

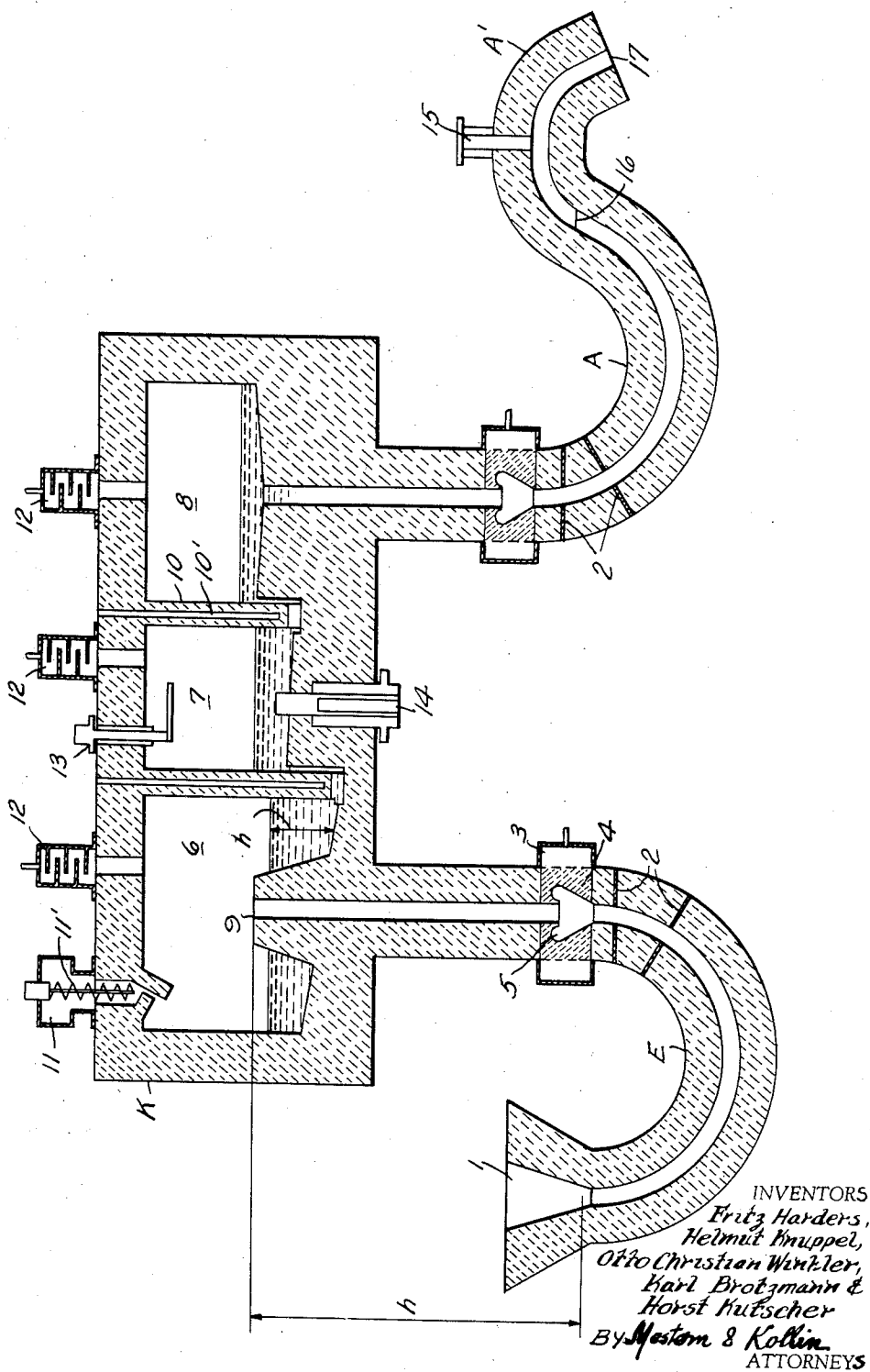
Nov. 4, 1958

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2,859,262

APPARATUS FOR DEGASIFYING LIQUID METAL

Filed Sept. 4, 1956



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2,859,262

## APPARATUS FOR DEGASIFYING LIQUID METAL

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Application September 4, 1956, Serial No. 607,873

Claims priority, application Germany September 5, 1955

7 Claims. (Cl. 13—31)

It is known to degasify steel in a vacuum. For this purpose, heatable degasifying chambers are employed to which feed and delivery pipes for the metal are connected. The inlet and outlet pipes, which consist of refractory material, are straight pipes having one end connected to the degasifying chamber and the other end immersed in vessels filled with liquid steel and which are under normal pressure. In this way, barometric sealing of the degasifying chamber is produced.

Such arrangements are disadvantageous and unreliable in operation because they cannot maintain the necessary vacuum for long. The ends of the straight inlet and outlet pipes immersed in the molten steel cannot, in fact, be kept vacuum-tight as any metal coatings there may be melted away and the refractory brick-work located behind them is gradually dissolved and slagged in the steel.

