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Korshunov et al.

[11] **3,875,991**

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[54] **ARRANGEMENT FOR CONVEYING AND BATCHING LIQUID METAL SUPPLIED FROM A RECEPTACLE INTO A MOULD FOR CONTINUOUS CASTING OF METAL INGOTS**

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[51] **Int. Cl.** **B22d 11/10**

[58] **Field of Search** ..... 164/49, 147, 250, 251, 164/281, 337; 222/372, 380, 383, DIG. 2; 417/50

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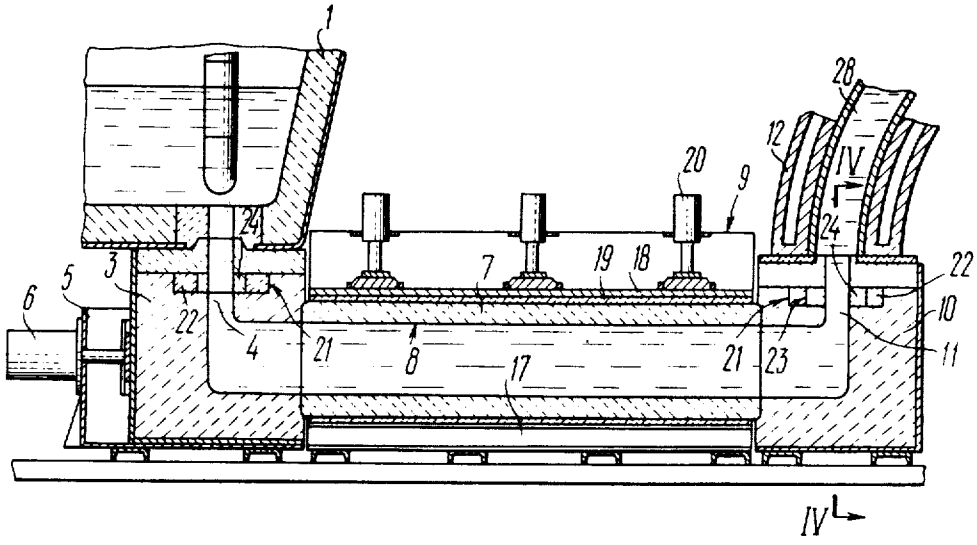
[57] **ABSTRACT**

An arrangement for conveying and batching liquid metal supplied from a receptacle into a chilled mould comprises an inlet and an outlet boxes for liquid metal and an intermediate section of the arrangement located therebetween. The inlet box is provided with a drive for axially moving this box, and the intermediate section has a liquid metal duct provided with induction pumps. The walls of the liquid metal duct, which are adjacent to the induction pumps located outside these walls, are made inwardly convex so as to project into the inerior of the passage in such a manner that the passage is of restricted cross section in the intermediate zone thereof. In addition, there is provided at least one drive for developing a force in said walls to overcome the tensile stresses therein appearing under the action of the liquid metal pressure. This liquid metal duct is durable, and the arrangement can operate under pressure changes from 0 to 10 atm.

