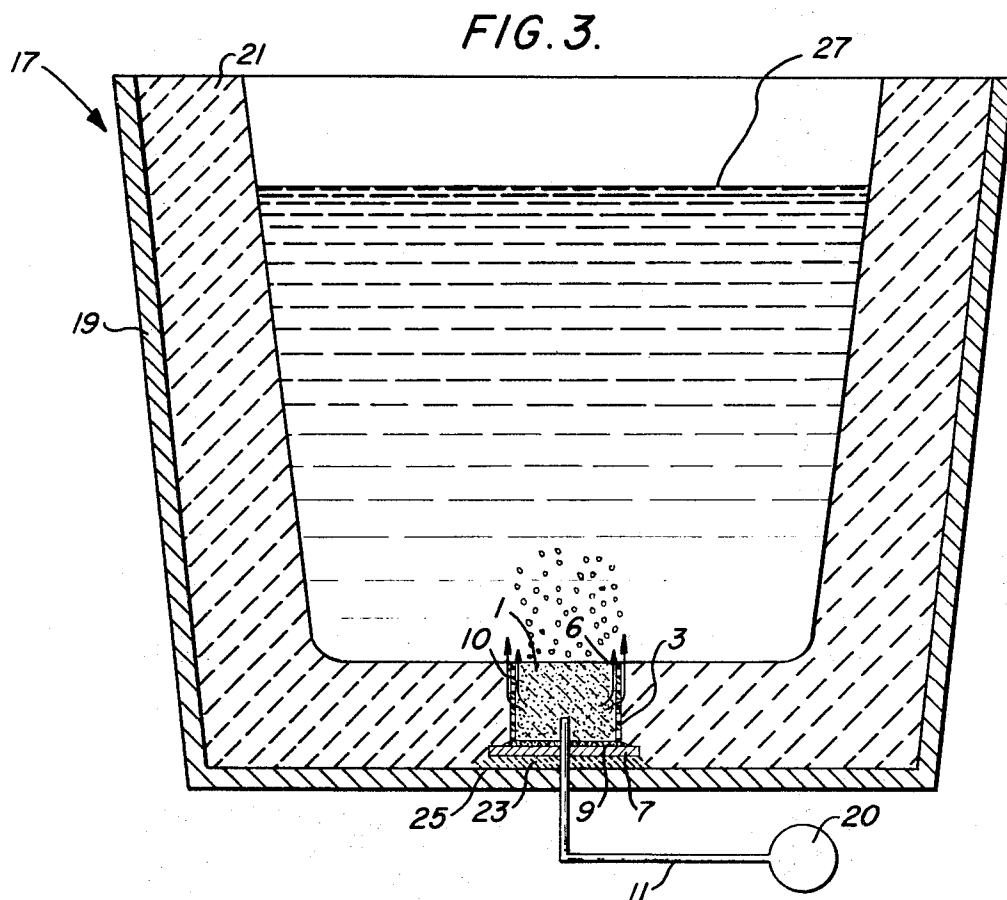
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2 Sheets-Sheet 2



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APPARATUS FOR STIRRING MOLTEN METAL
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at-law and legal representatives, Kalamazoo, Mich.,
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Loren L. Whitney, Lewiston Heights, N.Y., assignors
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6 Claims

ABSTRACT OF THE DISCLOSURE

A porous plug assembly wherein the porous plug is provided with a gas impermeable bottom surface seal and a gas permeable side wall sheath.

The present invention is directed to apparatus for the introduction of gas into molten metal for the purpose of stirring and agitating the metal. More particularly, the present invention is directed to a novel apparatus which employs a gas permeable refractory block or plug through which gas is passed to provide effective mixing of the constituents of a molten metal bath, including slag-metal mixing.

Gas permeable or porous refractory plugs have previously been used in various arrangements for the gas agitation of molten metal. Such devices have employed a coherent mass of refractory particles, formed by sintering or chemical bonding, which is permeable to gases but substantially impermeable to molten metal. For convenience, the gas permeable refractory mass, generally called a porous plug or block, is frusto-conical in shape and is commonly installed in combination with a ladle in the form of a refractory lined metal shell, with the upper surface of the porous plug being arranged substantially level with the surface of the refractory ladle lining. Conduit means are also provided to introduce gas into and through the porous plug into molten metal in the ladle. The gas, after passage through the porous plug, is in the form of bubbles which, if properly introduced, agitates and stirs the molten metal.

