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(71) Applicant : **FOSECO INTERNATIONAL LIMITED**
285 Long Acre
Nechells Birmingham B7 5JR (GB)

(72) Inventor : **Cullen, Liam**
39 Allman Road
Erdington, Birmingham, B24 9DY (GB)
Inventor : **Clark, Michael Robert**
41 Red Hill
Stourbridge, West Midlands (GB)

(74) Representative : **Eyles, Winifred Joyce**
Burmah Castrol Group Patents Department,
Foseco International Limited, 285 Long Acre,
Nechells
Birmingham B7 5JR (GB)

(54) Purifying molten metal.

(57) Unwanted solid, non-metallic inclusions are removed from molten metal in a refractory-lined vessel by bubbling inert gas upwardly through the metal.

The invention provides a gas permeable nozzle block (16) shaped to contain a nozzle (17) with a centrally-disposed through bore and to be sealingly set in the refractory lining (13) of a vessel (10) to contain molten metal, the nozzle block (16) having a gas-receiving channel (18) to extend around the nozzle (17) and means to connect the gas-receiving channel (18) to a source of gas.

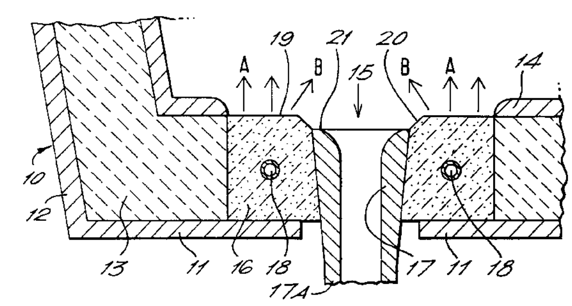

FIG.1.

EP 0 576 212 A2

This invention relates to a means for the purification of molten metal, i.e. the removal of unwanted solid non-metallic inclusions contained in the molten metal.

The need to provide 'clean' metals, e.g. steel, is well known and many methods have been proposed to that end. One well known general technique is to bubble an inert gas through the molten metal, the gas removing inclusions with which it comes into contact by floating them up to the surface of the molten metal.

Various means have been proposed in order to provide the desired stream of inert gas bubbles through the molten metal.

For example, EP-A-404641 discloses the use in a tundish of a gas duct set into the permanent refractory lining and leading to a gas distribution chamber in the bottom of, and extending across, the tundish, the chamber being covered with a gas-permeable plate.

GB-A-2164281 discloses the use of a porous refractory tile extending across the width of, and sitting on the floor of, a tundish, the tile containing a gas conduit with a plurality of exits to deliver gas into the tile.

EP-A-0239257 discloses passing steel in a tundish through an apertured upright board, while introducing an inert gas at the foot of the board at its upstream side to cause a stream of bubbles to flow over its upstream side.

EP-A-0059805 discloses the use of a porous nozzle in the bottom of a molten metal vessel, the nozzle having a flanged upper portion and cylindrical lower portion, its body being enclosed in a gas tight steel shell, with means to provide gas into the porous nozzle to escape into the molten metal in the vessel.

The present invention aims to provide an improved means of bubbling gas into molten metal in the region of a nozzle in the bottom of a molten metal vessel.

In a molten metal vessel, such as a tundish used in the continuous casting of steel, it is usual practice to have one or more outlets in the bottom of the vessel, which can be opened to allow the metal to empty out. The vessel will normally be of metal, usually steel, lined with refractory material, e.g. brick or a cast refractory concrete. Each outlet is provided by a nozzle positioned in a correspondingly-shaped hole though the floor of the lined vessel. It is conventional practice not to set the nozzle directly into the vessel lining but to set it into a so-called nozzle block, which latter is set into the vessel lining.

We have now found that an improved means of removing inclusions can be provided by utilising the nozzle block surrounding the nozzle as the conduit for inert gas into the vessel.

Accordingly, the invention provides a means of supplying gas into a refractory-lined vessel containing molten metal in which an outlet through the floor of the vessel comprises a nozzle with a centrally-disposed through bore, the nozzle being sealingly set in a nozzle block which is itself sealingly set in the lining of the floor of the vessel, the nozzle block being gas-permeable and having a gas-receiving channel extending around the nozzle, and means to connect the gas-receiving channel to a source of gas.

Preferably, the gas-receiving channel extends completely around the nozzle.

Gas, e.g. argon, supplied to the channel escapes upwardly through the porous nozzle block and emerges into the molten metal in the vessel in streams of bubbles rising from the vessel floor around the nozzle.

