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(54) Apparatus for discharging molten metal from a vessel to another vessel

(57) The invention provides apparatus and methods for discharging molten metal from a vessel based upon increasing the amount of molten metal moved into the vessel per unit time by a molten metal mover, such as a pump. This causes the level for at least part of the vessel to increase and so discharge through a discharge location. More reliable, safer to operate discharge of molten metal is provided as result.

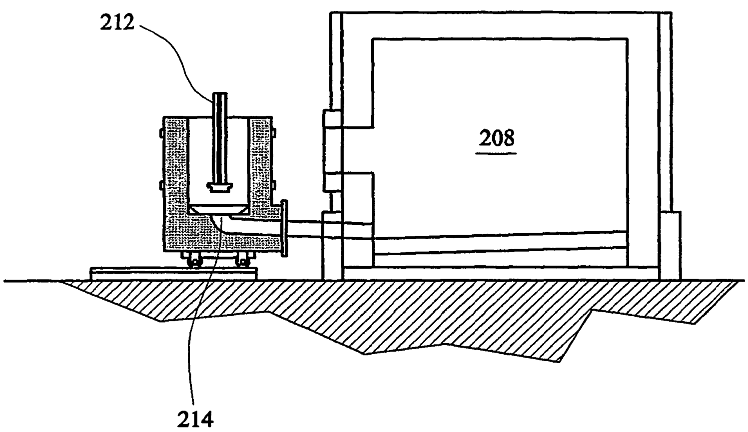

FIG. 5

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Description

[0001] This invention concerns improvements in and relating to the movement of metal, particularly the discharge of molten metal from a vessel.

[0002] In a variety of situations it is necessary to discharge molten metal from a vessel, such as a furnace. The process, commonly referred to as tapping, involves forming a hole in the vessel below the level of the molten metal. The metal then drains from the vessel into a further vessel due to the action of gravity. The hole can be formed by breaking a seal. This is a hazardous process and faces difficulty in controlling the amount of metal tapped. More complicated systems involve opening an aperture positioned below the level of the liquid and then closing the aperture once the desired amount of material has been discharged. Such systems are costly, require substantial maintenance and still face difficulties with reliability of operation due to the hostile nature of the metal being conveyed.

[0003] The present invention has amongst its aims to provide a more reliable method and apparatus for discharging molten metal from a vessel. The present invention has amongst its aims to provide a more controllable method and apparatus for discharging molten metal from a vessel.

[0004] In an alternative form, the invention is concerned with enabling the amount of metal within a furnace to be reduced to a very low level. Processing operations arise in which it has become necessary to transfer molten metal from one vessel to another, but in relation to which flow due to gravity cannot work due to the minimal differences in height between the two vessels. Such problems increase as the level of metal in one is reduced and the level in the other increases. In a number of instances the emptying of the vessel in this way is not feasible. Changing the relative heights of the vessels is not an option due to their size and weight. The present invention aims to enable complete or near complete emptying of vessels.

[0005] According to a first aspect of the invention we provide a method of discharging molten metal from a vessel to a further vessel, the method comprising
providing a vessel, the vessel having a discharge location;
providing a molten metal mover connected to the vessel by an inlet;
introducing molten metal to the vessel through the inlet using the molten metal
the molten metal having an operating level in the vessel, the operating level being at or below the level of a discharge level;
increasing the amount of molten metal moved by the molten metal mover per unit of time, the increase in the amount of molten metal moved causing the molten metal to have a discharge level in the vessel, the discharge level being higher than the level of the discharge location and/or operating level around at least a part of, and preferably the full, internal perimeter of the vessel;
molten metal discharging through the discharge location to the further vessel.

[0006] According to a second aspect of the invention we provide a apparatus for discharging molten metal from a vessel, the apparatus comprising
a vessel, the vessel having a discharge location;
a molten metal mover connected to the vessel by an inlet, the molten metal mover having a first throughput which provides molten metal at an operating level in the vessel and having a second, higher, throughput which provides molten metal moved at a discharge level, the discharge level being higher than the operating level around the full internal perimeter of the vessel and being higher than the discharge location.

[0007] The first and/or second aspects of the present invention may include any of the following features, options and possibilities.

