

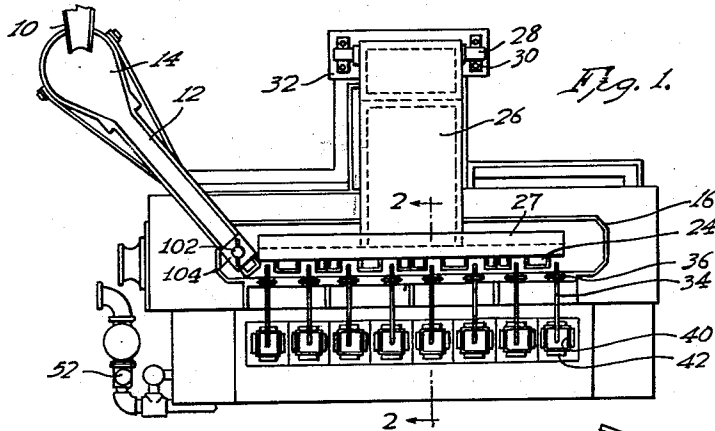
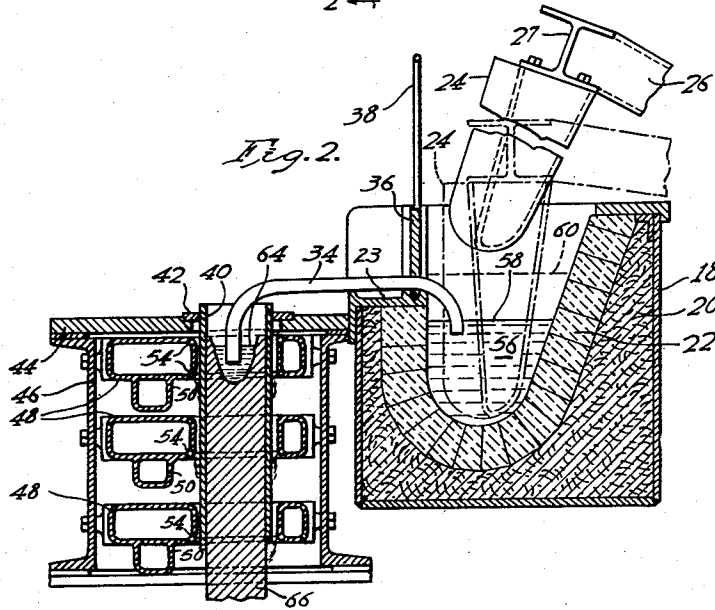
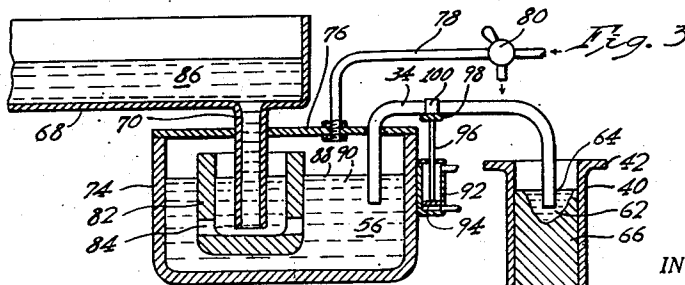
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METAL TRANSFER METHOD AND APPARATUS

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METAL TRANSFER METHOD AND APPARATUS

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1

2

This invention relates to method and apparatus for transferring molten metal to the molds in both continuous and semi-continuous casting processes. The term continuous, as here used, refers to the progressive and uninterrupted formation of a cast body in a mold or die which is open at both top and bottom. The pouring operation may continue indefinitely if the cast body is cut into sections of suitable length below the mold or the pouring operation may be started and stopped in making each ingot. In the latter case the process is often referred to as being semi-continuous.

In any continuous or semi-continuous casting process for producing ingots in which molten metal is introduced into a relatively short chilled mold and a solidified or partially solidified ingot is withdrawn from the mold, it is necessary to supply molten metal to the mold at a rate equal to the rate of withdrawal of the ingot. Various methods have been proposed for supplying metal to the mold which have included discharge from a vertically disposed tube above the mold and metal contained therein; overflow from a horizontal trough or basin adjacent to the mold; unrestricted downward flow from a tube whose lower end is below the surface of the pool of metal in the mold; flow of metal through a fixed orifice in a tube at a rate controlled by varying the pressure behind the orifice and flow through an orifice the size of which may be controlled and adjusted during transfer of the metal. Two major and some minor difficulties attend the foregoing transfer methods.

