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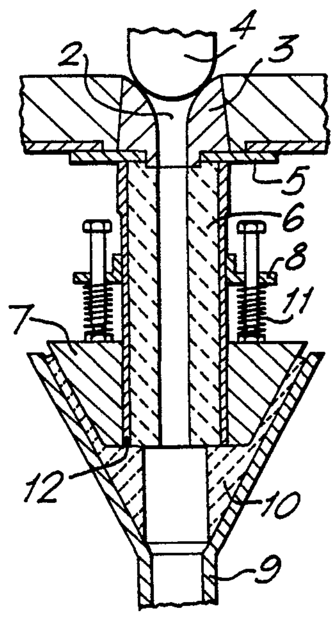
(54) **Controlled transfer of molten metal.**

(57) A transfer tube (6) is provided to transfer molten metal between a first vessel e.g. a ladle and a second vessel e.g. a foundry mould or gating system therefor at a fast flow rate independent of the operative's control. The tube may be fixed to the underside of the ladle and be releasably connectable to the mould inlet. A filter element may be provided at the mould inlet.



EP 0 073 573 A1

CONTROLLED TRANSFER OF MOLTEN METAL

The invention relates to the controlled transfer of molten metal. More particularly, the invention is concerned with the transfer of such metal from a vessel, e.g. a ladle, to another vessel, typically to a mould. Such ladles are usually provided with an opening at the base of the ladle, e.g. a stopper rod/nozzle assembly or sliding gate mechanism. The ladle is normally moved until the bottom pour opening in the ladle is situated directly above the sprue of a mould and the bottom pour opening is opened, e.g. by lifting of a stopper rod or movement of a plate within a sliding gate mechanism. The skill of the operator determines the pouring characteristics and in turn the quality of the cast product. A high pouring rate is desirable for many reasons, but principally because the product quality is improved. Unfortunately adequately high pouring rates are difficult to achieve because the operator is exposed to any liquid metal splashes which occur, and at high pouring rates this can be extremely hazardous. There is a tendency therefore for ladle operators to throttle the ladle, i.e. to limit the volume flow rate of metal from the ladle. Long pouring times are typically encountered in practice and these have a detrimental effect on product quality. The inconsistency of throttling leads to wide variations in pouring time so that product quality varies in such a way as often to mask the cause of defects in the casting. Probably the greatest disadvantage of a throttled ladle discharge is that a much larger surface area of metal is exposed to atmosphere than would be the case with an unthrottled stream. In consequence, reoxidation of the metal occurs to a significantly greater extent than would otherwise be the case, and this results in dirtier metal and a tendency to lapping defects.

It is one object of this invention to provide a means and method by which metal may be transferred from one vessel to another under controlled conditions and independently of the level of skill of the human operative.

According to one aspect of the invention, there is provided a molten metal transfer system comprising a first metallurgical vessel (e.g. a ladle) having an outlet, a control valve for the outlet having an open position and a closed position, a second metallurgical vessel, e.g. a mould, having an inlet, a transfer tube connecting the outlet of the first vessel and the inlet of the second vessel, and means to allow molten metal to pass from the first vessel to the second vessel at a rate determined solely by the dimensions of the first vessel outlet, the transfer tube and/or the second vessel inlet.

In general the rate of flow of molten metal will be controlled by the smallest diameter of the first vessel outlet, the transfer tube and the second vessel inlet. The volume of metal in a ladle is usually greater than that required to fill any one mould and so one ladle will typically be used to fill several moulds which may have gating systems of different diameters. The nozzle of the ladle will be selected to have a diameter corresponding to the largest diameter of the different gating systems but when the ladle is used to fill a mould having a smaller diameter gating system the operative will tend to throttle the stream and this will give rise to castings of poor quality. By the use of this invention, the rate of pour will be determined by the diameter of the ladle nozzle or the diameter of the gating system where that is smaller. The rate of pour will be at a maximum in each case.

In a much preferred and convenient aspect of the invention, the first metallurgical vessel is a foundry ladle having a bottom pour outlet and the second metallurgical vessel is a foundry mould and the inlet is a gating system therefor.

Preferably the transfer tube is sealed to both vessels at each end. Most conveniently, the transfer tube will depend from the underside of the first vessel e.g. ladle, and is fixed to that vessel. Most preferably, the lower end of the transfer tube is provided with spring biased sealing means for reception or engagement with the inlet of the second vessel e.g. mould or gating system therefor to form a sealed connection.

