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TREATMENT OF METAL MELTS

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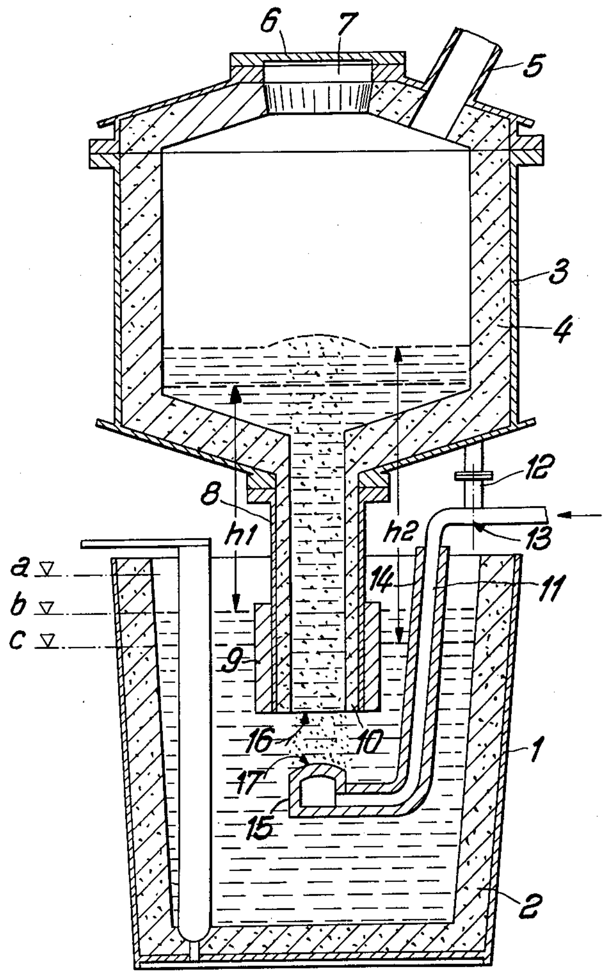

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TREATMENT OF METAL MELTS

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For the vacuum treatment of metal melts, especially in the degasification of steel, use may be made of an evacuated vessel which is arranged above a container which is under atmospheric pressure and is connected to the container by a rising pipe which is filled with the metal melt during the treatment. The difference between the level of the melt in the container and that in the evacuated vessel cannot therefore exceed the barometric height which is determined by the specific gravity of the melt. For steel the barometric height is, on the average, 1.4 metres. If it is desired to keep a substantial quantity of the melt in the evacuated vessel during the treatment, the apparatus must be designed in such a way that the evacuatable vessel is disposed at only a small distance above the container which is under atmospheric pressure, and it must be borne in mind that the container frequently consists of a ladle filled with a melt and otherwise designed from the usual points of view. For these and other reasons it has not been possible to increase the amount of melt in the evacuated vessel above a certain amount which is in no way sufficient.

Attempts have, therefore, been made to devise means whereby the distance between the level of the melt in the vacuum vessel, on the one hand, and in the container, which is under normal pressure, on the other hand, may be increased so that this distance exceeds the barometric height.

Theoretically such an increase in height is actually possible by allowing a current of gas to flow through the melt in the rising pipe so as to impart as it were a certain amount of dynamic buoyancy to the melt. For this purpose a nozzle has been introduced into the wall of the rising pipe through which nozzle a gas was continuously blown into the melt rising in the pipe. The effect of this expedient, however, has been found to be too small to be of practical interest. The possible increase in the distance between the levels of the melt in the vacuum vessel and in the container does indeed qualitatively meet the theoretical expectation but does not do so quantitatively would have practically justified the blowing in of gas into the rising pipe. When this was done, however, the effect became noticeable only when a considerable quantity of gas was used and, when degasifying steel, for example, it counteracted the effect of the process and led even to an undesirable increase in the necessary output of the vacuum pumps and to an increase in the size of the vacuum vessel being necessary because the melt boils vigorously owing to the large additional amount of gas. The invention is based on the discovery that the dynamic buoyancy produced by the current of gas flowing upwardly in the rising pipe is such as to be practically useful only if the current of gas is introduced in such a way that it is distributed over the entire cross-sectional area of the rising pipe. If the process is carried out in this way it has been surprisingly discovered that even relatively small amounts of gas, which have no appreciable effect when the known method is used, effect a considerable raising of the level of the melt in the vacuum vessel. The explanation of this unexpected effect is probably that a current of gas which is not distributed over the full cross-section of the rising pipe only causes turbulence in the rising pipe but not buoyancy.