The gas-receiving channel preferably contains a pipe connected to the source of gas, the pipe having perforations or slots, preferably in its upper surface, to allow escape of the gas into the porous nozzle block.

The nozzle block may be a shaped refractory brick containing a centrally-disposed hole shaped to receive the nozzle but preferably it is made of a cast refractory cement into which the nozzle is set. The refractory cement may be of any suitable composition, well known per se in the art, but formulated to have the desired degree of porosity.

If desired the nozzle block may be designed to have greater porosity above the gas-receiving channel and lesser, e.g. approaching zero, porosity below the gas-receiving channel so as to help to direct the emerging gas upwardly into the molten metal.

The porous refractory composition may be, for example, of a high alumina content formulation containing alumina and cement. The alumina content should be at least 65% by weight of the composition, preferably at least 75% and especially in the range 90 to 97% by weight. Where an area of different composition or porosity is used, e.g. corresponding to the above-described area of lesser porosity, this may also be a cheaper formulation and hence, contain less of the better refractory component, i.e. alumina. Thus, part of the alumina may be replaced by an ore such as andalusite and/or bauxite.

The construction of the present invention is particularly useful in that it can provide inert gas scouring in the immediate vicinity of the nozzle which, in a tundish, can prevent unwanted build up of deposits such as alumina on the nozzle itself while, moreover, it provides streams of inert gas in a wider region surrounding the nozzle to give, thereby, very effective inclusion-removal in the vessel itself.

One embodiment of the invention is illustrated in the accompanying drawing, which is a cross-section through a portion of a tundish in the region of an outlet.

The metal tundish 10 has a base 11 and sidewalls 12, one only of the latter being shown. It is lined with a permanent refractory lining 13 which is itself covered with an inner, i.e. molten metal-contacting, expendable lining 14. An outlet 15 is provided in the base 11. This can be opened and closed by any conventional means (not shown), for example, by a stopper rod or a slide-gate valve beneath the base.

A nozzle block 16 of cast refractory cement is positioned in a suitably-shaped recess in the tundish lining so as to rest on the base 11 surrounding the outlet 15. A nozzle 17 sits in the nozzle block so that its lower portion 17A protrudes below the base 11 of the tundish.

Nozzle block 16 is of gas-permeable formulation and contains a feed pipe 18 to receive gas from a source (not shown). Feed pipe 18 runs completely around the interior of the nozzle block so as to surround the nozzle 17. The pipe 18 is conveniently set into the nozzle block as it is cast. The pipe is perforated in the manner indicated above so as to allow gas to escape into the nozzle block 16 and thereby into the interior of the tundish.

Escaping gas is indicated by arrows A and B. As shown, the upper surface of nozzle block 16 has a horizontal portion 19, which is set above the level of the upper surface 21 of the nozzle 17, and an angled surface 20 which slopes down to the level of the nozzle surface 21. Gas stream A escapes from horizontal surface 19 and rises vertically to capture inclusions in the molten metal contained in the tundish. Gas stream B escapes upwardly and inwardly over the upper surface 21 of nozzle 17 and thereby helps to scour the nozzle of alumina or other deposits that would otherwise form on the nozzle.

Claims

1. A refractory-lined vessel to contain molten metal having an outlet through its floor and comprising a nozzle with a centrally-disposed through bore, the nozzle being sealingly set in a nozzle block which is itself sealingly set in the lining of the floor of the vessel whereby the outlet is defined, the nozzle block being gas-permeable and having a gas-receiving channel extending around the nozzle, and means to connect the gas-receiving channel to a source of gas.

2. A refractory-lined vessel according to Claim 1, in which the gas-receiving channel extends completely around the nozzle.

3. A refractory-lined vessel according to Claim 1 or 2, in which the gas-receiving channel contains a pipe having perforations in its upper surface.

4. A refractory-lined vessel according to Claim 1, 2, or 3, in which the nozzle block is a shaped refractory brick having a centrally-disposed bore to receive the nozzle.

5. A refractory-lined vessel according to Claim 1, 2 or 3, in which the nozzle block is of cast refractory cement into which the nozzle is set.

6. A refractory-lined vessel according to any preceding claim, in which the nozzle block has greater porosity above the gas-receiving channel than below it.

7. A refractory-lined vessel according to Claim 6, in which the nozzle block is substantially non-porous below the gas-receiving channel.

8. A refractory-lined vessel according to any preceding claim, in which the composition of the nozzle block comprises at least 75% by weight of alumina.