The transfer tube may be formed from a metal having a higher melting point than the molten metal in the ladle. It is preferred to provide a refractory lining in the tube or possibly a refractory pipe, which refractory lining or pipe can be contoured to eliminate so-called dead-zones in the molten metal flowing through the pipe. Preferably the refractory lining adjacent to the metal stream is heat insulating to minimise the likelihood of metal freezing in the transfer tube. The tube may be straight or include angled portions.

It will be understood that the tube may be secured to the ladle but need not of necessity extend directly to the top of a mould proper. The tube may, for instance, be received in sealed manner e.g. embedded in a trumpet feeding several moulds in an uphill pouring system or into the inlet of a continuous casting plant.

The invention further includes a method of transferring molten metal using the system outlined above. In a preferred method, after tapping molten metal into the ladle having a depending transfer tube, the ladle is lowered on to a mould until the free end of the tube is located centrally about the sprue of the mould. The tube is then received in the pouring cup, which may be moulded in sand or preformed in refractory material. Once located, the bottom pour opening in the ladle is then fully opened and as soon as the metal reaches a desired position in the mould cavity, the bottom pour opening is closed and the remaining molten metal in the transfer tube flows into the sprue as the metal level equilibrates. The ladle can then be lifted and positioned on the next mould.

Because the system is effectively sealed, the operator may fully open the ladle without any danger of being splashed by molten metal. The rate at which the mould fills is independent of the operator and is dependent only on either the discharge characteristics of the ladle or the dimensions and design of the gating system, both of which are quantifiable. Consequently, the pouring time is completely predictable and it becomes possible to design a pouring system to ensure consistent achievement of the prescribed pouring rate. By being a closed system, exposure of the stream to atmosphere is avoided and there is no risk of reoxidation from this source. Because the system is effectively sealed, the entrainment of air in the metal stream, which otherwise occurs to a marked degree, is prevented, eliminating a further source of reoxidation. The air which would normally be entrained is carried through to the mould cavity which, as a consequence, is vented to provide channels through which the air may escape. The need for vents is therefore eliminated or substantially reduced by pouring in the manner described.

In a further preferred feature, the mould is made by the Vacuum Moulding Process or V-Process. Such moulds consist of loose sand held in place by a vacuum, the mould system being sealed by heat destructible plastic sheeting. When pouring such moulds it is desirable that very high filling rates are achieved and that metal splashing onto the plastic cover on the top surface of the mould is avoided otherwise vacuum losses occur. In extreme cases, failure to meet these conditions can result in partial or even complete collapse of the mould. When using the transfer system of the invention splashing is completely eliminated and the required very high pouring rates can readily be achieved. It will be apparent that in a vacuum assisted moulding process the prevention of entrained or aspirated air achievable with the invention is also highly desirable.

It is well known that inclusions, typically refractory particles, are entrained in the stream delivered to the mould. These inclusions originate from several sources and it is extremely difficult to reduce the inclusions to an acceptable level in the context of a foundry operation for example. One suggestion has been to incorporate a ceramic filter in the gating system which would trap any undesirable particles. However, the limited permeability of the filter reduces the volume flow rate through the gating system so that with conventional pouring practice the gating system would back-fill and overflow at the pouring cup. An advantage of the transfer system of this invention is that the system is sealed so that overflow does not occur and another advantage is that the increased ferrostatic head effectively forces molten metal through the filter element. It may be desirable to increase the cross-sectional area of the gating system to compensate for the choking effect of the filter element.

Preferably, the filter element is located at the ingate(s) so that clean metal enters the mould cavity proper at a low velocity or the filter element may be located in the pouring cup to serve as a gasket to seal the transfer tube and to minimise the restriction to flow.

The invention includes a ladle and a foundry mould for use in the system or method and a casting made by the method.

In order that the invention may be well understood, it will now be described with reference to the accompanying diagrammatic drawings, in which:

Figure 1A is a sectional elevation of a ladle and the upper part of a mould including a transfer tube in accordance with the invention before metal transfer and Figure 1B shows the same view during metal transfer, and

Figure 2 is the same view as Figure 1B of another embodiment of the invention.