An apparatus for carrying the process of the invention into effect can be constructed in many different forms. The most obvious way is to insert a large number of nozzles through the wall of the rising pipe, the nozzles projecting to different distances from the wall. This, however, would lead to structural complications which could scarcely be overcome. It would also be possible to construct a part of the wall of the rising pipe of porous refractory brickwork through which the gas is blown. However, only by the use of very high pressures, which would not be practicable, could the gas be driven so far radially inwards from the pores that it would be distributed over the entire cross-sectional area of the rising pipe.

These difficulties are obviated by means of the invention by using a gas inlet pipe having an outlet opening which opens below the lower opening of the rising pipe. According to the invention, therefore, the place at which the gas is introduced into the melt is situated outside the rising pipe. It is, therefore, easily possible to form the mouth of the gas inlet pipe in such a way that the gas which escapes from it enters the rising pipe from a short distance below it and is distributed over the entire cross-sectional area of the rising pipe.

As regards the shape of the mouth of the gas inlet pipe it would be possible to provide a single opening which is approximately equal in area to the cross-sectional area of the rising pipe and to allow gas bubbles to enter rhythmically through this opening, the gas bubbles being so large that they entirely or nearly entirely fill the cross-sectional area of the rising pipe. It has been found, however, that the desired effect can be considerably enhanced by introducing the current of gas in a state of fine sub-division. This can be done by arranging at the outlet end of the gas inlet pipe a head having a number of nozzles, the total cross-sectional area of which is preferably at least half as great as the internal cross-sectional area of the rising pipe.

A sufficient fine distribution of the gas current is obtained if the cross-section of an individual nozzle is, at the most, equal to 1 mm.^{2}. In this case excellent results are obtained particularly if the nozzle head is made of refractory porous material.

As regards the shape of the nozzle head in other respects it is advisable to make it conform in shape and size to the internal cross-sectional area of the rising pipe. The upward flow of the melt is not interfered with by the nozzle head arranged below the mouth of the rising pipe if the distance between the mouths of the rising pipe and of the gas inlet pipe is made approximately equal to or greater than the internal diameter of the rising pipe. The effect of the flow is then to hold together the rising streams of gas bubbles.

In many treatment processes the degasified melt in the vacuum vessel is returned through the rising pipe to a ladle or container below it. When this is done the nozzle head disposed below the mouth of the rising pipe may cause some interference. Since the uniformity of a vacuum treatment depends on whether the degasified material can mix completely with the metal in the ladle, or is, at least partly, disposed in a layer below this metal, it is particularly advantageous if the degasified material on its return to the ladle flows to the bottom thereof in a substantially closed stream and first distributes itself over the bottom so that mixing then takes place from the bottom upwards. In order to prevent this advantageous action being interfered with by the device for introducing the current of gas, according to the invention, the gas inlet pipe and its mouth are so arranged that they can be moved out of alignment with the rising pipe, for example by mounting the gas inlet pipe so that it can be swung aside.

An apparatus for carrying out the process of the invention is illustrated, by way of example, in the accompanying drawing which shows a longitudinal section through an apparatus for degasifying a steel melt.

Referring to the drawing, the apparatus illustrated consists of a lower ladle **1** which is under atmospheric pressure and is provided with the usual closure plug and with a refractory lining **2**, and an upper vessel **3** which has a refractory lining **4** and can be closed on all sides and is connected by a pipe **5** to a vacuum pump. The vessel **3** has a cover **6** having a closable opening **7** through which other substances can, if necessary, be added in regulated quantity to the melt in the vessel **3**.

The ladle **1** and the vessel **3** are in communication through a rising pipe **8** which is protected on the inside and partly also on the outside by a refractory lining **10** and a refractory jacket **9**. A curved pipe **11** extends into the container **1** and is suspended from a support **12**. The support **12** allows the pipe **11** to be swung about a vertical axis **13** and also permits its height to be adjusted. The pipe **11**, which is protected by a refractory covering **14** is provided at its lower open end with a hollow member **15** of porous brick or stone which is disposed in alignment with and below the opening of the rising pipe **8**. The pipe **11** is connected, by means not illustrated, to a vessel containing gas under pressure.