[0008] The vessel may be connected to a further vessel, particularly a larger vessel, such as a furnace. The molten metal may be moved to the vessel from the further vessel, particularly by the inlet. The molten metal may be returned from the vessel to the further vessel, particularly by an outlet from the vessel. The vessel may be provided to the side of the larger vessel.

[0009] The vessel may be used solely for discharge. The vessel may be used for one or more additional purposes to discharge, for instance to introduce material to the molten metal. The vessel may be used as a charge well to introduce solid metal to the molten metal.

[0010] The further vessel may be a launder. The molten metal may flow within the further vessel to a location within that vessel or to a still further vessel. The further vessel may be permanently positioned relative to the discharge location. The still further vessel may be permanently positioned relative to the further vessel. The operating level of the vessel or larger vessel may be lower than the operating level of the still further vessel, particularly at the time of transition from operating to discharge mode. The further vessel and/or still further vessel may be a ladle and/or transfer crucible. The further vessel may be removably positioned relative to the discharge location. The still further vessel may be removably positioned relative to the further vessel.

[0011] The internal shape of the vessel is preferably cylindrical, at least in part. Preferably the upper part of the internal shape of the vessel is cylindrical. The lower part of the internal shape of the vessel may be a truncated cone. Preferably the outlet from the vessel is provided in the base of the vessel. A removable stopper may be provided for the outlet. Preferably the inlet to the vessel is provided through the side of the vessel. Preferably the internal shape of the vessel is defined by a refractory lining.

[0012] The discharge location may be provided at the top of the vessel, but is preferably provided in a side wall of the vessel. The discharge location may be provided at between 60% to 80% of the distance between the bottom and top of the vessel in one embodiment, particularly an embodiment in which the metal in the vessel has a level below the level of the discharge location for the majority of its operating time.

[0013] The discharge location may be provided at between 5 and 25% of the distance between the internal bottom and top of the vessel in another embodiment, particularly an embodiment in which the metal in the vessel has a level above the level of the discharge location for the majority of its operating time, the increase in molten metal moved occurring at a time when the level of molten metal has dropped below the discharge level.

[0014] The discharge location may be formed by an aperture passing through the vessel. The discharge location may include a portion extending away from the vessel and inclined downwards. The discharge location may be sealable. The discharge location may be sealed by a plug or valve. Preferably the plug is removed or the valve opened before the amount of molten metal moved per unit of time is increased. Preferably the plug is returned or valve shut after the amount of molten metal moved per unit of time is decreased again. The sealing may be effected outside of the vessel and/or away from the side wall thereof.

[0015] The molten metal mover may be a pump, particularly an electromagnetic pump. The molten metal mover is preferably provided between the larger vessel and the vessel. The inlet to the vessel is preferably of circular cross-section.

[0016] The operating level may be consistent across the width of the molten metal's top surface and/or across the entire top surface of the molten metal. Preferably the operating level is not consistent across the entire top surface and/or the width of the molten metals top surface. The surface at the operating level may be highest around the internal perimeter of the vessel. The surface at the operating level may be lowest at the centre of the vessel, particularly the axis thereof. The operating level may be between 40% and 60% of the distance up the side wall from the internal base of the vessel, in one embodiment, particularly an embodiment in which the metal in the vessel has a level below the level of the discharge location for the majority of its operating time. The operating level may be between 2% and 25% of the distance up the side wall from the internal base of the vessel, in an alternative embodiment, particularly an embodiment in which the metal in the vessel has a level above the level of the discharge location for the majority of its operating time, the increase in molten metal moved occurring at a time when the level of molten metal has dropped below the discharge level. The operating level in such an embodiment may be the level after a period of gravity drainage from the vessel. The operating level may be the level at which gravity drainage through the discharge location stops. The discharge level is preferably high enough to restart or increase the rate of gravity drainage.

[0017] The point of contact between the top surface of the metal and the side wall of the vessel may be constant at the discharge level or, more usually, may vary within a range between a maximum and minimum height. Different points on the contact perimeter may have different heights within that given range at any one time.

[0018] The maximum height of the operating level may be at least 25cm and more preferably at least 50cm below the level of the discharge location. The level of the discharge location may be considered as the lowest level at which metal can flow under the influence of gravity through the discharge location.

