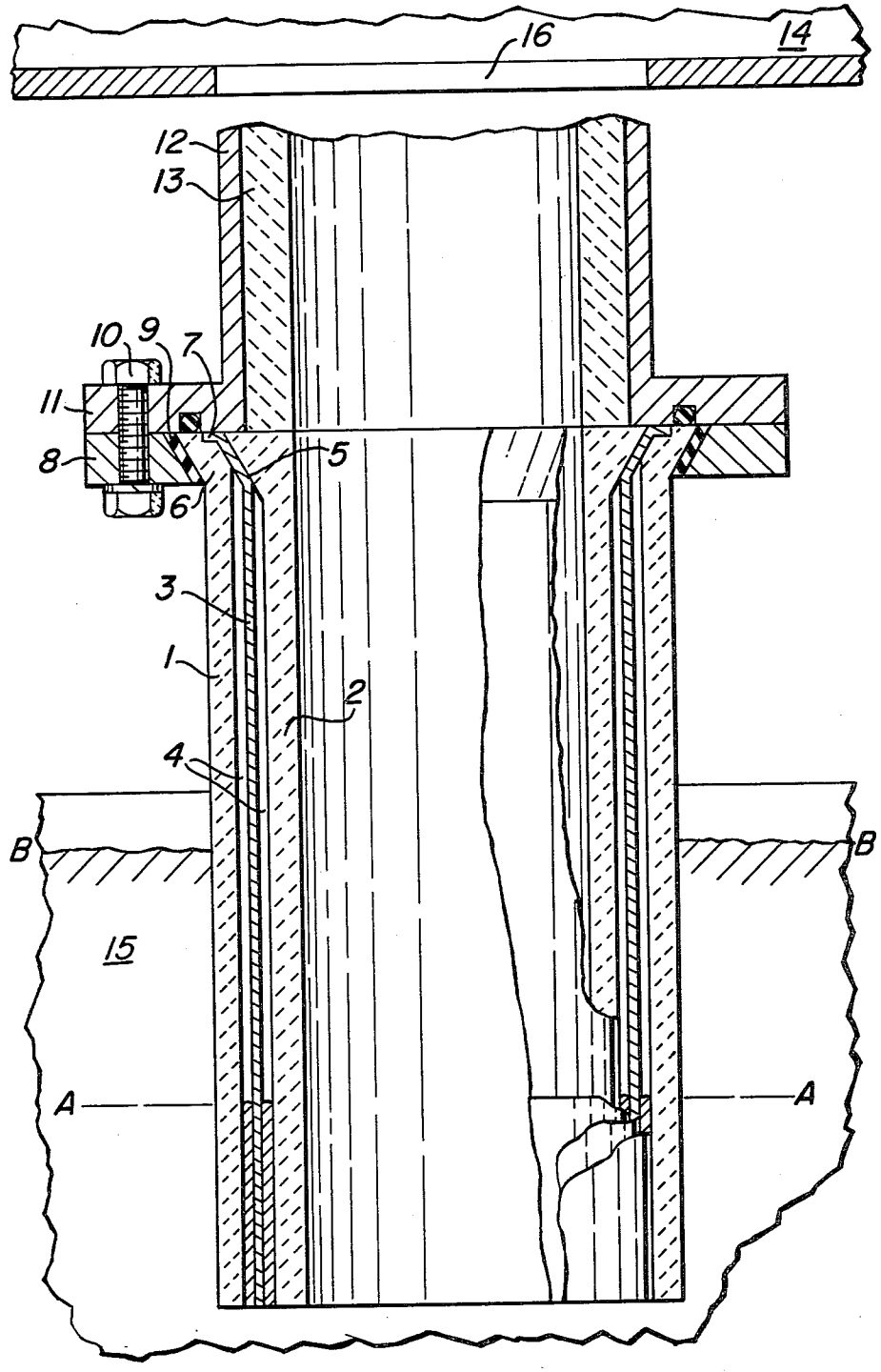
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IMMERSION PIPE FOR VACUUM DEGASSING APPARATUS

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3,131,245 IMMERSION PIPE FOR VACUUM DEGASSING APPARATUS

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The present invention relates to an immersion pipe for vacuum apparatus for degassing molten metals and particularly steel.