The steel to be degasified is charged up to the level *a* into the ladle **1**. After this, the vacuum pump connected to the pipe **5** is switched on, so that the vacuum produced in the vessel **3** draws part of the steel from the ladle **1** into the vessel **3**, whereby the level in the ladle is lowered to the level *b*. The distance between the levels of the melt in the ladle **1** and in the vessel **3** now amounts to h_1, an amount which cannot be greater than the barometric height which, in the case of iron, only amounts on the average to 1.4 metres. Now, a valve which is not illustrated and is disposed between the pressure gas container and the pipe **11** is opened so that gas emerges in a finely divided form from the outer surface **17** of the member **15**. The gas bubbles which are indicated by dots in the drawing rise in the melt and arrive at the mouth **16** of the rising pipe **8** and then rise upwards in the pipe **8** until they arrive in the gas chamber of the vacuum vessel **3**. This current of gas which is produced in the form of finely distributed bubbles produces a dynamic buoyancy, the result of which is that the distance between the level of the melt in the ladle and in the vacuum vessel rises from the original mount h_1 determined by the barometric height to the amount h_2 and the level in the ladle sinks to *c*. The drawing shows clearly the extent to which the amount of melt in the vessel **3** is thereby increased.

After a certain time of treatment in the vessel **3** the vacuum is disconnected so that the melt in the vessel **3** is returned to the ladle **1**. In order to prevent the gas pipe **11** and its hollow head **15** from interfering with the return flow of the melt, the gas pipe **11** is previously swung laterally about the axis **13**, so that the nozzle head **15** is disposed outside the extended axis of the rising pipe **8**.

The interchange of the portions of the melt in the vacuum vessel **3** with portions in the ladle **1** need not be effected by alternately connecting the disconnecting the vacuum at **5**. Instead of doing this it is possible to increase and reduce the distance between the vessel **3** and the ladle **1**, that is to say to raise and lower either the vacuum vessel **3** or the ladle **1**. Then, in all cases, when the vessel **3** is emptied into the ladle **1** through the rising pipe **8** the head **15** is swung aside. In the reverse process when the melt is returned through the rising pipe **8** into the vacuum vessel **3** the nozzle head **15** can at first remain in its swung aside position. However, in order to effect a more rapid charging of the vessel it is usually advantageous to bring the nozzle head **15** into its swung-in position in alignment with the rising pipe **8** at the same time as the inflow into the vessel **3** begins.

When the nozzle head is swung out, the current of gas which escapes through the pores in the nozzle **15** can, and should in general, be maintained, in order that the pores may not be blocked by parts of the melt.

The effect of the cross-section of the gas inlet nozzle which, in the example illustrated, is constituted by the pores of the nozzle member **15**, will finally be explained by means of a numerical example. With a diameter of 1 mm. the result could be obtained that the distance of the two levels exceeded the barometic height by 10 centimetres. This is already considerable seeing that, in the arrangement illustrated, h_1 amounts to about 1.4 metres. A reduction in the diameter from 1 mm. to 0.2 mm., however, gave the surprising result that the increase in the difference of level amounted to 50 centimetres. At the same time the gas consumption fell from 50 cubic metres per hour to 5 cubic metres per hour, that is to say to one-tenth of that which had to be used for 1 mm. diameter nozzles or pores for increasing the level by only 10 centimetres.

The steel which flows from below into the rising pipe may, in some circumstances, have a restrictive and compressive effect on the gas bubbles in the cross-sectional area. If the uniformity of the distribution of the current of gas is too strongly impaired in this way, then additional gas can be introduced from the inner surface of the pipe, so that a sufficient number of gas bubbles also rise up in the edge zone and prevent the liquid steel from flowing back in this zone.

I claim:

1. Apparatus for the vacuum treatment of metal melt comprising a closed vessel, means for evacuating said vessel, a container for the melt disposed below said vessel and under atmospheric pressure, a rising pipe forming the sole connection between said vessel and said container, the upper end of said pipe being connected to said vessel and the lower open end extending into said container, and a gas inlet pipe with its outlet disposed below, in alignment with, and spaced from the lower open end of said rising pipe, said gas inlet pipe having a plurality of outlet nozzles of small size relative to the cross-sectional area of said rising pipe, said nozzles being uniformly distributed over an area the shape and size of which equals substantially that of the internal cross-sectional area of said rising pipe, whereby the gas is distributed over the cross-sectional area of said rising pipe.

2. The apparatus as claimed in claim 1, in which the total cross-sectional area of said nozzles is at least half the internal cross-sectional area of said rising pipe.

3. The apparatus as claimed in claim 1, said gas inlet pipe having a nozzle head in which the cross-sectional area of any individual nozzle is at the most 1 mm.^{2}.

4. The apparatus as claimed in claim 1, said gas inlet pipe having a head of porous refractory material.

5. The apparatus as claimed in claim 1, in which the distance between the mouth of the gas inlet pipe and the mouth of the rising pipe is at least equal to the internal diameter of the rising pipe.

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