[0019] The amount of molten metal moved may be increased by increasing the speed of the pump. The amount of molten metal may be increased by increasing the magnetic field strength.

[0020] The discharge level may be consistent across the width of the molten metal's top surface and/or across the entire top surface of the molten metal. Preferably the discharge level is not consistent across the entire top surface and, more preferably, even the width of the molten metals top surface. The surface at the discharge level may be highest around the internal perimeter of the vessel, that may be to say at the junction of the metal's top surface with the internal side wall of the vessel. The surface at the discharge level may be lowest at the centre of the vessel, particularly the axis thereof. The operating level may be between 60% and 80% of the distance up the side wall from the internal base of the vessel.

[0021] The point of contact between the top surface of the metal and the side wall of the vessel may be constant at the discharge level or, more usually, may vary within a range between a maximum and minimum height. Different points on the contact perimeter may have different heights within that given range at any one time.

[0022] The discharge level may be at least 25 cm higher than the operating level at the same position.

[0023] The discharge level may be higher than the operating level due to an increase in the total amount of metal within the vessel and/or due to the redistribution of metal within the vessel.

[0024] The amount of metal discharged through the discharge location may be controlled by the time at which the metal moving means operates at the higher throughput. Preferably the amount of molten metal moved by the molten metal mover per unit of time is decreased to cease discharge and/or return the level in the vessel to a level lower than the discharge level, preferably the operating level.

[0025] Particularly in relation to the embodiment in which the metal in the vessel has a level above the level of the discharge location for the majority of its operating time, the increase in molten metal moved occurring at a time when the level of molten metal has dropped below the discharge level, the method of discharging metal to the further vessel may commence with opening a valve, plug or the like in the discharge location. Preferably initial drainage is due to gravity. The level within the vessel may drop with time to the operating level in such a case. The operating level may be a level at which gravity drainage stops or is diminished. A level monitor, for instance a laser, may be used to trigger a transition from operating throughput to discharge throughput. Preferably the discharge throughput is used to restart or increase gravity drainage and/or to empty substantially all the remaining metal from the vessel and/or larger vessel. At a level, for instance this level or a lower level, a removeable stopper may be introduced to seal the outlet from the vessel. Preferably this prevents metal returning to the larger vessel and assists in maintaining a discharge level in the vessel.

[0026] The inlet to the vessel may be pointed upwards and/or towards the discharge location. preferably the highest part of the metal within the vessel is at the discharge location.

[0027] Various embodiments of the invention will now be described, by way of example only, and with reference to the accompanying drawings, in which:-

Figure 1 is a cross-sectional side view through apparatus according to one embodiment of the present invention at the operating level;
Figure 2 is the cross-sectional side view of Figure 1 showing the discharge level;
Figure 3 is a plan view showing a vessel attached to a larger vessel according to another embodiment;
Figure 4 is a side view of the Figure 3 embodiment showing the inlet and discharge location configuration; and
Figure 5 is a side view of the Figure 3 and 4 embodiment showing a removeable plug for the vessel outlet.

[0028] The vessel 1 of Figure 1 is connected to a furnace, not shown, by an inlet 3 from the furnace and an outlet 5 back to the furnace. An electromagnetic pump 7 pumps molten metal from the furnace into the vessel 1. The swirling motion that results causes the top surface 9 of the metal to have a higher level 9' at the contact with the side 11 of the vessel than the level 9" at the centre 13 of the vessel. As shown, even the highest level 9', which is considered as being the operating level, is below the discharge location 15.

[0029] The discharge location 15 is formed by an aperture in the refractory wall 17 of the vessel 1. The discharge location 15 is inclined down, away from the vessel 1. The discharge location 15 can be sealed off by mechanism 19. The discharge location 15 leads to a transfer crucible 21. This can be used to move tapped molten metal to other locations.

[0030] To discharge metal from the vessel 1, the amount of metal pumped through the pump 7 in a given unit of time is increased. This results in an increase in the total amount of metal in the vessel 1 and/or a redistribution of the metal in the vessel due to an increase in the swirling motion. The result is shown in Figure 2, where the surface of the metal 9 is raised to a level 9' at the internal perimeter 23 of the vessel which is above the operating level and is above the level of the discharge location 15. As a result metal flows out of the vessel 1 through the discharge location 15 to the transfer crucible 21. This continues as long as the higher throughput of the pump 7 is maintained. To stop the discharge the throughput of the pump is reduced.