The same reference numerals are used to describe the same parts where possible. A ladle 1 has a bottom pour opening 2 defined by a reverse taper nozzle 3 which may be closed by the end of a stopper rod 4. Part of the nozzle 3 extends below a retaining plate 5 to which is rigidly secured a transfer tube 6. The tube comprises an outer steel pipe having an inner lining of refractory heat insulating material. The outer face of the transfer tube 6 is accurately machined to form an accurate sliding fit with a tapered end piece or cap 7. The tapered end piece is spring loaded circumferentially about a point 8 by springs 11 so that when the springs are relaxed the tapered end piece 7 extends beyond the end of the transfer tube 6 as shown in Figure 1(a).

In use, molten metal is tapped into the ladle with the opening 2 closed by the stopper 4. The ladle is moved to bring the tapered end piece over the pouring cup of the downrunner 9 in Figure 1(a). The ladle is then lowered to locate the tapered end piece on a frustoconical compressible refractory gasket 10 which is positioned in the pouring cup 9. When contact is made the tapered end piece 7 slides up the transfer tube 6 against the resistance of the springs 11 which are compressed until two registers on the sliding part and fixed part are juxtaposed and the ends of the sliding piece 7 and fixed tube 6 are coincident, at point 12 in Figure 1(b). The pressure of the springs in this condition is great enough to create an effective seal on the gasket 10 so that ingress of liquid metal to the sliding faces is prevented and yet at the same time the downward force imposed is not so great as to damage the pouring cup or mould system.

The stopper rod 4 is then lifted to fully open the bottom pour opening and metal flows from the ladle into the mould at a rate determined either by the cross-sectional area of the nozzle 3 or the refractory lined tube 6 or the gating system 9. The gating system may incorporate a choke, not shown, i.e. a point where the cross-sectional area is less than that of the nozzle 3 or transfer tube 6, to control the filling rate. Control of the rate of filling is exercised by the pouring system in a predictable manner and in such a way that exposure of the stream to atmosphere is more or less completely eliminated. (If such a choke is located at the base of the downrunner say, the downrunner is said to be pressurised and becomes completely full of liquid metal so that no air is aspirated).

When the molten metal reaches the desired level in the mould, the stopper 4 is lowered to close the bottom pour opening, and molten metal in the nozzle block 3 and transfer tube 6 flows into the sprue as the metal level equilibrates. The ladle can then be lifted clear of the mould and positioned over the next mould to be poured.

In the embodiment of Figure 2 a filter plate 13 of permeable erosion resistant refractory material, e.g. zirconia or magnesia, is placed across the pouring cup below a flat compressible fibrous refractory gasket 10A to remove inclusions etc. from the molten metal. The cap 7A engages or is located adjacent the tapered inlet of the pouring cup 9. The filter plate could not be used without the closed pouring system of the invention, since the back-filling of the pouring cup and splashing which would otherwise occur would present a hazard to the operator. The closed system causes an increased ferrostatic head of pressure which urges the metal through the plate 13. In another embodiment, not shown, a filter plate is located in the gating system or adjacent the inlet to the mould cavity. The cross-sectional area of the gating system channel must be increased at the location point correspondingly to offset the restriction to flow caused by the filter.

In another highly advantageous feature, the molten metal passing through the tube is subjected, at a controlled rate, to a treatment for example, deoxidation or desulphurisation of steel, desulphurisation of pig iron, nodularisation and inoculation, by introduction into the stream via a hole in the tube wall or inlet of gases, powders, wires, encapsulated powders in wire form or the like.

CLAIMS

1. A molten metal transfer system comprising a first metallurgical vessel having an outlet, a control valve for the outlet having an open position and a closed position, and a second metallurgical vessel having an inlet, a transfer tube connecting the outlet of the first vessel and the inlet of the second vessel, means for opening the valve to an open condition to allow molten metal to pass from the first vessel to the second vessel, characterised in that the metal flow is at a rate determined solely by the dimensions of the first vessel outlet, the transfer tube and/or the second vessel inlet.

2. A system according to Claim 1 characterised in that the first metallurgical vessel is a foundry ladle having a bottom pour outlet and the second metallurgical vessel is a foundry mould and the inlet is a gating system therefor.

3. A system according to Claim 1 or 2 characterised in that the transfer tube is connected to the vessels in sealed manner.

4. A system according to Claim 3, characterised in that one end of the transfer tube is connected to the

first vessel in fixed sealed manner and the other end is releasably connectable to the second vessel or inlet thereof by means of a spring biased end adapted to engage the second vessel or inlet thereof in a sealed manner.