In the past the manner of installing a porous plug in a refractory lined ladle has generally been to provide arrangements whereby the porous plug is inserted through or attached to the bottom of the metal shell of the ladle. This practice has required rather complex and expensive mechanical arrangements which have not been advantageous in all instances.

It is therefore an object of the present invention to provide a straight-forward porous plug apparatus for the effective agitation of molten metal.

Other objects will be apparent from the following description and claims taken in conjunction with the drawing in which

FIG. 1 shows, somewhat schematically, a sectional elevational view of a stirring apparatus in accordance with the present invention;

FIG. 2 shows an isometric view of a stirring apparatus in accordance with the present invention;

FIG. 3 shows a somewhat schematic elevational section of the apparatus of the present invention in combination with a refractory lined ladle; and

FIG. 4 shows a sectional elevational view of a particular embodiment of the present invention.

Broadly, the present invention comprises a gas permeable but substantially molten metal impermeable plug or refractory block having a porous, gas permeable

sheath surrounding its side walls, and a gas impermeable seal at its bottom surface.

With reference to FIG. 1, the numeral 1 indicates a porous refractory plug or block which can be made of sintered or chemically bonded particles of alumina, magnesia, fire clay, graphite, silica or other materials presently used for the manufacture of porous refractory plugs. The plugs or blocks are coherent and have pores sufficient to permit the passage of gas through the block into molten metal and form bubbles therein. The porosity is such however that the plug or block is essentially impermeable to molten metal. With conventional ramming techniques porosity is commonly uniform throughout the porous plug, however, it may be desirable at times to provide higher porosity at the center of the plug, or even at the periphery of the plug, in order to develop particular stirring patterns in molten metal. As shown in FIG. 1, a gas permeable metal sheath 3 is provided in close-fitting mechanical contact with the porous refractory plug 1. Sheath 3 is foraminous as illustrated and is provided with holes or perforations 5. It is to be noted that the sheath 3 is not bonded or sealed to the porous plug 1 and the plug and sheath are only in mechanical contact at interface 6. The sheath 3 is preferably made of metal, e.g., low carbon steel, and in a preferred embodiment the sheath is in the form of expanded metal having uniformly spaced apertures. Other materials, which are not decomposed in use, such as low alloy and stainless steels can also be employed in sheath construction. Further with reference to FIG. 1 the porous plug 1 is provided at its bottom surface with a gas impermeable seal in the form of a steel plate 7. As indicated at 9 plate 7 is sealed and secured to the porous plug 1 by means of a gas impervious adhesive material such as high alumina mortar or Sauereisen cement which provides a ceramic seal. Conduit means for introducing gas into the porous plug are shown at 11.

With reference to FIG. 2, which illustrates essentially the same arrangement as FIG. 1 in a partially fragmented isometric view, porous plug 1 is shown provided with a surrounding sheath 3' formed of expanded metal. The sheath 3' is in close fitting mechanical contact with the porous plug 1 and is held in this condition by spot welded steel wires 13. As shown, the sheath 3' has openings or perforations 5' and an interface 6' is provided between the sheath and porous plug. A steel plate 7' with extensions indicated at 8' is provided as shown to establish a gas impermeable seal at the bottom of porous plug 1 and is sealed to plug 1 with gas impermeable adhesive to provide a ceramic seal as indicated at 9. Threaded gas conduit 11' communicates with porous plug 1 through plate 7' as shown.