[0031] The technique allows metal to be tapped from the vessel in a very safe way. No work on a discharge location below the metal level is required. Furthermore, the discharge can be tightly controlled using the operating throughput of the pump. There are also no moving parts exposed to the metal either to achieve the level change or control the discharge and hence reduce possibilities for problems and reduced maintenance needs.

[0032] In the first example the operating level is that generally present in the vessel. In the embodiment now described, the normal level 200 is quite high and the operating level 202 (at which the technique of the present invention is preferably used) is the level to which the metal has drained as a result of partial discharge of the metal to a further vessel through the discharge location 204. In such a case the majority of the vessel 206 and larger vessel 208 contents may have moved to the further vessel or still further vessel. The operating level 202 in this case is the level at which gravity drainage through discharge location 204 becomes small or stops because of the relative levels between the vessel/larger vessel and the further/still further vessel. The principal for further discharge in this embodiment is similar to that above, however.

[0033] When the operating level is reached the pump throughput is increased to give a discharge level 210. Because this is higher, gravity drainage is assisted. The ability to provide such a discharge throughput and the configuration of the discharge level allow far greater degrees of emptying of larger vessels than is presently possible in situations where the head is limited.

[0034] To assist in discharging as much as possible of the metal, see Figure 5, a removeable stop 212 can be lowered into position so as to block the base outlet 214 when desired. This prevents metal returning to the larger vessel 208 and hence increases the height of metal again within the vessel and hence the amount that discharges. If necessary, once the maximum amount of metal has been discharged, the pump can have its direct reversed to return the very little remaining metal to the larger vessel. The amount of metal remaining in the system can be reduced to advantageously low levels as a result of this approach.

Claims

1. Apparatus for discharging molten metal from a vessel, the apparatus comprising
a vessel, the vessel having a discharge location;
a molten metal mover connected to the vessel by an inlet, the molten metal mover having a first throughput which provides molten metal at an operating level in the vessel and having a second, higher, through-

put which provides molten metal moved at a discharge level, the discharge level being higher than the operating level around the full internal perimeter of the vessel and being higher than the discharge location;
an outlet from the vessel being provided in the base of the vessel;
a removable stopper being provided for the outlet.

2. Apparatus according to claim 1 in which the vessel is connected to a furnace.

3. Apparatus according to claim 1 or claim 2 in which a further vessel is permanently positioned or removeably positioned relative to the discharge location.

4. Apparatus according to any of claims 1 to 3 in which the discharge location is provided at between 60% to 80% of the distance between the bottom and top of the vessel particularly when the metal in the vessel has a level below the level of the discharge location for the majority of its operating time.

5. Apparatus according to any of claims 1 to 4 in which the discharge location is provided between 5 and 25% of the distance between the internal bottom and top of the vessel particularly when the metal in the vessel has a level above the level of the discharge location for the majority of its operating time, the increase in molten metal moved occurring at a time when the level of molten metal has dropped below the discharge level.

6. Apparatus according to any of claims 1 to 5 in which the molten metal mover is a pump, particularly an electromagnetic pump.

7. Apparatus according to awny of claims 1 to 6 in which the discharge level is at least 25 cm higher than the operating level at the same position.