Manual control of the pouring rate or varying the pressure or manually adjusting the size of the orifice is a difficult and exacting task, especially when several ingots of small cross section are being cast simultaneously and the flow of metal to each mold is separately controlled. Variations in the height of metal in the mold frequently occur which result in serious defects in the ingots such as cold shuts and gross inclusions. Methods for automatic control of the metal level that have been proposed lead to fluctuations of the metal level because of the unavoidable lag of operation of the controls.

The second major difficulty arises from the fact that in all the methods described the metal enters the mold at a relatively high linear velocity. Such a rapidly moving stream of metal tends to draw air into the metal within the mold. This brings about the formation of oxide film and film inclusions in the case of readily oxidizable metals such as aluminum and magnesium and their alloys, and may even cause porosity in the ingots, espe-

cially where the aforesaid light metals are being cast. The effect of such a high linear velocity can be offset to some extent by placing baffles in the path of the incoming stream of metal but no matter how carefully this is done currents of considerable velocity may still exist in the pool of metal and cause structural irregularities in the ingots.

Apparatus which has been proposed heretofore for automatic control of the metal level in molds in continuous casting processes has been complicated and required careful and continuing adjustment to maintain it in good operating condition. The problem is particularly difficult where a number of molds are being supplied with metal from a single source since it has been almost impossible to control and maintain the casting apparatus in such fine adjustment that there is negligible difference between the individual units. No commercially useful automatic apparatus has been devised which will permit simultaneous starting and stopping of the flow of metal to a plurality of molds where the metal is delivered to the molds from a central source.

It is an object of our invention to provide a method for transferring molten metal to a mold in a continuous or semi-continuous casting process at a low linear velocity. Another object is to provide a method for controlling the head of metal in the mold when transferring the liquid metal to the mold by atmospheric pressure. A further object is to provide a method for the relatively quiet transfer of molten light metals to a mold in a continuous casting process. A special object of our invention is to provide a method of transferring metal to a plurality of molds from a single source of metal supply in a continuous or semi-continuous casting process and simultaneously controlling the metal level in all the molds. A further object is to provide apparatus for the transfer of molten metal to a mold in a continuous casting process at a low velocity. Still another object is to provide apparatus for the siphonic transfer of metal to a plurality of molds which insures rapid and positive starting of all the siphons at one time. Another object is to provide an assembly of siphons for transfer of metal to a plurality of molds which permits removal of one siphon without disturbing the operation of the others.

Our method of transferring metal consists in providing a body of metal as a source of supply to a mold, maintaining the metal body at a substantially constant level and siphoning the metal to the mold. More particularly, the meth-

3

od consists in quickly starting the siphon, maintaining a substantially constant low difference in head of metal between the source of supply and that in the mold during the pouring operation thereby establishing a low velocity in the stream of metal, and abruptly stopping the siphonic action. Molten metal in controlled volume is supplied to the distributing container and the metal level therein kept as nearly constant as possible. The siphon transfer from container to mold is started by causing a surge of metal to pass through the siphon pipe and allowing a pool of metal to accumulate covering the discharge end of the siphon before starting downward movement of the ingot. The metal transfer is quickly halted by stopping the siphonic action. We have found that siphoning metal into the mold in a continuous casting process offers distinct advantages over previous transfer methods and that it is particularly well adapted to use in casting a plurality of ingots.

Our invention will be more clearly understood through reference to the accompanying drawings wherein:

Fig. 1 is a plan view of a multiple pouring unit employing the continuous casting process.

Fig. 2 is a cross-sectional and enlarged view of the portion of the apparatus shown in Fig. 1 taken on line 2—2, and

Fig. 3 is a somewhat diagrammatic section of apparatus which is a modification of that shown in Fig. 2.

Referring to Fig. 1, molten aluminum issues from any suitable source through spout 10 to enlarged end 14 of transfer trough 12. The metal flows through a bottom outlet or downspout in said transfer trough to an elongated container such as distributing trough 16 from where it is discharged to the individual molds 40 through siphons 34 leading to each mold. Valve 102 mounted on bracket 104 cooperates with said outlet and serves to control the flow of metal from the transfer trough.