4 Claims, 4 Drawing Figures



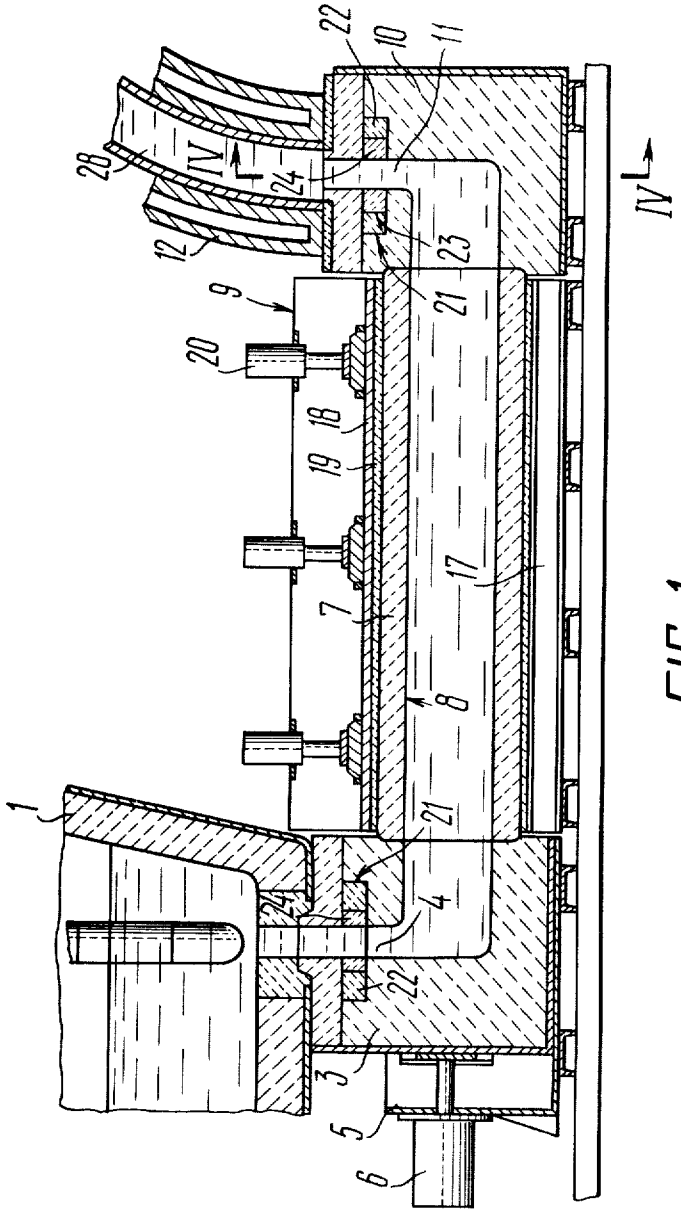


FIG. 1

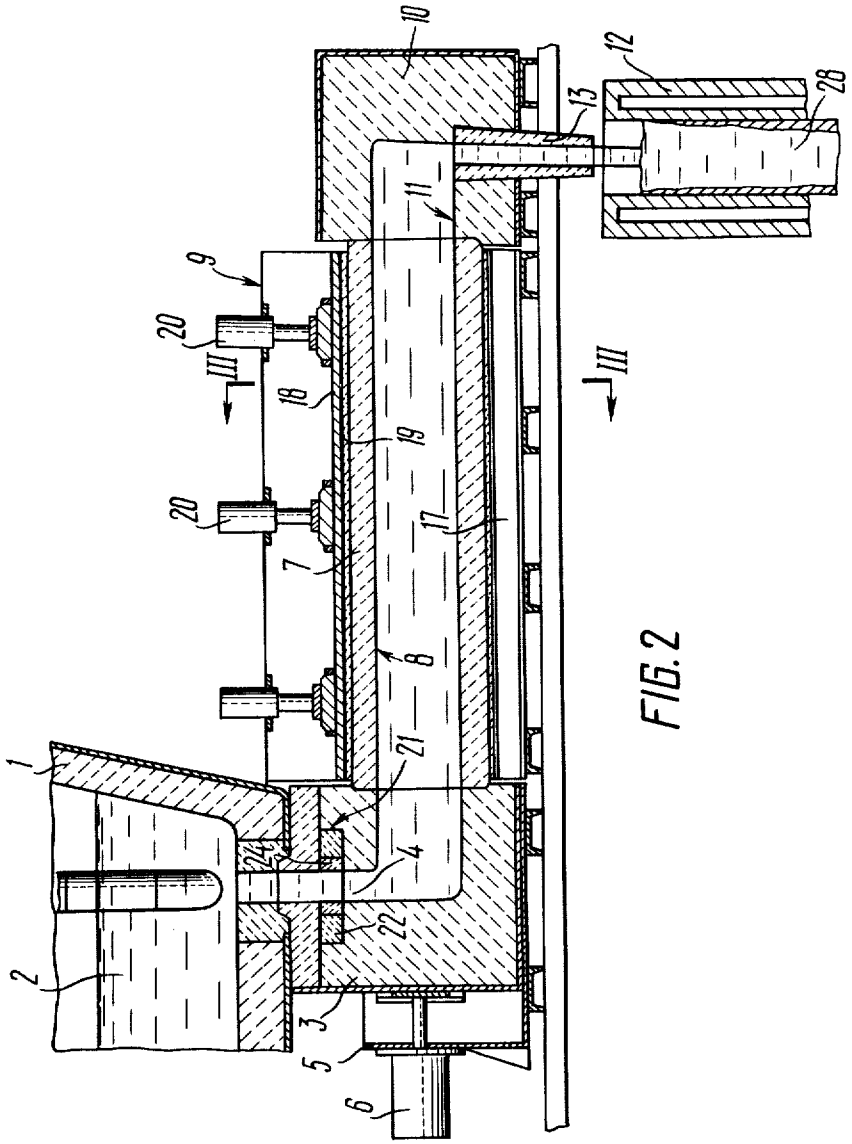


FIG. 2

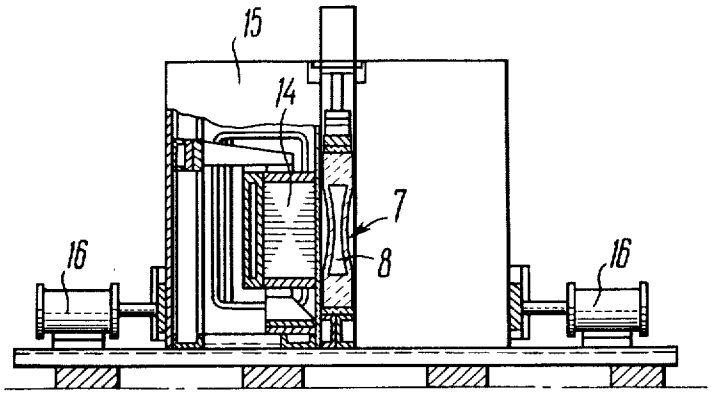


FIG. 3

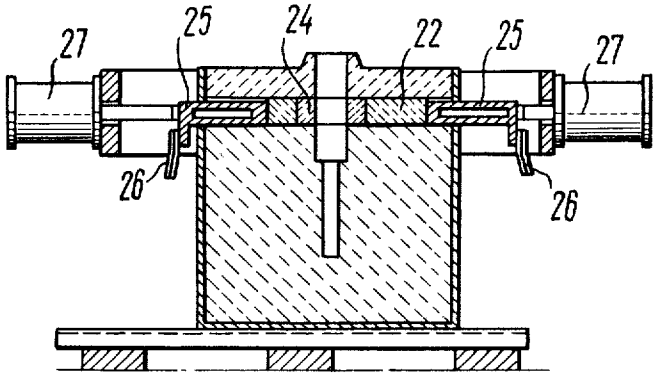


FIG. 4

ARRANGEMENT FOR CONVEYING AND BATCHING LIQUID METAL SUPPLIED FROM A RECEPTACLE INTO A MOULD FOR CONTINUOUS CASTING OF METAL INGOTS

The invention relates to arrangements for conveying and batching liquid metal supplied from a receptacle into the mould in a plant for continuous or semicontinuous casting of metal ingots.

Semicontinuous, and especially continuous metal casting plants have recently found a wide application.

Known plants are of the vertical, radial, arcuated and horizontal types.

These plants are provided with a receptacle for liquid metal from which it is fed into a chilled mould.

A metal ingot, which has been formed in the chilled mould, but is not yet completely solidifed, is fed into an arragnement for secondary cooling, wherein it is finally solidified, and then into an arrangement for cutting the ingot into predetermined lengths.

Different methods and arrangements are used to effect the supply of liquid metal from said receptacle into the mould. Metal may flow under gravity from a pouring ladle directly into the mould, and flow being controlled by checking the opening of the pouring ladle by means of a stopper. This method of liquid metal supply into the mould is used in the majority of the vertical, radial and aracuted plants in which the ingot is drown from the mould downards.

