United States Patent Office 3,402,921
Patented Sept. 24, 1968

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3,402,921
APPARATUS AND METHOD OF MAKING APPARATUS FOR VACUUM PURIFICATION OF METALS

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Filed Aug. 30, 1965, Ser. No. 483,601
27 Claims. (Cl. 266—34)

ABSTRACT OF THE DISCLOSURE

Vacuum treatment apparatus is constructed from solid blocks of a refractory such as graphite. The blocks are so shaped that when interfitted, they cooperate to form reservoirs, feedpaths, and exposure chambers.

This invention relates generally to the purification of metals and particularly to the removal of gases and other impurities from molten metals by vacuum treatment. More particularly, this invention relates to the vacuum treatment of nonferrous metals such as copper.

Vacuum treatment, in the present connotation, is the process of exposing molten metal to a gas pressure which is very low as compared to atmospheric pressure. It is of course well known in the metal purification art that vacuum treatment removes gases and volatile impurities from molten metals.

Broadly, the invention comprises means for continuously vacuum treating a stream of molten metal. Hence, for example, apparatus in accordance with the invention may be interposed between a furnace which continuously melts metal and a casting unit which continuously cools and resolidifies the metal so as to continuously vacuum treat the metal between continuous melting and continuous casting. Broad advantages of the invention over prior art are in the simplicity of construction and economy and efficiency of operation.

The most simple conventional apparatus for vacuum treatment comprises merely a heated open top vessel for containing molten metal, a sealed enclosure around the vessel and a pump for exhausting gas from the enclosure so as to create and maintain a very low gas pressure above the molten metal. It is well known that this simple vacuum treatment apparatus has two prime disadvantages; in the first place the purification action is very slow and in the second place this simple apparatus vacuum treats molten metal only a batch at a time. It is further well known that conventional means are available for overcoming these two disadvantages, these conventional means being based on the two principles that, firstly, agitation of the molten metal quickens the vacuum purification action and that, secondly, a low pressure enclosure can be fed and discharged via "pressure-locks" without disturbing the pressure conditions inside the enclosure. This is to say, vacuum treatment apparatus which achieves relatively high treatment rates in continuous operation is within the state of conventional art. However, such conventional, continuous vacuum treatment apparatus although widely known in principle has not reached practical fruition for treating nonferrous metals on a commercial scale because of its complexity. This complexity is compounded by the unusual combination of high temperatures, temperature gradients, pressure gradients and corrosive and erosive actions commonly encountered in vacuum treating molten metals.

A broad purpose of the present invention is accordingly to provide commercial means for the continuous, rapid vacuum treatment of molten metals particularly nonferrous metals considerably less complex than means already known or obvious to those skilled in the art.

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Another broad purpose of the present invention is to provide more economic commercial means for vacuum treating molten metals, particularly nonferrous metals, than available hitherto. Yet another broad purpose of the present invention is to provide means for purifying molten metals, particularly nonferrous metals, to a greater extent than hitherto.

Somewhat narrower purposes of the present invention are as follows:

First, to provide less complex, more economic and more efficient apparatus for vacuum treating molten copper;

Second, to provide apparatus for vacuum treating molten copper which is particularly adapted to molten copper containing dissolved hydrogen;

Third, to provide forms of apparatus for vacuum treating molten copper in which the heat losses are minimal;

Fourth, to provide forms of apparatus for vacuum treating molten copper in which the ratio of surface exposure to volumetric flow is maximal;

Fifth, to provide forms of apparatus for vacuum treating molten copper which are simple to construct, simple to use and simple to maintain;

Sixth, to provide forms of apparatus for vacuum treating molten copper in which the design difficulties due to pressure gradients, temperature gradients and corrosive effects are minimized;

Seventh, to provide forms of apparatus for vacuum treating molten copper in which some porosity in the construction material can be tolerated; and

Eighth, to provide apparatus for vacuum treating molten copper in which the constructional material in contact with the molten copper and subject to molten copper temperatures is substantially entirely graphite.

An understanding of these above various purposes of the present invention and how they are accomplished will be gained from the following descriptions and drawings of which:

FIGURE 1 illustrates "cold" vacuum treatment apparatus of the "detached reservoir" type;

FIGURE 2 illustrates "cold" vacuum treatment apparatus of the "external reservoir" type;

FIGURE 3 illustrates U-tube and internal reservoir arrangements for "cold" vacuum treatment apparatus;

FIGURE 4 is a series of diagrammatic outlines of various "cold" vacuum treatment apparatuses;

FIGURES 5, 6, 7, 8, 9 and 10 are a series of cross-sectional and other views of "cylindrical block" adaptation some of the apparatus forms of FIGURE 4 in accordance with the present invention;

FIGURE 11 is a cross-sectional view of a typical "hot" vacuum treatment apparatus in accordance with the present invention.

As already mentioned in the introduction the combination of hostile conditions met in molten metal vacuum treatment apparatus creates many unusual design difficulties. These hostile conditions include high temeratures, high temperature gradients, pressure gradients and corrosive effects of molten metals. The design difficulties are due mainly to the fact that constructional materials which are capable of withstanding all these hostile conditions simultaneously are, generally speaking, unavailable. Consequently, in those parts of typical, conventional vacuum treatment apparatus where these hostile conditions apply simultaneously, special contrivances involving combinations of materials are generally required to surmount the difficulties. An appreciation of how these hostile conditions cause difficulty in the design of molten metal vacuum treatment apparatus and of how these difficulties may be overcome will be gained from the following comparison between a "cold" vacuum treatment apparatus and a "hot" vacuum treatment apparatus.