For degassing molten metals and particularly steel by means of a vacuum, numerous types of apparatus are known. Especially suitable for this purpose has proved to be an apparatus in which the molten metal is contained within a vessel and conducted therefrom through a continuously evacuated chamber into a second vessel or, even better, back into the same vessel. Since such degassing apparatus are usually mounted above the vessel containing the molten metal, immersion pipes are required which are inserted to a certain depth into the molten metal and through which the metal can pass into the degassing apparatus and back into the vessel.

These immersion pipes have usually been made of metal and were provided with a lining of a highly refractory material which was built closely around it or firmly tamped thereon. Such a lining on the metallic immersion pipe was also provided in the form of an inner lining as well as an outer jacket of ceramic material so that the metal pipe itself with the possible exception of its lower edge did not come into any direct contact with the molten metal. In such a case, the metal pipe formed the positive support of the inner and outer ceramic covering.

Immersion pipes of this type have not proved successful in the art of degassing molten metals by means of a vacuum. Their disadvantages were caused primarily by the different coefficients of expansion of the two materials, that is, of the metal pipe and the refractory covering, which often led to a loosening of the connecting member leading to the degassing apparatus and thus caused serious leakages and breakdowns in the operation of the apparatus.

It is an object of the present invention to provide an immersion pipe for vacuum degassing apparatus which considerably facilitates, improves, and safeguards the operation of the degassing apparatus and overcomes all of the disadvantages of the immersion pipes previously used.

For attaining this object, the present invention provides an immersion pipe which consists of a highly refractory nonmetallic material, and preferably ceramic material, which is freely suspended in the molten metal to be degassed and not reinforced or carried by any metallic elements.

The special advantages of such immersion pipes according to the invention are based upon the following facts: Molten steel has generally a temperature of at least 1500° C. The immersion pipes connecting the molten material with the degassing apparatus cannot be preheated to such high temperatures and must be immersed into the molten metal at their own temperature, that is, at about 50° C. Since immersion pipes of metal as previously used which were firmly connected along their length with a highly refractory inner lining and outer jacket, for example, of a ceramic material, greatly expanded at such a sudden change in temperature, these refractory layers would frequently break completely or at least develop cracks resulting in a leakage and possibly even in a breakdown in the operation of the vacuum apparatus, particularly if the refractory material would

break away from the metal pipe and leave the same exposed to the temperature and erosive action of the molten metal flowing therethrough.

These disadvantages are partly overcome if, according to an earlier proposal, the immersion pipes are freely suspended and consist of highly refractory materials. It has unexpectedly been found that such pipes are capable of complying with the requirements of a degasification of molten metals despite the fact that they are not provided with any metallic reinforcements. Prior to this invention it was erroneously assumed that freely suspended ceramic parts could not be used for this purpose since the strong temperature differences in the order of about 1500° C. to which such pipes are subjected might easily result in a breaking of such unsupported ceramic parts so that these parts or portions thereof would fall into the molten metal and at least clog up the passages for the molten metal, and, for example, prevent the outlet of a casting ladle from being securely closed. In order to prevent this, the supporting parts of these previous immersion pipes were always made of metal which was covered with ceramic material which was intimately connected thereto by tamping, bricking, or the like. This resulted in the above-mentioned disadvantages which were caused by the great difference in the coefficients of expansion of the two different types of material. Instead of preventing the danger of breakage of the refractory covering and the attending disadvantages thereof, this danger was therefore increased by the use of the previous immersion pipes.