In the horizontal-type plants liquid metal is normally fed into the mould through a closed liquid metal duct.

The disadvantage of known arrangements for feeding liquid metal from a receptacle into the mould in semicontinuous and continuous metal casting plants consists in the fact that it is difficult to accurately control the metal supply into the mould using these arrangement. These difficulties become more pronounced, where elevated pressure is created in the mould zone either by increasing the gas pressure in a closed space between the receptacle and mould, or by raising the pressure of liquid metal in the closed duct, e.g. in casting metal in the horizontal-type plant.

A method of casting metal ingots has been recently contemplated which involves the positive supply of liquid metal through a siphon arrangement from the bottom into a radially arcuated chilled mould and an intermittent drawing of an ingot upwards into an arrangement for secondary cooling under intermittent changes in the pressure of the liquid metal exerted upon the ingot skin in the mould zone.

The plant for carrying out the above-mentioned method comprises a receptacle for liquid metal which is positively fed through a siphon arrangement from the bottom into a radially arcuated chilled mould, the arrangement for secondary cooling being disposed above the mould in the direction of the production flow.

In this plant the initial formation of the ingot skin is effected under elevated pressure, and for that reason the quality of the ingot as a whole, and especially the surface finish of the ingot being cast, can be substantially better as compared to the ingots made in the plants of other types.

By the above-described method the pressure exerted upon the ingot skin is raised at regular time intervals by raising the pressure of the liquid metal in the siphon arrangement. When it is required to draw the ingot from the mould, the pressure exerted upon the ingot skin in the mould zone is reduced by lowering the pressure of the liquid metal in the siphon arrangement.

The pressure in the siphon arrangement may be raised either by increasing the pressure of gas above the metal in said receptacle, or by raising the pressure directly in the passage of the siphon arrangement by using induction pumps, which are now being widely used for pumping liquid metals.

In the plant for carrying out the above-described method the pressure in the siphon arrangement is built-up by raising the pressure in the liquid metal receptacle. However, this results in more complicated structure of the plant, since in this case tight sealing of said receptacle is required thereby making difficult the pouring of fresh batches of metal into the receptacle.

Induction pumps are preferably used in the siphon arrangement. However, liquid metal ducts in known induction pumps for pumping liquid metals having high melting point are not reliable in operation, and in the majority of cases these ducts comprise a thick-walled pipe of a ceramic refractory material.

It is the main object of the invention to provide an arrangement for conveying and batching liquid metal supplied from a receptacle into a chilled mould in a continuous metal casting plant which can operate without damages when liquid metal having high melting point is passed therethrough under changes in the metal pressure within the range of from 0 to b **10** atm.

Another not less important object of the invention is to provide an arrangement for conveying liquid metal from a receptacle into the mould in a metal casting plant which can ensure the control of liquid metal supply from said receptacle into the mould independent of the head of the liquid metal in the receptacle.

Still another object of the invention is to provide an arrangement which can be the most efficiently used for conveying liquid metal from a receptacle into the mould for casting ingots so as to ensure accelerated solidification of the end face of the tail portion of the ingot at the end of the casting operation, whereby a current casting operation can be completed in the plant so as to prepare it for the next casting during a short time interval.

These and other objects are accomplished by the provision of an arrangement for conveying liquid metal supplied from a receptacle into a chilled mould in a plant for casting metal ingots comprising an inlet box, an intermediate section including an induction pump and a liquid metal duct having the walls defining a passage, and an outlet box, the inlet and outlet boxes having passages communicating with the passages of the liquid metal duct, wherein according to the invention each of the walls of the liquid metal duct adjacent to the inductors of the induction pump is inwardly convex so as to project into the interior of the passage, thereby restricting the cross section of the passage in the intermediate zone thereof, while the inlet box is axially movable relative to the intermediate section of the arrangement, and there is provided drive means providing this axial movement and the application of a pressure for sealing joints between the parts of the arrangement.