9. A refractory-lined vessel according to Claim 8, in which the composition of the nozzle block comprises from 90 to 97% by weight of alumina.

10. A refractory-lined vessel according to Claim 6, 7, 8 or 9, in which the nozzle block comprises a composition of at least 75% by weight of alumina above the gas-receiving channel and a composition containing less alumina below the gas-receiving channel.

11. A gas permeable nozzle block shaped to contain a nozzle with a centrally-disposed through bore and to be sealingly set in the refractory lining of a vessel to contain molten metal, the nozzle block having a gas-receiving channel to extend around the nozzle and means to connect the gas-receiving channel to a source of gas.

12. A nozzle block according to Claim 11, in which the gas-receiving channel extends completely around the nozzle.

13. A nozzle block according to Claim 11 or 12, in which the gas-receiving channel contains a pipe having perforations in its upper surface.

14. A nozzle block according to Claim 11, 12 or 13, in which the nozzle block is a shaped refractory brick having a centrally-disposed bore to receive the nozzle.

15. A nozzle block according to Claim 11, 12 or 13, in which the nozzle block is of cast refractory cement into which the nozzle is set.

16. A nozzle block according to any one of claims 11 to 15, in which the nozzle block has greater porosity above the gas-receiving channel than below it.

17. A nozzle block according to Claim 16, in which the nozzle block is substantially non-porous below the gas-receiving channel.

18. A nozzle block according to any one of Claims 11 to 17, in which the composition of the nozzle block comprises at least 75% by weight of alumina.

19. A nozzle block according to Claim 18, in which the composition of the nozzle block comprises from 90 to 97% by weight of alumina.

20. A nozzle block according to Claim 16, 17, 18 or 19, in which the nozzle block comprises a composition of at least 75% by weight of alumina above the gas-receiving channel and a composition containing less alumina below the gas-receiving channel.

21. A refractory-lined vessel to contain molten metal substantially as hereinbefore described with reference to and as shown in the accompanying drawing.

22. A gas-permeable nozzle block substantially as hereinbefore described with reference to and as shown in the accompanying drawing.

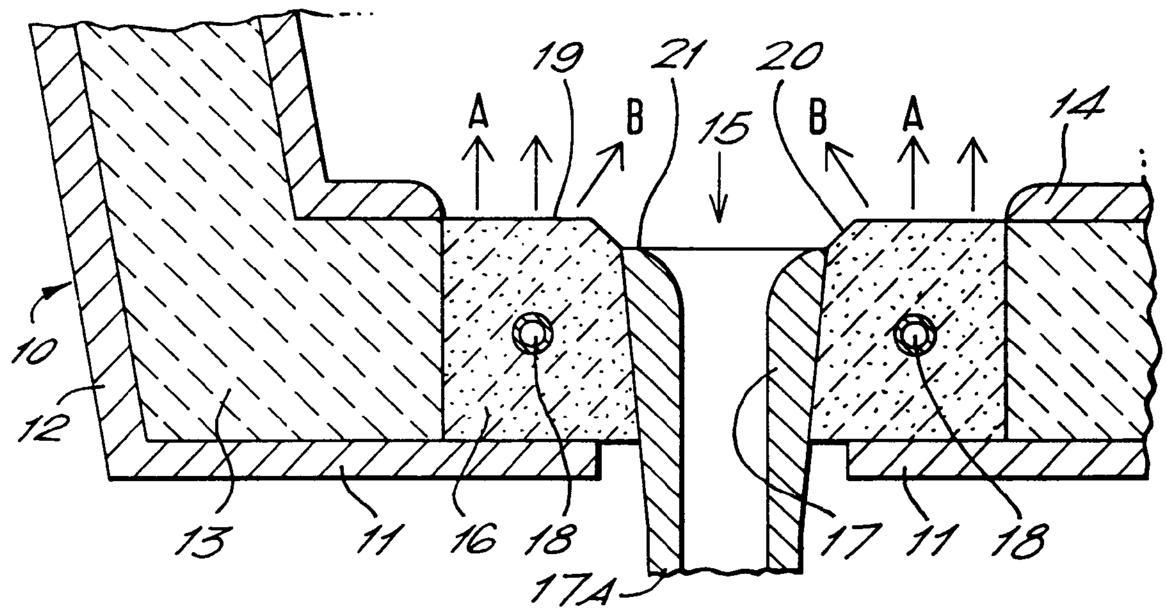

FIG.1.