Fig. 1.
Fig. 2.
INSTALLATION FOR THE VACUUM TREATMENT OF MELTS, IN PARTICULAR STEEL MELTS, AND PROCESS FOR ITS OPERATION

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ABSTRACT OF THE DISCLOSURE

An apparatus is provided for vacuum treatment of molten metal which comprises a primary vacuum vessel connected by a depending leg to a supply of molten metal and a stream degassing chamber connected to said primary vessel by a nozzle and depending leg.

The invention relates to a new mechanism for the vacuum treating of metal melts, in particular of steel melts.

The mechanism permits a significant degassing by vacuum, it is further suited to enable a continuous adding or draining of the melt, in particular to continuous casting molds, and is further suited to automate the process entirely or partially.

The installation consists of a primary evacuation vessel equipped with vacuum pipe, the type of the container familiar from the so-called circulation degassing process (compare Williams Patent U.S.A. 1,921,060). This primary evacuation vessel has a nozzle which dips into the melt through which the heat can be sucked up from the melt vessel which can also be a metallurgical furnace, for instance a Siemens-Martin furnace, electro-furnace, converter, or oxygen converter, into the circulation evacuation vessel (upward sucking nozzle) and otherwise a second nozzle to which the melt can drain into another container (drain nozzle).

According to the invention, the vessel designated to absorb the vacuum treated melt from the outlet nozzle is constructed as a vacuum installation.

The outlet nozzle of the primary evacuation container is therefore vacuum tight coupled to a container equipped with vacuum pipe (pouring stream degassing chamber).

The pouring stream degassing chamber, with preferably lower underpressure than in the primary evacuation container, further has advisably at least one outlet opening in order to enable the removal of the heat without separation of the chamber from the outlet nozzle.

In many cases, in particular if the heat entering the pouring stream degassing chamber has a strong tendency to diverge, a tubular shell encasing the pouring stream may be arranged in the pouring stream degassing chamber, which, if necessary, reaches down to the vicinity of the bottom of the chamber.

The pouring stream degassing chamber can preferably have an oxygen adding device, for instance, a blowing pipe.

An outlet pipe of the pouring stream degassing chamber can lead back to a melt vessel or molten metal supply vessel, for instance, be coupled to it through which a back-flow of the already vacuum treated steel is made possible. The back-flow pipe can be equipped with a metal pump as accelerator, preferably an electrical pump, with which the back-flow can either be promoted or retarded or also be operated in the reverse direction, for instance, in order to transport metal out of the melt vessel.

The installation can be made heatable at various places, that is, the nozzle sucking upward, the primary evacuation container, the outlet nozzle, the pouring stream degassing chamber and its outlets may be heatable individually or several at one time as required.

In particular, a controlled removal of the heat is made possible by such an installation, whereby the amount of metal passing through the primary evacuation vessel can be controlled by changing of the barometric height in the upward sucking nozzle and/or by conveying an installation (pump). In the first case, one can change the distance between the melt level in the primary evacuation container and the melt level in the melt container into which the upward sucking nozzle is dipped and/or the underpressure in the primary evacuation container. The conveyed amount becomes greater if the distance between these melt levels is reduced; it becomes less if the distance between levels is widened, assuming uniform underpressure in the primary evacuation container. However, it is also possible to change the underpressure, for instance, by throttling of the vacuum pipe, whereby controlled addition of "false gas," for instance, continuously or pulsating (for instance, air, CO₂, O₂, CO; H₂, H₂S; argon; N₂, CO₂; methane; CO₂; etc., depending upon the metallurgical requirements planned). Through these possibilities, it is also possible to perform an adjustment, in particular following sudden refilling into the melt container.

The installation also enables a fully continuous vacuum treatment and, if necessary, fully continuous pouring. To accomplish this, it only becomes necessary to continuously supply the vacuum nozzle with fresh metal and to remove correspondingly degassed metal from the pouring stream degassing chamber. It is thereby particularly advantageous to directly continuous cast the heat taken from the chamber. Such a continuous casting unit can also be replaced by a pressure casting installation with a shut-off part located between its pressure chamber and the pouring stream degassing chamber. The continuous casting of ingots, slabs and the like is also possible with the aid of casting buggies or corresponding pressure teeming.