Mounted above the distributing trough and operatively associated therewith is displacer 24 attached to arm 26 through H beam 27. The displacer may be a hollow or a solid body but preferably it is of hollow construction to reduce its weight and to facilitate its movement. The displacer arm 26 may be pivoted on trunnions 28 which are journaled at 30 in bearings resting upon support 32. The displacer may be operated by a power cylinder or any other means which permits relatively rapid or slow movement as desired.

The distributing trough as may be seen in Fig. 2, is comprised of a metal shell 18 in which is packed insulation 20 and laid upon it, in turn, is fire brick lining 22 to form a trough-like cavity.

The metal is transferred from said trough to mold 40 through detachable siphon pipe 34 made of a ferrous metal, i. e. iron or an iron alloy, or a more refractory material. This pipe passes through and is welded to plate 36 that rests in a marginal groove about a suitable opening in the vertical portion of the sill section 23 which forms a portion of the wall of the trough facing the mold. The aforesaid opening and plate 36 fitted therein should have a shape, such as a V-shape, which permits convenient vertical placement and removal of the plate, as illustrated in companion application Serial No. 96,043. A rod and handle 38 are attached to plate 36 to facilitate convenient handling thereof.

The mold is of the conventional design used

4

in continuous casting processes and may consist of aluminum alloy or bronze plate about $\frac{1}{4}$ inch in thickness. The mold is supported by flanges 42 resting on plate 44 secured to spaced channels 46. Surrounding the mold are spray chambers 48 which include a conduit 50 for supplying water to the chambers. Said conduit is connected in conventional manner to a supply of water 52. Streams of water are projected against the mold and descending ingot by holes 54 in the spray chambers. The position and function of the above described metal transfer apparatus as part of a casting system are shown in co-pending application Serial No. 96,043, filed May 28, 1949, now abandoned.

In the modification shown in Fig. 3 the transfer trough 68 carries downspout 70 for delivering metal to covered trough 74. The downspout should extend nearly to the bottom of the trough 74 so that the discharge end will at all times be submerged in the body of liquid metal. This arrangement prevents any upward escape of air or gas through the downspout as a result of change in metal level incident to operating the siphon. Trough 74 is provided with a tight-fitting cover plate 76 and an air line pipe or conduit 78 passes through the plate. Siphon pipe 34 also passes through the cover, the fit being loose enough to allow the pipe to be raised and lowered. A number of siphons and molds may be employed as shown in Fig. 1. Compressed air or other gas from a suitable source is admitted by operation of three-way valve 80 which can also serve to release any air under pressure in the covered trough. Below the end of the downspout 70 is a self operating metal flow control means consisting of a floating cup-like member 82 having lateral discharge ports 84 close to the bottom thereof. To obtain the desired buoyancy the cup should be made of a material having lower density than that of the molten metal or it may be provided with appropriate air chambers. It will be understood that other means may be provided for controlling discharge of metal from trough 74 such as a manually operated valve rod similar to that shown in Fig. 1. Attached to the side of trough 74 or on some other support is a means of elevating the siphon tube above the body of metal in the trough consisting of an air cylinder 92 and the associated piston 94 and rod 96 attached thereto. The siphon 34 is supported by a bar or channel 98 which in turn is mounted on rod 96. The bar member can be of any length and support any number of siphons. The siphon is secured to the bar by strap 100 or other convenient fastening means. For convenience in replacing siphon pipes the strap 100 should be easily removable. The elevating means is operated at the end of a pouring period to abruptly stop the siphonic action. It is essential in any case, however, that the elevating means be designed to raise the discharge end of the siphon tube above the level of the metal body in the trough 74.

In both forms of metal transfer apparatus described above, the siphon pipe is of relatively short length and height. In the preferred form of apparatus the distributing container or trough is very close to the mold receiving the molten metal. The short length of the siphon offers important advantages. The molten metal is cooled but little, if any, in passing through the pipe. The short legs mean that but little pressure for elevation of molten metal is required to start operation of the siphon. The short length

reduces the cost and permits greater ease in handling for initial insertion or replacement. The last named feature is of special importance in transferring molten aluminum because it attacks iron, and the pipes even though protected by the customary wash become perforated in time, usually at the intake end where the metal is hottest.