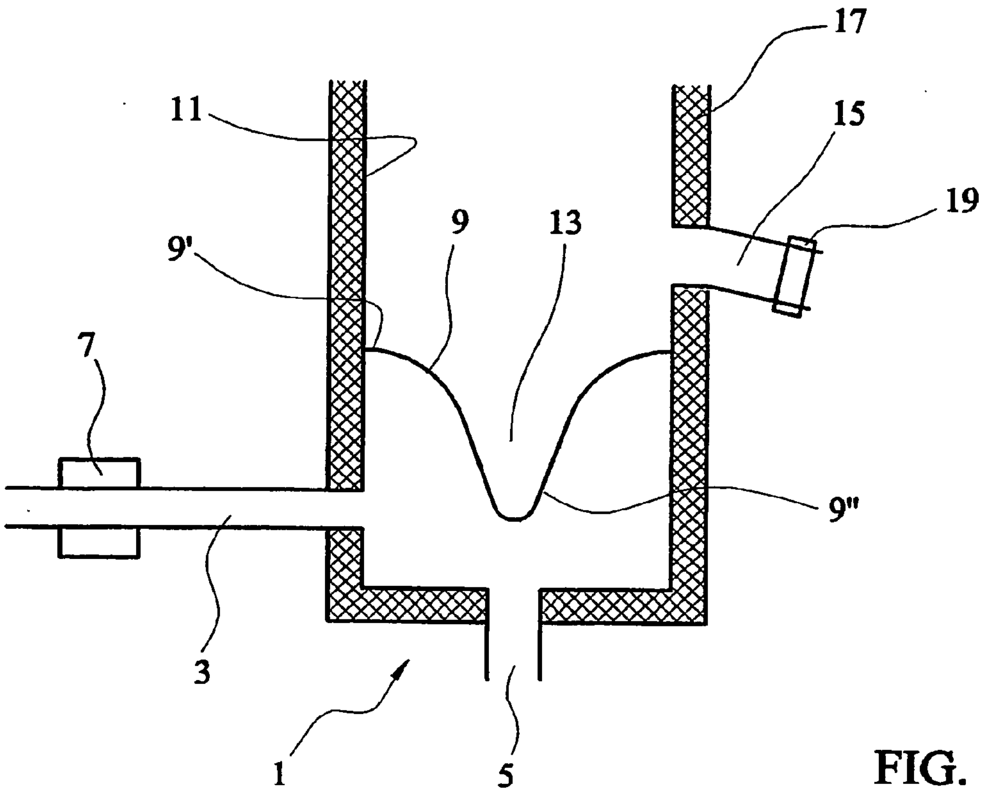

FIG. 1

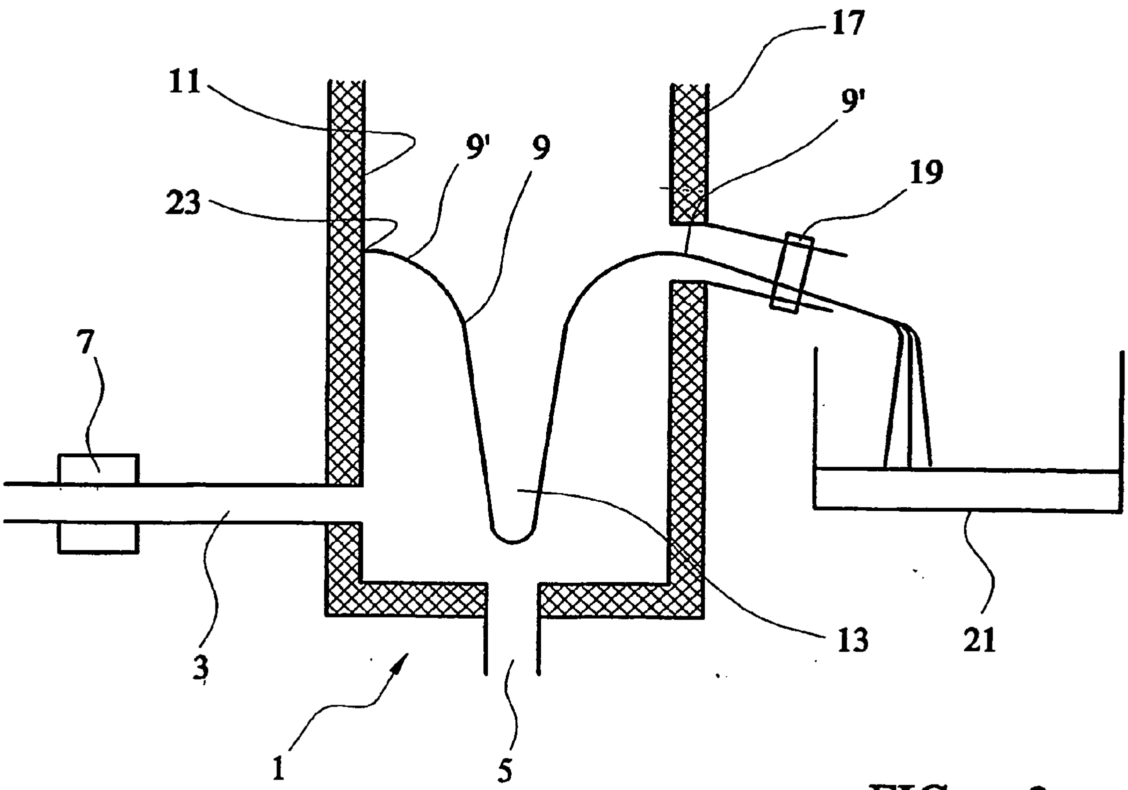

FIG. 2

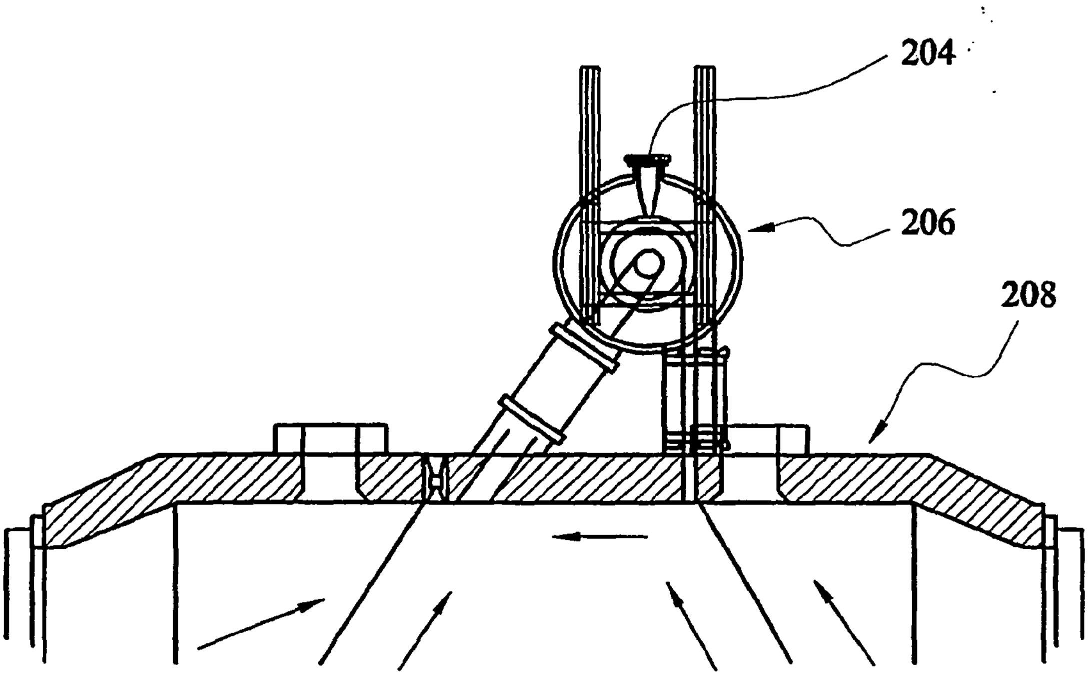

FIG. 3

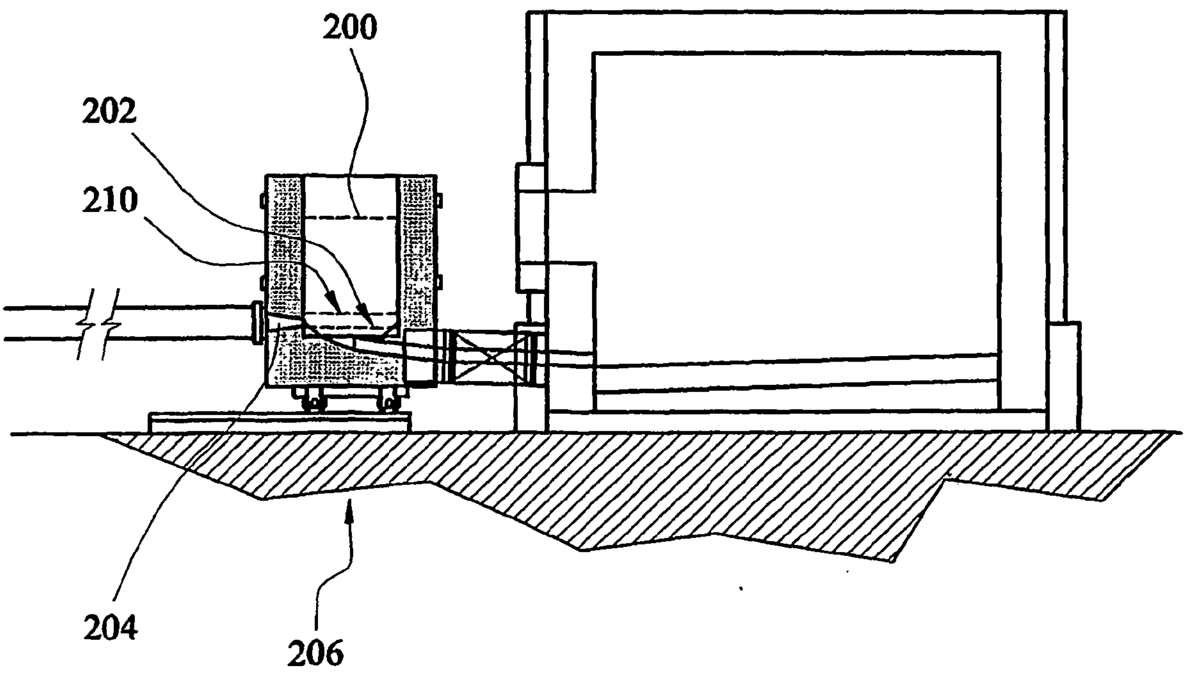