The treatment processes possible with this installation, for instance decarburization, refining, back-pumping and casting can also be performed automatically, and that automatically controlled or regulated.

To these possible processes also belongs the removal of undesired accompanying elements of the steel which are solid at normal temperature, such as copper, lead, tin, zinc, bismuth, antimony, cadmium, and arsenic. These are partly evaporated by the vacuum treatment, partly by the addition of media which increase the partial vapor pressure of the particular element or its bond or alloys. In particular, halide compositions belong to these media.

The drawing illustrates a longitudinal view through an installation according to the invention, that is, in FIG. 1 an installation without (in FIG. 2 with) back-flow of the vacuum treated steel into the melt container.

The primary evacuation container 1 with the vacuum pipe 2 has a vacuum nozzle 3 as well as an outlet nozzle 4, which is vacuum-tight coupled to a pouring stream degassing chamber 5. The upward sucking nozzle 3 dips into the melt contained in the melt container 6 in (case of non-continuous operation, preferably a tapping ladle), which is refilled from the refill container 7 (possibly a furnace). A continuous casting installation 8 is in this case coupled to the pouring stream degassing chamber.

The tubular shell 9, which reaches down to the vicinity of the bottom of the pouring stream degassing chamber 5, connects to the outlet nozzle 4. This chamber is evacuated through the vacuum pipe 10. The tubular shell 9 preferably has, for instance, an oxygen blow pipe for the refining of the steel.
The various component parts of the installation in FIG. 2 are identified with the same reference symbols as in Fig. 1. Drawing from FIG. 1 is the layout of the installation with a back-flow from pouring stream degassing chamber 5 into the melt container 6 through the outlet opening 13 and back-flow pipe 16, or alternately 16'. The back-flow pipe 16 has an electrical pump 17. The back-flow pipe 16 can be conducted through the wall of the melt container 6, however, instead it can also be introduced into the area of container 6 from above as illustrated by dotted line (16').

It is possible to install stopper parts, for instance, stoppers, eventually also vacuum cut-off parts, at random places in the back-flow. Besides the electrical pump 17, the cut-off parts have not been illustrated.

21, 22 are alucides for the addition of processing and alloying media, 20 a manhole cover.

Outlet 11, which serves for the removal of the steel, is also sensibly equipped with a cut-off part (stopper 12). 18 designates a slope which guarantees a good removal of the rests from the pouring stream degassing chamber 5. The melt or hot metal chamber 6 can also have an outlet with stopper rod 26. The melt container 6 can also be utilized as end position of the treatment, for instance, as pouring ladle; in that case, the outlet opening 11 may be lacking. 23, 24, and 25 identify pipe lines for gas, gas and gas and eventuall preheated "lift gas," for instance to 1000° C. and above.

In both illustrations, the level of the heats have been drawn in, that is, the level in the pouring stream degassing chamber 5 has been designated with 14, the level in the melt container 6 with 15, and the level in the primary evacuation container 1 with 27. The level difference between 15 and 27 has to be less than the barometric pressure, that is, less than 1400 mm. high opposite the outlet. The height of the level may be less if a conveying mechanism, for instance an electrical pump 17' is provided for in the outlet 11.

For the particular case of FIG. 2, the following is to be considered:

If the back-flow pipe 16, or alternately 16', between chamber 5 and chamber 6 is to become operative, it may become necessary to equalize the eventually present level difference by activation of a conveying mechanism 17, for instance an electrical pump. The flow from the pouring stream degassing chamber 5 can be adjusted by this conveying mechanism 17 in the following manner:

1. The entire degassed heat can flow back into the container 6 through the back-flow pipe 16, respectively 16', at closed out-flow nozzle, possibly supported by the conveying mechanism 17.