FIG. 3 further illustrates the apparatus of the present invention in combination with a ladle 17 having a steel shell 19 and a refractory lining 21 which is conventionally installed in the shell 17 by ramming a refractory such as silica and subsequently thoroughly drying the refractory. As shown in FIG. 3 the porous plug 1 with surrounding sheath 3 and extending steel plate 7 is embedded in the refractory lining 21 of ladle 17. The plug assembly is installed from inside the ladle, as hereinafter more fully described, and the only connection through the bottom of the ladle is gas conduit 11 which is supplied by the tank shown schematically at 20. As shown in FIG. 3 steel plate 7 is sealed to the bottom of the porous plug 1 with gas impermeable adhesive refractory as indicated at 9 and plate 7 is embedded in the ladle lining 21 and is spaced away from the ladle shell 19 by a layer of gas impermeable refractory 23 which forms a ceramic seal at the under side of plate 7 and the surface of the ladle shell indicated at 25. This feature is an important aspect

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of the present invention since it has been discovered that with porous plugs installed to be completely inside the ladle, the bottom surface of the porous plug is most prone to allow the escape of gas into the ladle refractory and along the ladle shell. Any significant escape of gas into the ladle refractory and/or along the ladle shell 17 is a serious defect in that it limits and makes erratic the agitation of the molten metal by bleeding off the incoming gas and, in addition, results in less economical operation.

This problem of excessive gas loss through the ladle lining with porous refractory plugs has been solved in the present invention by providing in conjunction with a plug bottom seal, a gas permeable porous sheath 3. Gas permeable sheath 3, as previously described, is only in mechanical contact with porous refractory plug 1 and establishes an interface 6 therebetween. Consequently, when the gas is introduced into the porous plug 1 via conduit 11 it is partially forced toward the side walls and bottom of the plug due to the pressure of the head of molten metal 27. However, such portion of gas, instead of passing into the relatively permeable ladle refractory lining, is largely directed upward into the molten metal along interface 6. Gas also actually passes through openings 5 in sheath 3 and this gas preferentially passes upward along second interface 10 instead of through the more dense ladle refractory 21. Interface 10 between the ladle refractory 21 and sheath 3 can be enhanced by dusting or lightly coating the outer surface of sheath 3 with silica flour to avoid any significant adhesion between the sheath and ladle refractory.

In the present invention, the gas impermeable seal at plate 7 and gas permeable sheath 3 act together to provide efficient porous plug gas agitation. For example, the ceramically sealed bottom seal plate 7 prevents gas leakage at the base of the porous plug and at the junction of conduit 11 and plate 7, but only on account of the provision of gas permeable sheath 3 which relieves the gas back-pressure at the bottom of the plug and directs the diverted gas upward into the molten metal via the interfaces 6 and 10. These interfaces are important in order to permit the upward escape of gas and avoid excessive gas pressures in the porous plug assembly and are provided by an essentially mechanical contact between the adjoining surfaces. This mechanical contact at the interfaces is also important in order to prevent the downward passage of molten metal along the sides of the plug which would eventually seal the side walls of the plug. Such a condition, i.e., sealing of the side walls, as has been observed, results during operation in high back gas pressures at the bottom seal and the seal-conduit junction with the danger of eventual rupture and gas leakage into the ladle lining.

It has also been observed in the course of the present invention that sealing of only the side walls of the plug, without provision of a bottom seal, results in the escape of very large volumes of gas into the ladle lining via the bottom of the plug and this prevents the development of satisfactory stirring in the molten metal.

The present invention is more fully illustrated in FIG. 4 which shows a preferred embodiment of the present invention. With reference to FIG. 4, and the practice of the present invention, a porous refractory block 1 having a surrounding and mechanically contacting foraminous sheath 3 is provided with a cylindrical slot 29 communicating with its bottom surface 31 of the porous refractory plug 1 and the sides of slot 29 and the bottom of refractory block 1 are coated with an air setting refractory cement 33, e.g. high alumina mortar or Sauereisen cement. Threaded conduit 11, passes through and is attached to plate 7 into contact with cement coated bottom surface 31 of the porous plug 1. At this stage, the sheathed porous plug and bottom seal plate resemble the arrangement of FIG. 2.

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A layer of air setting cement 35 is then applied to the ladle shell 19 and conduit 11 is inserted through opening 37 in ladle shell 19 and plate 7 is brought to rest on cement layer 35. Lock nut 37 is then engaged with the threaded portion of conduit 11 and tightened so as to firmly seal plate 7 on cement layer 35. After permitting cement layer 35 to set, e.g. about 15-20 minutes is ordinarily sufficient, refractory material is conventionally rammed into shell 19 and fired to provide the ladle lining 21.