The invention eliminates these difficulties in that the outer ends of the inlet and outlet pipes for the metal connected to a heatable degasifying chamber and sealing the chamber barometrically are of U-shaped form similar to siphons.

Such siphon-like barometric closures or seals permit the operation of the degasifying chamber without it being necessary to bring the outside of the refractory material of the inlet and outlet pipes also into contact with liquid steel. In fact, the steel is now simply poured into the siphon of the inlet pipe which, for this purpose, is funnel-shaped.

The liquid steel can be fed to and drawn off from the degasifying chamber continuously through the inlet and outlet pipes without the vacuum prevailing in the chamber being impaired.

Advantageously, the degasifying chamber sealed barometrically by the inlet and outlet pipes is subdivided by partition walls dipping into the steel bath in the chamber into several chambers or compartments which, for the purpose of maintaining different working pressures, are each in communication with a vacuum pump. In this way, a gradually progressing degasification of the melt becomes possible, the working pressures within the individual compartments being subject only to slight variations.

Further features of the degasifying apparatus and the mode of operation thereof will now be described with reference to an embodiment illustrated diagrammatically and by way of example in the single figure of the accompanying drawing.

The metal to be degasified is poured into the funnel 1 of the inlet pipe E sealing the degasifying chamber K, which is under vacuum, barometrically. The difference between the pressure in the chamber K and the external atmospheric pressure is equalized by the height of the column of metal  $h_1$ . For this reason, the metal can be locked continuously into the degasifying vessel.

In order to establish as reliable a vacuum-tight sealing of the inlet pipe E as possible, the pipe E is provided with

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a refractory, gas-tight lining. Steel plates 2 are so fitted inside the pipe at such a distance from one another that they extend as far as the flow aperture of the pipe.

Finally, a suction chamber 3 is arranged around the inlet pipe E, the pressure in the chamber being preferably adjusted below the pressure in the degasifying chamber. In this way, any gases which may have penetrated through the sheet metal seals 2 can be drawn off. It is expedient to arrange the suction chamber 3 substantially at a height corresponding to the height of the funnel 1. The refractory lining of the inlet pipe consists of gas-permeable bricks 4 in the region of the suction chamber 3. These bricks have internal recesses 5 of substantially heart-shaped cross-section and they serve to collect gases which have a tendency to ascend at the pipe wall.

The degasifying vessel K may be subdivided into chambers 6, 7, 8, in which a stepwise degasification can be carried out.

In order to be able to degasify iron or steel in the first degasifying compartment 6 at as constant a pressure as possible of, for example, 100 torr; a torr is a unit of pressure equalling 1 mm. mercury or  $\frac{1}{760}$  atmosphere. The refractory lining of the inlet pipe E at its mouth 9 is somewhat above the normal bath level in the degasifying vessel. In the compartment 6, the difference between atmospheric pressure and working pressure is equalized by the height difference  $h_1$  (about 130 cm. at 100 torr). If the pressure in the degasifying compartment rises above 100 torr, no more liquid steel is delivered. Only when the working pressure drops to below 100 torr, is fresh metal sucked in. The bath height  $h_2$  in the compartment 6 may be relatively high (e. g. 30 cm.), since preferably only an initial degasification takes place in the first degasifying stage.

In the second compartment 7, in which, for example, there is a working pressure of 40 torr, the level of the bath must be about 12 cm. higher. As the height of the bath in this stage should be only about 15 cm., the bottom of the compartment 7 is arranged about 27 cm. higher than the bottom of the first compartment 6.

In the last compartment 8, if a pressure of 10 torr is to prevail therein, the bottom must again be arranged about 16 cm. higher, if the height of the bath in this stage is to amount to approximately 5 cm.

The sealing off of the degasifying compartments 6, 7, 8 with respect to one another is effected by means of partition walls 10, which consist of a refractory material. The walls advantageously contain a double-walled cooling insert 10' which is made of iron and may be cooled by a gas current.

The subdivision of the degasifying vessel into a plurality of compartments offers the following advantages:

Owing to the only partial pumping off of the gases at first at a fairly high pressure, a large number of pumps is saved. In view of the stepwise degasification, there is always a metal in the same condition of degasification within each degasifying stage. This simplifies operation and permits the production of a product of high-grade quality. The quantity of steel put through can be regulated by suitably adjusting the pressure in the compartments. This regulation can be controlled externally.

In order, for example, to remove by means of the degasifying arrangement the oxygen combined in a steel melt for the most part in the form of FeO, chemical conversion with suitable reducing agents is required. Carbon, for example, or hydrogen can be used for this purpose. Usually, the reduction of the FeO is carried out using solid carbon. For feeding the carbon, an arrangement 11 is provided on the compartment 6, the said arrangement supplying the carbon continuously, for example by a worm conveyor 11'. The addition of the carbon in the first degasifying stage at a relatively high pressure

has the advantage that the reaction does not take place turbulently, as is the case at lower pressures.