5. A system according to any preceding Claim characterised in that the rate of flow is determined by the smallest diameter of the first vessel outlet, the transfer tube and the second vessel inlet.

6. A system according to any preceding Claim, characterised by the presence of a filter element in the second vessel or inlet thereof.

7. A system according to any preceding Claim, characterised in that the second vessel comprises a foundry mould having a seal or cover of heat destructible plastics sheeting.

8. A method of transferring molten metal characterised by using a system according to any preceding Claim, in which the ladle is lowered on to a mould until the free end of the transfer tube depending therefrom is located centrally about the sprue of the mould, the bottom pour opening in the ladle is then

opened and the molten metal is allowed to pass therethrough at a high flow rate, and when the metal reaches a desired position in the mould feeder head, the bottom pour opening is closed and the remaining molten metal in the transfer tube is allowed to flow into the sprue as the metal level equilibrates.

9. A method according to Claim 8, characterised by supplying to the stream of molten metal in the transfer tube via a hole in the tube a treatment agent to treat the metal passing towards the second vessel.

10. For use in a system according to any of Claims 1 to 7 or a method according to Claim 8 or 9, a ladle having a bottom outlet with a control valve having an open position and a closed position, characterised in that a transfer tube depends from the ladle and is fixed to the underside of the ladle, and has spring biased sealing means adjacent its free end for engaging the second vessel or inlet thereof in a sealed manner.

11. For use in a system according to any of Claims 1 to 7 or a method according to Claim 8 or 9, a foundry mould having an inlet characterised in that a compressible refractory gasket is present in the inlet for sealing the end of a transfer tube.

12. A foundry mould according to Claim 11 characterised in that a filter element is present below the compressible refractory gasket.

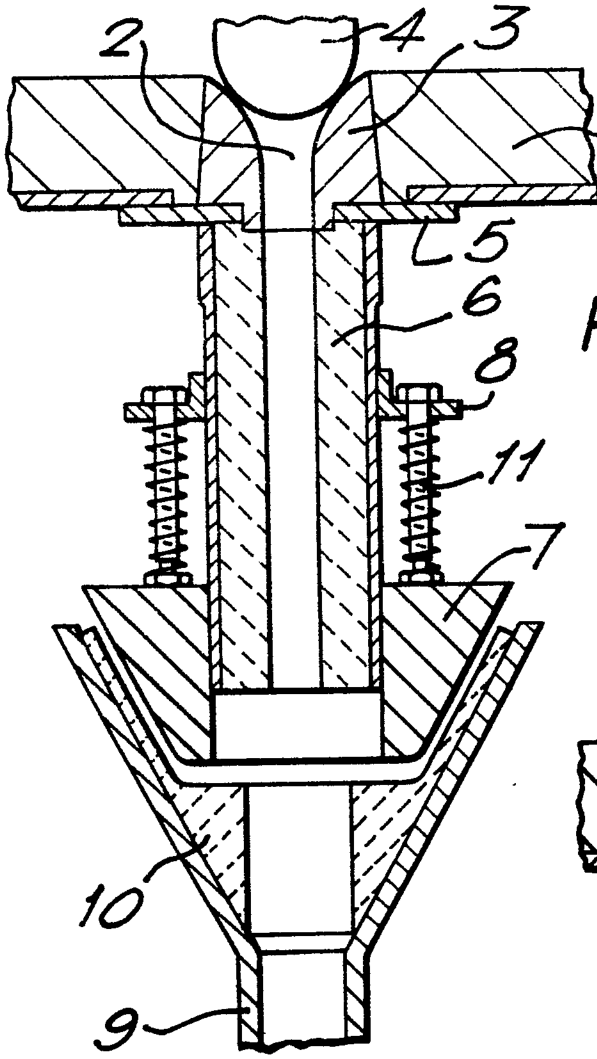


FIG.1A.