The arrangement incorporating the above-described embodiment of the liquid metal duct has sufficient strength and is not damaged under intermittent changes of the liquid metal pressure therein.

the above-described liquid metal duct is preferably provided with at least one drive means which develops

a force compressing the convex walls of the metal duct in the transverse direction so as to prevent them from being tensioned under the action of the liquid metal pressure, and there is preferably provided a pressure exerting plate, said drive means acting upon said walls of the liquid metal duct through this plate.

Such method of compressing the walls of the liquid metal duct eliminates the development of dangerous tensile stresses therein which could otherwise damage the cermaic liquide metal duct.

At the input side of the passage of the inlet box and at the output side of the outlet box there are preferably provided axially slidable members, each of said members having an integral portion for closing said passages, as well as a portion with an opening of a size about equal to that of the passage to be closed by this member.

These sliding members can be used for batching the liquid metal and for closing the passages for liquid metal in the inlet and outlet boxes in the case of troubles in the operation of the arrangement for conveying liquid metal, as well as at the end of the casting operation.

Said members in the inlet and outlet boxes are preferably made of a highly refractory electrically- and heat-conductive material, and a bushing of an electrically non-conductive material is preferably mounted in the opening of each member, the size of the bore of the bushing being about equal to that of the passage with which it cooperates.

The use of the sliding members made of a highly refractory electrically- and heat-conductive material allows on the one hand, to feed electric current thereto through chilled shoes so as to heat with this current through the sliding members the refractory lining at the input of the inlet box and at the output of the outlet box, and on the other hand, where electric current is not passed through the sliding members, and where chilled shoes are brought in contact therewith, said shoes comprising boxes having the cavity connected to a coolant source, to effect rapid freezing of the end of the ingot being cast. The bushings of the sliding members made of electrically non-conductive material prevent the current leakage when it is passed through the blocks.

The invention will now be described with reference to the specific embodiments of an arrangement for conveying and batching liquid metal from a receptacle into the mould in a plant for casting metal ingots illustrated in the accompanying drawings, in which:

FIG. 1 shows a longitudinal axial section of the arrangement according to the invention for supplying liquid metal from the bottom into a radially arcuated chilled mould;

FIG. 2 is a longitudinal axial section of the arrangement according to the invention for supplying liquid metal from the top into a chilled mould;

FIG. 3 is a partially sectional view taken along the line III—III in FIG. 2;

FIG. 4 is a sectional view taken along the line IV—IV in FIG. 1.

The arrangement for conveying and batching liquid metal is located under a receptacle 1 (FIG. 1) for liquid metal 2. A movable inlet box 3 having a passage 4 for reception of the liquid metal being supplied is connected to the outlet opening of the receptacle 1.

The movable inlet box 3 is mounted in a stationary casing 5 which is provided with a drive 6 mounted thereon and adapted to move the inlet box axially relative to a liquid metal duct 7 having a passage 8 and located in an intermediate section 9 of the arrangement. The drive 6 is used to urge the inlet box 3 against the liquid metal duct 7 of the intermediate section 9 of the arrangement, and the passage 4 of the inlet box is in register with the inlet opening of the passage 8 of the liquid metal duct of the intermediate section 9 of the arrangement.

The outlet end of the liquid metal duct 7 is connected to a stationary outlet box 10 having a passage 11 for passing liquid metal, the outlet opening of the passage 8 of the liquid metal duct 7 also being in register with the inlet opening of the passage 11 of the outlet box 10.

The passages of the inlet and outlet boxes for passing liquid metal at high melting point are provided with a refractory lining. It should be noted that the passage 11 of the outlet box 10 of the arrangement for conveying liquid metal may have different constructions depending upon the direction of the metal outflow in different types of the metal casting plants.

Where the metal is fed into a chilled mould 12 of the plant from the bottom, the chilled mould 12 (FIG. 1) in this case is mounted on the outlet box 10, and the size of the passage 11 of the outlet box 10 is selected such as to ensure that the opening be located in the internal space of the mould 12.