FIG. 4

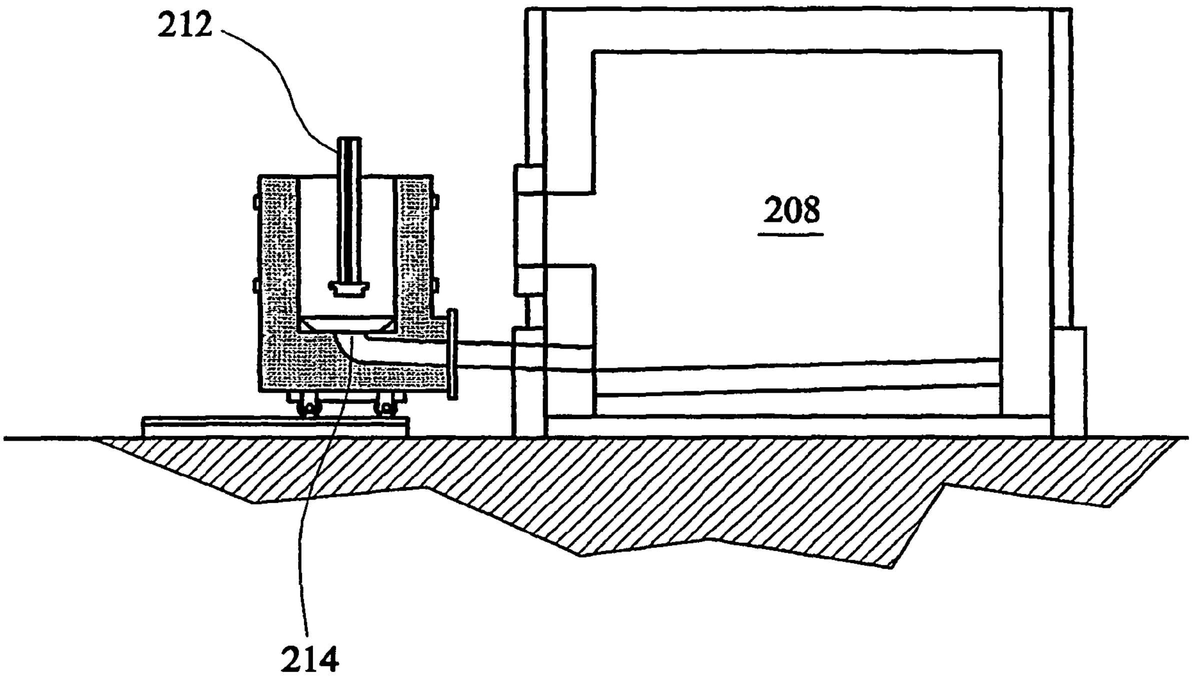

FIG. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 01 2977

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	26 July 2007	Catana, Cosmin

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X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 07 01 2977

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