The feature of the present invention consists in making the immersion pipe of a pair of ceramic pipes which are mounted concentrically within each other and both of which are freely suspended from their upper end and spaced from each other along their entire length. Since ceramic pipes, even though sufficiently gastight at lower temperatures, usually increase in permeability when subjected to high temperatures, it is another important feature of the invention to insert a metallic pipe as a gas seal between the outer and inner ceramic pipes and to mount the same so as to be likewise freely suspended from its upper end and to leave a small tubular gap between such metal pipe and each ceramic pipe. Since this metallic pipe is not covered by any protective layer at its lower end which is immersed into the molten metal, the latter will enter into the two gaps between the metal pipe and the two ceramic pipes and form a vacuum-tight seal therein. Such sealing action is particularly effective since the molten metal entering into these gaps and rising therein to a certain level will gradually soften and melt the metal pipe so that the latter will combine or alloy with the molten metal. Consequently, the sealing action will remain secure even though cracks might be formed in the walls of the ceramic pipes. Since all three pipes are to be freely suspended independently of each other and are only mounted at their upper ends, and since the ceramic pipes when vitrified frequently do not keep their intended truly cylindrical shape, it is necessary to make the gaps between the ceramic pipes and the metal pipe of a sufficient width. Although the metal pipe may be made of any suitable wall thickness, it is preferably made of a thickness of, for example, 2 or 3 mm. The gap between the metal pipe and each ceramic pipe may then be made of a similar or a slightly larger size. This will be adequate to compensate for the deformation of the ceramic pipes caused by vitrifying thereof, and also to compensate for the difference in the thermal expansion of the ceramic pipes and the intermediate metal pipe, and it will still leave sufficient space for the molten metal to enter into the gaps between the pipes.

It has further been found according to the invention that the freely suspended pipes of refractory material

are each preferably made in one integral piece rather than by being composed of individual parts. This will not only increase the solidity and mass density of these pipes, but also considerably improve their sealing and protective action, as well as their stability.

Still another advantage of the immersion pipes according to the invention resides in the fact that, due to the free suspension of the three tubular portions along their entire length, they may be much more easily exchanged and also manufactured at a considerably less expense.

These and other objects, features, and advantages of the present invention will become further apparent from the following detailed description thereof, particularly when read with reference to the accompanying drawing of one preferred embodiment of an immersion pipe according to the invention shown in a central longitudinal section, in which the inner ceramic pipe and the metal pipe are broken away at one side for a clearer illustration.

As illustrated in the drawing, the immersion pipe according to the invention consists of a pair of tubular members of highly refractory, preferably ceramic, material forming an outer pipe **1** and substantially concentrically therein and spaced therefrom an inner pipe **2**. These two ceramic pipes are mounted merely at their upper ends so as to be freely suspended along their entire length. The substantially cylindrical space between pipes **1** and **2** contains a metallic pipe **3** which is likewise mounted merely at its upper end and freely suspended along its entire length without engaging the ceramic pipes **1** and **2**. The interior of the immersion pipe connects an upper molten metal degasification chamber with a lower molten metal container. The degasification chamber is schematically indicated by the degasification vessel **14** shown in section and broken away outline and having the aperture **16**, through or into which the immersion pipe passes, being therein suitably secured (not shown) with the formation of a vacuum-tight seal, as is conventionally understood. The molten metal container is schematically indicated by the broken outline of the container **15**. Inasmuch as the immersion pipe when being immersed into the molten metal is subjected to a sudden temperature change from a practically cold condition to a temperature of about 1500° C., the two different materials thereof will undergo an entirely different thermal expansion. While the ceramic material of pipes **1** and **2** will only slightly expand, the metal of pipe **3** will expand very greatly. As previously pointed out, this led in the previous types of immersion pipes, in which the different materials were in direct engagement with each other, to an unavoidable immediate breakage of the refractory material. For this reason primarily, the three different pipes are merely connected at their upper end and otherwise freely suspended independently of each other with a cylindrical gap **4** separating the metal pipe **3** from each ceramic pipe **1** and **2**. These cylindrical gaps should therefore be of a width sufficient to compensate for the difference in the thermal expansion of the ceramic pipes **1** and **2** and the metal pipe **3**. Furthermore, the width of these gaps should be sufficient to take into account the fact that the ceramic pipes, although originally of a true cylindrical shape, will when being vitrified become slightly deformed so that, when inserted into each other, they will no longer be exactly concentric and the gaps **4** will also no longer be truly cylindrical. In determining the minimum width of these gaps, there is still one more important factor to be considered, namely, the fact that, according to the present invention, these gaps also serve the important purpose of admitting a small amount of molten metal from the body of metal to be degassed so that such metal will rise within these gaps to a certain level A depending upon the depth of immersion B of the pipe unit into the molten metal bath and will form a gas and vacuum-tight seal therein. Such seal is particularly effective due to the fact that the ribbon

of molten metal surrounding the metal pipe **3** will slowly dissolve or melt the latter along its points of engagement therewith and thereby combine or become alloyed with the metal pipe. In view of such gradual dissolution of the lower part of the metal pipe **3** which is thus in direct contact with the liquid metal, the metal pipe should of course be made of a wall thickness so as to last for at least one complete degassing operation of the body of metal into which it is immersed. Usually, a wall thickness of about 2 or 3 mm. will be sufficient, while each of the gaps **4** should have a similar width or be made slightly larger.