Where the arrangement is to be used to feed liquid metal into the mould 12 from the top (FIG. 2), the passage 11 of the outlet box 10 is made so as to enable the metal outlet downwards from the outlet box, a pouring ladle 13 being accommodated in the outlet box 10 for a better shaping of the metal stream.

Two walls of the passage 8 of the liquid metal duct 7 (FIG. 3) are made inwardly convex so as to project into the interior of the passage. Flat inductors 14 of an induction pump are mounted adjacent to these walls from the outside. The inductors 14 of the induction pump are accommodated in houings 15 so as to be movable relative to the liquid metal duct 7 when acted upon by drives 16. At the closest position of the inductors 14 relative to the liquid metal duct 7 there are air spaces between the inductors and the side (as illustrated in this example) walls of the liquid metal duct 7.

The liquid metal duct 7 (FIG. 1) of the intermediate section 9 of the arrangement for conveying and batching liquid metal from the receptacle 1 into the mould 12 of the plant for casting metal ingots is mounted on a support 17. Mounted on the flat wall of the liquid metal duct 7 above is a pressure exerting plate 18 located thereabove and having a heat insulating layer 19 on the underside and provided with at least one drive means 20 which is adapted to create compressive stresses in the walls of the liquid metal duct 7 in the transverse direction through the pressure exerting plate.

Drive means 20 of the pressure exerting plate 18 comprises a plurality of preferably pneumatic jacks, each being pivotally secured to a housing 15 of one inductor 14 and fixed to the housing of the other inductor by means of a latch.

Mounted in through slots 21 (FIG. 1) of the inlet box 3 and outlet box 10 of the arrangement are sliding members 22. They are made of a highly refractory electrically- and heat-conductive material and have open-

ings 23 accommodating refractory bushings 24 of an electrically non-conductive material, the size of the bushing openings corresponding to the cross-sectional size of the passage 11 closed by this member.

Water-chilled shoes 25 having current supply buses 26 (FIG. 4) are urged against the sliding members 22 from both sides.

The water-chilled shoes 25 are urged against the sliding members 22 by means of drives 27 which are also adapted to move the members 22 along the slot 21 to close the passage of the liquid metal duct.

The arrangmeent for conveying and batching liquid metal from a receptacle into the mould of a plant for casting metal ingots operates as follows.

Prior to the beginning of the casting of a metal ingot the liquid metal duct 7 is mounted onto the support 17 (FIG. 1) and the duct may be either integral or assembled of separated parts lengthwise depending upon the length. During the installation of the liquid metal duct 7 onto the support 17 the movable inlet box 3 and the stationary outlet box 10, as well as the housings 15 accommodating the inductors 14 are at the maximum distance relative each others. This enables unobstructed installation of the liquid metal duct 7 onto the support 17, whereafter a thin layer of plastic refractory is applied to the end faces of the duct.

The movable inlet box 3 is axially moved by the drive 6 relative to the liquid metal duct 7, and a force is created, which should be sufficient for reliable sealing of joints between the inlet box 3, metal duct 7 and the outlet box 10.

Then the inductors 14 of the induction pump are brought closer to the liquid metal duct 7 by means of the drives 16, and the pressure exerting plate 18 is mounted onto the liquid metal duct 7 from the top, the plate being then preliminary urged against the liquid metal duct 7 by the rods of the drives 20. In order to do so, the pneumatic jacks of the drives 20 are preliminary mounted in the operative position so as to be connected to the housing 15 of one inductor 14 through a pivotal connector and to the housing 15 of the other inuctor 14 by means of the latch.

The sliding members 22 are brought by the drives 27 into such a position, at which the bores of their bushings are in register with the openings of the passages in the inlet and outlet boxes of the arrangement.