It is also possible to carry out the removal of the oxygen using gaseous reducing agents, for example with hydrocarbons. The hydrocarbons may be admitted to compartment 6 by means of a tube. The hydrogen component thereof does not cause any trouble in this case because it is substantially removed in the following degasifying stages. It is particularly advantageous to employ carbon compounds, in particular hydrocarbons, which are not decomposed at the high temperatures and react only with the FeO content of the bath. With such compounds, it is possible to carry out a quantitative deoxidation of the bath without the carbon content thereof increasing. This is very important for the production of particularly soft iron.

It is also readily possible to alloy steels in the degasifying arrangement according to the invention. This process advantageously takes place in the last compartment 8. In this case, there is a special advantage in that the metal bath has already been substantially freed of those foreign bodies in steel which may form inefficient combinations with the alloy materials.

The degasifying compartments 6 to 8 may be of different sizes. At the same time, it may be expedient to make the first compartment, in which a greater bath height is permissible, of comparatively small proportions and to form the following compartments progressively larger.

The bottom of the degasifying vessels is advantageously provided with small elevations. The effect of these elevations is to make the height of the bath small at these points, over which the whole of the metal to be degasified flows, and that therefore a practically complete degasification takes place at the said points.

It is also expedient to arrange the bottoms of the compartments so that they are inclined towards the outlet. This has the advantage that the metal can be forced out of the first degasifying compartment 6, through the other compartments and into the outlet pipe A at a somewhat higher pressure than the normal working pressure without special tilting apparatus having to be provided for emptying the compartments.

Plates 12 shown at the top of each compartment are advantageously mounted in the suction pipes leading to vacuum pumps, not shown, and serve as a protection against heat and radiation; the said plates are arranged in labyrinth fashion. The outlet pipe A, which is likewise of siphon-like form, is connected to the bottom of the last compartment 8. The said pipe also has at its free end a siphon-like overflow A'. The overflow pipe A' is provided on the top arch with a connection 15 for the attachment of a suction pipe. The bends in the siphon A and the overflow A' should be such that, at a working pressure of 10 torr in the last degasifying compartment 8, the liquid metal is disposed approximately in the centre 16 between the upper and lower bends.

When the degasified metal is to be poured off from the vacuum vessel, the outlet opening 17 of the siphon A, A' is closed with a refractory brick and a pump connected to the suction pipe 15 is started. The steel is thereby sucked through the overflow A', after which it can flow out. If the flow is to be interrupted, it is merely necessary for the suction pipe attached to the connection 15 to be placed under normal pressure by a valve provided on the pump.

The pouring of the degasified metal is effected under normal pressure. This has the advantage that under the external pressure the formation of gas bubbles in the ingot is obviated.

The degasifying vessel is heatable by any known means used for such purposes.

It is particularly advantageous to heat the degasifying apparatus by means of a glow discharge. In addition to the fact that it is simple to construct the electrode lead-ins, the uniform heating of the entire bath and the small wear on the electrodes has a particularly favourable effect. In the embodiment shown, the second compartment 7 is heated by a glow discharge. In this compartment, 13 designates the anode, the bath being operated as the cathode. The current is supplied to the cathode via a water-cooled iron rod 14, the cathode being preferably connected to earth potential together with the vacuum vessel.

We claim:

1. Apparatus for degasifying liquid metal, comprising a chamber, means for heating said chamber, partition means whereby said chamber is divided into a number of compartments, means for producing a sub-atmospheric pressure in each of said compartments, inlet and outlet pipes each in the form of a siphon communicating respectively with the end compartments of said chamber, and a vacuum pump communicating with each of said compartments.

2. Apparatus for degasifying liquid metal, comprising a vacuum chamber, means for heating said chamber, partition means dividing said chamber into a number of compartments, inlet and outlet pipes each in the form of a siphon communicating respectively with the interior of the end compartments of said chamber and a suction chamber enclosing a part of said inlet and outlet siphons, the pressure in said suction chamber being maintained below the pressure in said vacuum chamber and the part of the inlet and outlet siphons enclosed by the suction chambers being made of gas permeable bricks.

3. Apparatus as claimed in claim 2, said gas permeable bricks being provided with recesses of substantially heart-shaped cross-section where enclosed by said suction chambers.

4. Apparatus as claimed in claim 1 in which said inlet pipe opens into said first compartment above the level of the metal contained in said compartment.

5. Apparatus as claimed in claim 1, the bottoms of said compartments being arranged at different levels so that the depth of the liquid metal decreases towards the last compartment.

6. Apparatus as claimed in claim 1, the bottoms of said compartments being arranged at different levels and being inclined in a direction towards the outlet siphon.

7. Apparatus as claimed in claim 1, said partition means contain a double-walled metal insert through which a cooling medium, for example an inert gas under reduced pressure, flows.

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