As in the previously described embodiments, interfacial gas passage 6 is established at the mechanical contact between the foraminous sheath 3 and the porous refractory plug 1. Also, interface 10 between the outer surface of sheath 3 and the ladle refractory 21 is established, and molding sand can be provided in sheath apertures, in order to maintain maximum sheath porosity during and after the ramming of the ladle lining 21. As illustrated in FIG. 4 the refractory surfaces at interfaces 6 and 10 are not completely smooth on account of being formed of particulate material and hence establish a series of very small connected voids whereby gas is readily permitted to pass upward while downward flow of molten metal is prevented.

With the arrangement as aforescribed gas is introduced through conduit 11 into porous refractory block 1 and passes upward into molten metal 27 substantially along the paths indicated on account of the pressure relieving interfaces 6 and 10 and the presence of gas impervious ceramic layers 33 and 35 which, on account of the aforementioned pressure relief, are sufficient to prevent leakage at the ordinarily sensitive locations 40 and 42.

A further advantage of foraminous sheath 3 is that it acts as a strengthening member over the entire side wall surface of the plug and thus prevents minor thermal cracks from developing into fractures which could cause failure of the porous plug.

The following example will also serve to illustrate the present invention.

EXAMPLE 1

Two thousand pounds of cupola melted cast iron were poured into a refractory lined ladle in which a porous refractory plug assembly was installed as illustrated in FIG. 4. The iron before treatment had a sulfur content of 0.083% and the iron temperature was 2760° F. Twenty pounds of calcium carbide was added to the iron, and nitrogen gas was fed through the porous plug at a rate of about 10 cubic feet per minute which was sufficient to provide vigorous agitation of the molten iron. After three minutes, the sulfur content of the iron was reduced to 0.011%. The iron temperature after treatment was 2700° F.

The porous plug assembly of the present invention can also be used in the nodularizing of iron. In one test for example, 2,350 lbs. of iron was treated with 22 pounds of calcium carbide, and 12 pounds of carbon following the procedure of Example 1. During the initial three minutes of gas treatment the sulfur content of the iron was lowered from 0.055% down to 0.006% while the carbon content was increased from 3.26% to 3.70%. At that point, 44 pounds of 5% magnesium-ferrosilicon was added while gas treatment was continued for forty-five seconds. The magnesium content of the resulting nodular iron was found to be 0.048%.

What is claimed is:

1. In combination, a container for molten metal having a metal shell with a refractory inner lining and a porous plug assembly comprising a gas permeable plug which is substantially impervious to molten metal; a porous gas permeable sheath surrounding and in contact with the side walls of the gas permeable plug, means for providing a gas impermeable seal at the bottom surface of the porous plug; conduit means communicating with the gas permeable plug through the gas impermeable seal at the bottom

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portion of the gas permeable plug for the introduction of gas into the gas permeable plug, said porous plug assembly being embedded in the refractory lining of the container with the top surface of the porous plug being exposed to the interior of the container and the gas impermeable seal means at the bottom of the porous plug being spaced from the metal shell of the container.

2. Apparatus in accordance with claim 1 wherein a metal plate is sealably attached to the bottom portion of the gas permeable plug to provide a gas impermeable seal.

3. Apparatus in accordance with claim 1 wherein the gas permeable sheath is a foraminous metal sheath compressibly surrounding the side walls of the gas permeable plug.

4. A porous plug assembly comprising a gas permeable plug which is substantially impervious to molten metal; a porous gas permeable sheath surrounding and in contact with the side walls of the porous plug; means for providing a gas impermeable seal at the bottom surface of

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the porous plug; conduit means communicating through the metal gas impermeable seal at the bottom portion of the gas permeable plug for the introduction of gas into the gas permeable plug.

5. Apparatus in accordance with claim 4 wherein a metal plate is sealably attached to the bottom portion of the gas permeable plug to provide a gas impermeable seal.

6. Apparatus in accordance with claim 4 wherein the gas permeable sheath is a foraminous metal sheath compressibly surrounding the side walls of the gas permeable plug.

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JAMES M. MEISTER, Primary Examiner