The siphon pipes, of course, must have sufficient cross sectional area to transfer the desired quantity of metal at a low velocity and hence a relatively large diameter pipe is usually preferred. A pipe of relatively large diameter offers lower frictional resistance than a small pipe and any partial obstructions will have a smaller effect upon the flow of metal in a large pipe than in a small one. The use of a relatively large diameter pipe therefore has the important advantage of minimizing fluctuations in the level of metal in the mold and makes it easier to maintain the level within prescribed limits. In transferring metal to 6" x 6" square molds such as illustrated an iron pipe of about 1 1/4 inch I. D. serves very well. With this size of pipe and a difference in metal head between trough and mold of 1/4 to 1 inch, the velocity of the stream of aluminum entering the mold will be about 0.22 to 0.25 feet per second as compared to a velocity on the order of 6 to 8 feet per second in the conventional gravity pour systems now in use.

In operating the apparatus shown in Figs. 1 and 2, the troughs and siphons may be first coated with a conventional protective coating and preheated just before molten aluminum flows from transfer trough 12 into distributing trough 16. Preferably a flow control means is provided both at the furnace or other source of molten metal and at the delivery end of the transfer trough so that a uniform depth of metal will be maintained in trough 16 during the pouring operation. To start the casting operation, molten metal is allowed to flow from the transfer trough 12 to form a body of liquid metal 56 in the distributing trough 16 to a depth indicated by 53. The bottom of mold 40 is temporarily closed with a downwardly movable plate or plug so that the mold will hold the initial charge of molten metal and it will be below level 58. The displacer 24 is quickly lowered to a predetermined position close to the bottom of the trough 16 thus raising the metal level to 60 above the siphons 34 and rapidly filling them. The surge of metal drives out the air and immediately establishes good siphonic transfer to the mold. When the pool of metal in the mold has reached the desired depth, the displacer is withdrawn from the trough and the constant metal level 58 maintained slightly above that of the pool in the mold as at 54. In transferring light metals this difference may be on the order of 1/4 to 2 inches.

When a shell of solid metal of sufficient thickness has been obtained in the chilled mold, the shell is gradually lowered and further chilled to form an ingot 66. The liquid and solid phases of metal in the mold are illustrated in Fig. 2. By permitting the incoming metal stream to enter the mold at a low linear velocity the depth of the crater in the solidified ingot is kept at a minimum and formation of the ingot is hastened. The absence of strong currents of hot metal in body 62 also promotes more rapid and uniform chilling. This control results in fewer rejections for such defects as cold shuts that cause cracks during rolling and dross inclusions.

Near the end of the pouring operation when the flow of metal to the mold is to be terminated the supply of metal from transfer trough 12 should be stopped and displacer 24 gradually lowered into the body of molten metal 56 at a rate such that about the same metal level will be maintained as existed during the previous pouring operation. After the displacer has reached its lowermost position the metal level will continue to fall and when it nearly reaches the intake end of the siphon pipe the displacer should be rapidly raised thus causing the metal level to drop below the siphon and cut off further supply of metal to the mold. Where a plurality of molds are being operated as illustrated in Fig. 1, it is of considerable importance to simultaneously stop the flow of metal to all the molds and thereby obtain ingots of uniform length.

The temperature of the metal should be within the usual range used in pouring in the continuous casting process. In the case of aluminum and its alloys this is about 1200-1400° F.

The operation of the apparatus shown in Fig. 3 differs from what has been described only in that air pressure is employed to start the siphon action. Molten metal 56 from trough 68 is allowed to flow into covered distributing trough 74 to form a body of metal 56 until the desired depth of metal 88 is attained. At this stage, air or other gas under relatively low pressure is admitted into line 78 to quickly force metal into siphon 34 and start the transfer of the metal. If a metal such as magnesium is being cast, it may be necessary to use a non-oxidizing gas in place of air. The metal level 88 is thereby lowered to 90 which should be above that of the pool of molten metal formed in mold 40, as has been described above. When the flow of metal to the mold has been established, the compressed air supply is cut off at valve 80 which is turned to the position for relieving the air pressure in the trough thus restoring it to normal atmospheric pressure and allowing the metal level to rise to 88. The air pressure needed to start the siphon is small, usually on the order of no more than 1 lb. per sq. in. Air at this pressure may be conveniently obtained from conventional blowers. A further advantage of using only low air pressure is that some leakage around the cover and opening for the siphon pipe can be allowed without interfering with quick filling of the siphons.

The floating cup 82 merely serves as an automatic means for maintaining the metal level at 88 during the pouring operation. As previously mentioned, manual means similar to that in Fig. 1, may be used in place of the floating cup. As the metal level falls slowly the cup descends from the end of the downspout thus admitting more metal while under reverse conditions the cup reduces the flow of metal until the desired level is again obtained. When the pouring operation is to be halted the air cylinder is operated to raise the discharge end of the siphon above the metal level in the trough and thus quickly stop further metal flow.