2. The melt can flow out of the system at 11 at opened outlet opening when the back-flow has been prevented.

3. At opened outlet 11, its amount of out-flow can be controlled by an adjusting of the back-flow.

With the installation according to the invention, it is possible to produce steels, alloyed or unalloyed. It is also possible to produce particularly low-carbon steels in a simple manner. The low-carbon, as known, is particularly important for corrosion-resistant steels, for magnetic aging-resistant steels, or also for steels of which the magnetic or electrical properties are of importance. In particular, generating or transforming steel. Low-carbon unalloyed or alloyed steels can be produced by treating the steel melt in any refining furnace (Siemens-Martin, electric furnace, converts or oxygen converter) to a controlled carbon content in the order of 0.025 to 0.12%, preferably 0.03 to 0.06%, tapping the melt in rimmed condition, and treating the melt with a controlled vacuum such that carbon contents below 0.025%, preferably below 0.0080%, more preferably below 0.0050%, are obtained.

For the decarburization treatment it is of particular advantage if an oxygen partial pressure of several torr is maintained in the evacuation vessel and/or in the pouring stream degassing chamber during the vacuum treatment or a part thereof. In the event that the deoxidation, denitrifying, and/or oxygen sensitive alloying media are being added, it is advisable to utilize this oxygen partial pressure in vacuum only prior to the adding of the mentioned media. The oxygen required therefor may practically be added entirely or partially into the suction nozzle or below it. If the so-called lift gas, that is a gas which is to furnish an up-lift, is added to the metal heat to be sucked up to the suction nozzle, it is then possible to add the mentioned oxygen which may be in gaseous form or in form of oxygen yielding materials, for instance, in form of CO₂ with the lift gas.

The various metallurgical measures which are to be conducted in one of the installations, can be performed simultaneously or separated from one another. It is thus, for instance, possible to perform a decarburization treatment in one of the installations according to FIG. 1 and in the pouring stream degassing chamber a deoxidation and alloying treatment. A great advantage consists in an installation according to FIG. 2. There, one can work at first only with back-flow, for instance, for the purpose of decarburization if one aims to obtain particularly low carbon contents, for instance below 0.008 or less than 0.005%. The decarburization can take place either in the primary-evacuation container 1 or in the pouring stream degassing chamber 5, or in both. It is thereby possible to add required alloying additions already at the beginning of the decarburization treatment.

After the entire heat has been processed in this matter, one can, with or without back-flow, continue to perform a deoxidation treatment.

In similar manner, during the circulation or a part thereof, one can also take measures to remove the above mentioned undesirable accompanying elements which are solid at normal temperature.

In the foregoing specification, we have set out certain preferred practices and embodiments of our invention, however, it will be understood that the invention may be otherwise practiced within the scope of the following claims.

We claim:

1. Apparatus for the vacuum treatment of molten metal and particularly molten steel comprising a primary evacuation chamber having a depending suction line connected to a source of molten metal, a secondary evacuation chamber receiving metal from said primary evacuation chamber through an outlet nozzle in said primary chamber to provide a stream degassing area in said secondary chamber, said secondary chamber having a discharge outlet delivering treated molten metal therefrom and means in said secondary chamber controlling the flow through said discharge nozzle whereby normally to provide a pool of treated metal therein.

2. An apparatus as claimed in claim 1 wherein the outlet nozzle is surrounded by a tubular shell extending into the secondary chamber to a point adjacent the bottom thereof and means are provided for supplying a gas to said shell and secondary chamber.

3. An apparatus as claimed in claim 1 wherein connecting means are provided from said said secondary evacuation chamber to said source of molten metal whereby a portion of treated molten metal may be diverted to the said source.

4. An apparatus as claimed in claim 1 wherein each of the depending suction line, the primary evacuation chamber, the outlet nozzle and the secondary evacuation chamber are provided with selectively operable heating means.

5. An apparatus as claimed in claim 1 wherein pump means is provided at one of the depending suction line and the discharge outlet nozzle.

6. Process for vacuum treatment of molten metal and particularly molten steel comprising the steps of:
(a) subjecting said molten metal as a first changing pool to a vacuum,
(b) supplying molten metal to said first changing pool upwardly thru a conduit from a molten metal supply vessel located below said first changing pool,
(c) discharging said first changing pool of molten metal as a stream through an evacuated area to stream degas said metal,
(d) collecting said stream as a second changing pool and subjecting said second pool to a vacuum, and
(e) discharging said treated metal into a solidification container.

7. A process as claimed in claim 6 wherein a portion of said second pool is returned to said first changing pool.

8. A process as claimed in claim 6 wherein a treating gas is added to said discharge stream from the first changing pool.

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