Where it is desired to preheat the passage of the liquid metal duct 7 of the plant before the casting operation, this may be effected in the following way: the refractory lining is heated at the input and output end of the inlet and outlet boxes respectively by heating the sliding members 22, through which electric current of a predetermined value is passed for that purpose. The liquid metal duct 7 may be heated by using a heated pattern made of an electrically conductive material, and preferably of thin steel sheet, the shape of the pattern being as similar as possible to the shape of the passage of the liquid metal duct 7 into which the pattern is to be inserted. The pattern is heated by the induction method by currents induced therein using the inductors 14 of the induction pump.

Then the receptacle 1 containing liquid metal 2 is brought near to the arrangement for conveying and batching liquid metal prepared in the above-described manner. The receptacle 1 is connected to the inlet box 3 so as to eliminate any leakage of metal through the joints between the parts of the arrangement and between the latter and the receptacle.

The metal 2 is fed from the receptacle 1 into the arrangement for conveying it into the mould 12 upon lifting the stopper provided in the receptacle 1.

If the arrangement is used in a plant having the provisions for supplying the mould 12 (FIG. 2) from the top without application of excessive gas pressure over the metal meniscus in the mould, the metal may be fed into the mould 12 under gravity through the inlet box 3, liquid metal duct 7 and outlet box 10. However, in order to provide a stable supply of metal independent of the level of the liquid metal in the receptacle 1, the rate of metal discharge normally depending upon that level, the induction pump is energized by supplying electric power to the inductors 14 thereof. Depending upon the method of the ingot formation, the induction pump will be used either to increase, or to reduce the rat of metal flow through the passage of the liquid metal duct 7.

Where there is no pressure of gas over the menuscus of the metal in the mould 12 (FIG. 2), the pressure in the passage 8 of the liquid metal duct 7 will be comparatively low, whereby there is no need in creating substantially high compressive stresses in the passage of the liquid metal duct 7 by means of the drive 20.

In the case, where the space between the outlet box 10 and the mould 12 is tightly sealed (not shown in the drawing), and an excessive pressure is created over the meniscus of the metal in the mould 12, the mould can be supplied with metal, only if the pressure of the metal in the passage of the liquid metal duct of the arrangement at the output is greater than the excessive pressure of gas over the metal meniscus in the mould. The head of the liquid metal in the arrangement herein described may, however, become insufficient to overcome the gas pressure over the metal meniscus. In this case the induction pump will ensure an increase in the pressure of the liquid metal in the passage of the liquid metal duct 7, whereby the conditions for unobstructed passage of metal into the mould 12 will be created.

Upon considerable increse in the pressure in the passage of the liquid metal duct 7 dangerous tensile stresses may appear in its walls because the comparatively thin wall of the liquid metal duct 7 tends to bulge under the action of such pressure. It is known that the ceramic refractory material performs rather badly under flexure. In order to eliminate the development of dangerous tensile stresses in the walls of the liquid metal duct made of a ceramic material, compressive stresses are built-up in the walls of the liquid metal duct 7 in the transverse direction by means of the drive 20 acting upon the pressure exerting plate 18. The compression of the liquid metal duct in the transverse direction, as well as the convex shape of the two metal duct walls projecting into the interior of the passage, ensure reliable operation of the ceramic liquid metal duct, when the liquid metal flows therethrough under a substantial pressure.

The casting of metal with an intermittent drawing of the ingot from the mould 12 (FIG. 1) upwards involves changes in the pressure in the zone of the mould 12 at regular time intervals, and hence, the changes in pressure in the passage 8 of the liquid metal duct 7 of the arrangement for conveying the metal, as well as the intensive metal supply into the zone of the mould 12 during the accelerated drawing of an ingot 28 from the mould. In this case elevated and the highest admissible

compressive stresses are created in the transverse and longitudinal direction in the walls of the liquid metal duct **7** by means of the drive **20** of the pressure exerting plate **18** and the drive **6** of the inlet box **3**, and since the liquid metal pressure in the liquid metal duct is intermittently changed, the additional compression of the walls of the liquid metal duct **7** in the transverse direction is preferably intermittently changed in step with the pressure changes in the passages **8** of the liquid metal duct **7**.