For mounting pipes **1**, **2**, and **3** so as to be freely suspended along their length without engaging each other, the outer wall of the inner pipe **2** is preferably tapered outwardly at its upper end so as to form a conical end portion **5**, whereas the upper end **6** of the outer pipe **1** is preferably conical at both sides. The upper end portion of the metal pipe **3** is likewise conical so as to fit tightly between the conical end portion **5** of the inner ceramic pipe **2** and the conical inner surface on the upper end **6** of the outer ceramic pipe **1**. The upper end of the conical part of the metal pipe **3** may also be provided with a small flange **7** which is seated in a corresponding annular recess in the upper end of the outer ceramic pipe **1**. The outer conical surface on the upper end portion **6** of pipe **1** is seated within an inner conical surface of a mounting ring **8** and is separated therefrom by a suitable packing **9** of a relatively soft compressible material. Mounting ring **8** is firmly secured, for example, by bolts **10**, only indicated by dot-and-dash lines, to a flange **11** on the lower end of a metal pipe **12** which is securely connected to the degassing chamber, not shown, of the degassing apparatus. This metal pipe **12** forms an airtight covering and carries a relatively thick inner lining **13** of ceramic or other highly refractory material which insulates the metal pipe **12** sufficiently from the heat of the flowing molten metal ascending from or descending to the body of metal into which the lower end of the immersion pipe is inserted. The lower end of the ceramic lining **13** in metal pipe **12** abuts flush against the upper end surface of the inner ceramic pipe **2**, while flange **11**, when bolted to ring **8** presses tightly upon the upper surface of the small flange **7** on metal pipe **3**, and also compresses the packing **9** so as to seal the entire immersion pipe air- and gas-tight toward the outside.

Although my invention has been illustrated and described with reference to the preferred embodiment thereof, I wish to have it understood that it is in no way limited to the details of such embodiments, but is capable of numerous modifications within the scope of the appended claims.

Having thus fully disclosed my invention, what I claim is:

1. In a vacuum degasification device for molten metal having, as elements thereof, in one above the other arrangement, container means for molten metal to be degasified, degasification chamber means for such metal and conduit means connecting said chamber means with said container means, said conduit means being positioned for immersion in said container means into a molten metal zone therein, in combination, conduit means for molten metal positioned to extend into said zone and having two substantially concentrically extending, radially spaced apart ceramic tubular members, a metallic tubular member disposed concentrically between said ceramic members and having a length substantially extending at least to the upper level of said molten metal zone, all of said tubular members extending into said molten metal zone, and means at the upper end of said tubular members positioned at a point above the level of the molten metal for suspending said tubular members to form cylindrical gaps between said metallic tubular member and each of said ceramic tubular members, said cylindrical gaps extending from said suspending

means to the ends of the tubular members disposed in said molten metal zone, said cylindrical gaps between said tubular members being of a width at least sufficient to compensate for any slight deformations of said ceramic members and for the difference in the thermal expansion of all of said members.

2. Improvement in accordance with claim 1 in which said conduit means include an upper separable molten metal conduit means having a ceramic inner tubular surface of an inner diameter substantially the same as that of the inner surface of the inner tubular ceramic member, in which said upper conduit means are positioned above said zone, in which there are defined at the upper ends of said tubular members conical mating surfaces which when in mating contact hold said tubular members in said spaced relation, and in which means are provided to secure said upper conduit means into registry position with the internal diameter of the inner tubular member and clamp said tubular members into their said spaced relation..

3. An immersion pipe as defined in claim 1, wherein each of said tubular ceramic members is vitrified as one integral element.

4. An immersion pipe as defined in claim 1, wherein the said tubular metallic member substantially extends into said molten metal zone and is made of a metal which is adapted to be slowly dissolved by the molten metal rising into the gap between said concentric non-metallic ceramic tubes, when the lower ends of the tubes are immersed into said molten metal.

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