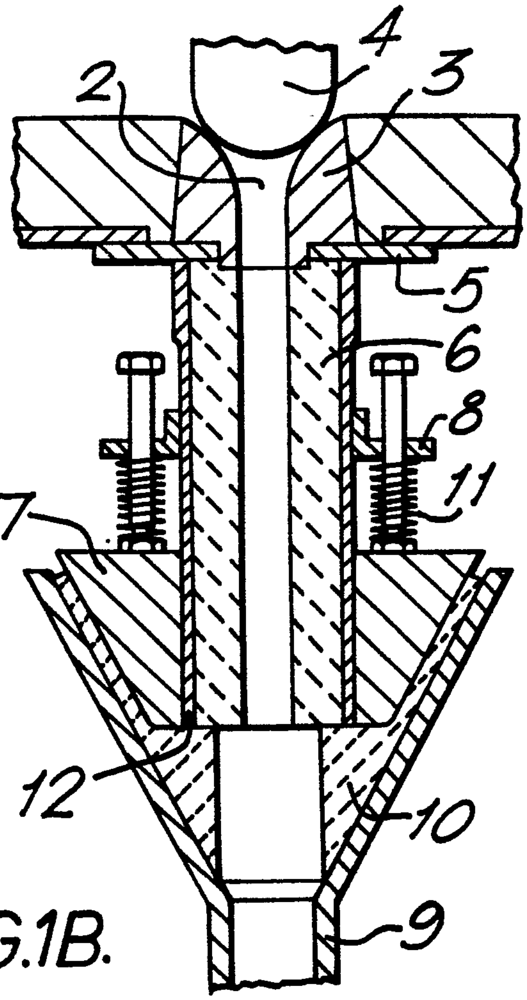
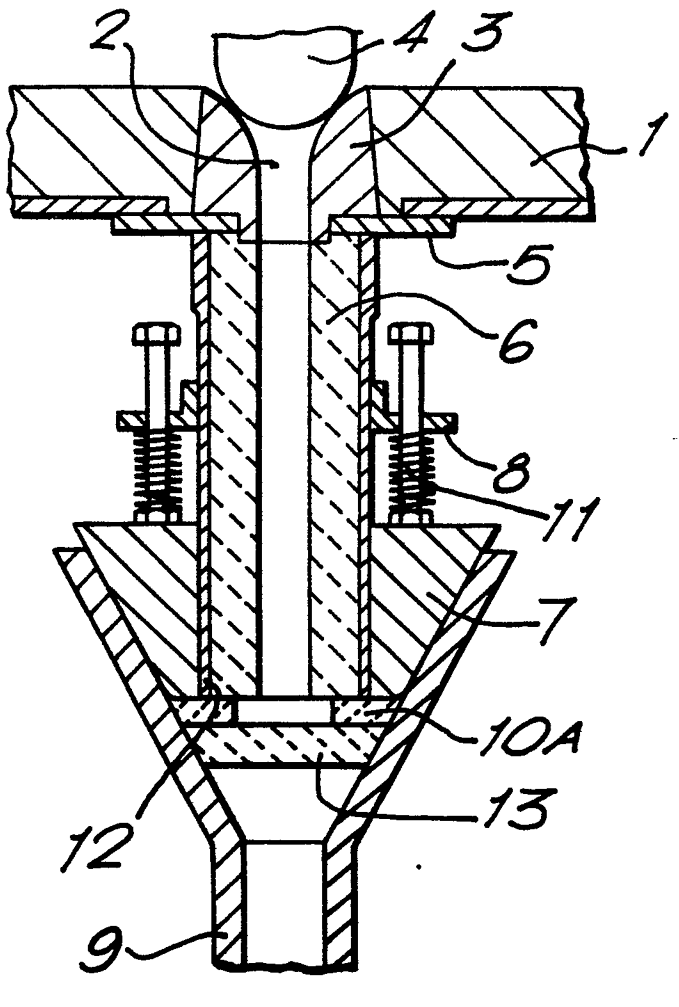


FIG.1B.

FIG.2.



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EUROPEAN SEARCH REPORT

Application number

EP 82 30 4056.3

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
X	US - A - 3 511 304 (R. BAIER et al.) * claims 1 to 4 * --	1-8	B 22 D 41/08 B 22 D 39/00 B 22 D 37/00
A	DE - A - 2 013 215 (USS ENGINEERS AND CONSULTANTS, INC.) * claims 1 to 4 * & GB - A - 1 299 104 --	10	
A	CH - A - 441 633 (MACHIN ANSTALT) * fig. * --	1	TECHNICAL FIELDS SEARCHED (Int.Cl. 3)
A	FR - A - 2 050 387 (USS ENGINEERS AND CONSULTANTS INC.) * fig. 1 * & GB - A - 1 299 668 ----	1	B 22 D 37/00 B 22 D 39/00 B 22 D 41/00

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D: document cited in the application
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&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Berlin	19-10-1982	GOLDSCHMIDT

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