Where liquid metal is fed into the mould **12** (FIG. **1**) through the arrangement according to the invention from the top, the metal supply at the end of the casting operation is stopped by lowering the stopper in the receptacle **1** for liquid metal to close the outlet opening of the receptacle **1**.

The completion of the casting operation with the bottom supply of metal into the mould **12** (FIG. **1**) is somewhat more complicated. In this case, at the end of the casting operation the stopper is lowered in the receptacle **1**, and the receptacle **1** is then disconnected from the inlet box **3** as quickly as possible, while the input opening of the inlet box **3** is closed by moving the sliding member **22**. At the same time, the liquid metal is pumped by the induction pump into the passage **11** of the outlet box **10** and into the mould **12** at the greatest discharge rate possible, and then the passage **11** of the outlet box **10** is closed by moving its sliding member **22** (FIG. **4**) by means of the drive **27**. Since at that time there is no current supplied to the sliding member **22**, and the water-chilled shoes are urged against the sliding members, while the metal is not supplied from the receptacle **1** (FIG. **1**), the end face of the tail portion of the ingot **28** is rapidly cooled and solidified, whereby the movement of the ingot **28** upwards can be continued in the direction towards an arrangement for secondary cooling of the plant (the arrangement for secondary cooling of the plant for metal casting is not shown) without any danger of leakage of the liquid metal from the ingot **28** being cast, which is not yet solidified.

Upon closing the output opening of the outlet box **10** and disconnection of the inductors **14** from a power supply source the movable inlet box **3** is moved away from the liquid metal duct **7**, and a small residue of the liquid metal is discharged into a preliminarily prepared receptacle (not shown).

After the visual inspection and cleaning of the joint between the inlet box and the liquid metal duct **7**, and if the arrangement for conveying liquid metal is in satisfactory state, it is prepared for the next casting operation.

In this case, where the refractory lining of the inlet box **3** and outlet box **10**, and or the liquid metal duct **7** are in abnormal state, the above-mentioned parts of the arrangement are replaced, and the preparation for the operation is repeated in the above-described order.

The arrangement is reliable in operation under changes in the liquid metal pressure from 0 up to 10 atm., and the members **22** for closing the passages for liquid metal ensure the control (batching) of the metal flow supplied for the formation of the ingot.

What is claimed is:

1. An arrangement for conveying and batching liquid metal from a receptacle into a mould for continuous or semicontinuous casting of metal ingots comprising: an axially movable inlet box having a passage for reception of the liquid metal from said receptacle; an intermediate section disposed downstream said inlet box in the production flow direction and including a liquid metal duct having two inwardly convex opposite walls projecting into the interior of a passage of the liquid metal duct so as to restrict the cross section of the passage in the intermediate zone thereof; induction pumps located outside each of said convex walls of said liquid metal duct and adjacent thereto; an outlet box in communication with said mould located downstream said intermediate section in the direction of the production flow; drive means providing the axial movement of said inlet box and the application of a force so as to ensure the sealing of joints between said boxes and said intermediate section of the arrangement.

2. An arrangement as claimed in claim **1**, wherein said liquid metal duct includes at least one drive means adapted to develop a force to compress in the transverse direction the convex walls of the liquid metal duct so as to prevent them from being tensioned under the action of the liquid metal pressure, and a pressure exerting plate, said drive means acting upon said walls of the liquid metal duct through said plate.

3. An arrangement as claimed in claim **1**, wherein at the input of the passage of said inlet box and at the output of the passage of said outlet box there are provided slidably movable members, each having an integral portion for closing one of said passages and a portion with an opening of a size about equal to that of the passage to be closed by this member.

4. An arrangement as claimed in claim **3**, wherein said members in said inlet and outlet boxes are made of a highly refractory electrically- and heat-conductive material, and a bushing is mounted in said opening of each member, said bushing being made of an electrically non-conductive material and having a bore of a size which is substantially equal to the size of the passage with which the bushing cooperates.

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