We have found that the method and apparatus described above produce aluminum ingots of satisfactory quality for fabrication and that control of the metal level in a plurality of molds is greatly simplified through use of this invention. Other metals and alloys may be cast using the same principles but with suitable variations to accommodate any peculiarities of the metal being handled.

Having described our invention and illustrated embodiments thereof, we claim:

1. Apparatus for the simultaneous transfer of molten metal to a plurality of molds in a continuous casting process comprising means for holding a supply of molten metal and continuously delivering the same at a substantially constant rate during the transfer operation, an open refractory lined trough for receiving metal from said supply means, said trough having a plurality of openings in the upper part of one side wall, a water cooled mold adjacent each opening in said trough, a detachable siphon tube mounted in each opening and extending from said trough to the corresponding mold for effecting transfer of metal from said trough to said mold, the intake end of said siphons being above the bottom of said trough, said siphon tubes being rigidly mounted in removable plates shaped to fit corresponding openings in the side wall of said trough, said openings being above the level of metal during the pouring operation, and a displacer body acting in said trough to displace the metal upwardly therein and in each of said siphon tubes and thereby initiate the flow of metal there-through.

2. In a continuous casting process wherein molten metal is fed to an open ended mold and solidified metal is withdrawn from the bottom thereof the method of transferring molten metal from a source of said supply to said mold in which the metal is supplied to a distributing container and siphoned therefrom into said mold, the steps of filling said container to pouring level, quickly raising the metal level above the siphon, initiating the flow of metal through the siphon, quickly lowering the metal level to the pouring level, supplying additional molten metal at such a rate as to maintain a substantially constant pouring level in said container, at a substantially constant elevation above the molten metal in the mold, terminating the flow of metal to said distributing container, gradually displacing said metal in said container at a rate such that the pouring level is maintained and finally quickly bringing the metal below the point of intake of said siphon.

3. A method of transferring molten metal through a siphon from a body of metal in a distributing container to a mold in a semi-continuous casting process comprising inserting a displacement member in the container to raise quickly the level of metal in the container above the siphon, withdrawing the displacement member to return the level of metal in the container to its normal pouring level, supplying a controlled flow of metal to the container to maintain said normal pouring level, toward the end of the casting operation cutting off the flow of metal into the container, maintaining the metal in the container at the normal pouring level by gradually inserting the displacement member and when the displacement member reaches its lowest position, terminating the flow of metal through the siphon by quickly raising the displacement member.

4. A method of transferring molten metal through a siphon from a body of metal in a closed distributing container to a mold in a continuous casting process comprising filling said container to pouring level with molten metal, initiating flow

of metal through said siphon by the application of air pressure in excess of atmospheric pressure to the surface of the metal body in said container, terminating the applied air pressure, supplying a controlled flow of metal to said container to maintain a substantially constant pouring level above the metal level in said mold, toward the end of the casting operation cutting off the supply of metal to said container, re-applying air pressure to the body of metal in the container to maintain the flow of metal through the siphon as the metal level is lowered in the container, cutting off the applied air pressure and terminating the flow of metal in the siphon.

5. Multiple ingot casting apparatus comprising a source of liquid metal, a transfer trough pivoted adjacent the end where the molten metal is received whereby the trough is swung into or out of pouring position, valve means at the discharge end of said trough, a second refractory lined trough receiving molten metal from said transfer trough, a plurality of open ended molds in fixed position in side by side relationship adjacent said refractory lined trough, detachable siphon tubes attached to V-shaped plates fitting in complementary V-shaped openings in a side wall of said trough, said siphon tubes extending from the interior of said trough to said molds, the number of tubes corresponding to the number of molds, a displacer body operative within said trough and of a size to occupy a substantial portion of the space in said refractory lined trough in its lowermost position, said displacer being mounted at the free end of a pivoted supporting arm and power means attached to said arm to raise and lower said displacer body.

6. Multiple ingot casting apparatus comprising a source of liquid metal, an open receptacle for receiving metal from said source having V-shaped openings in the upper portion of a side wall thereof, a transfer trough for delivering metal from said source to said receptacle, a plurality of open ended molds in fixed position adjacent said receptacle, siphon tubes mounted in removable V-shaped plates fitted in said V-shaped openings, said siphon tubes extending from the interior of said receptacle to said molds, the number of siphon tubes corresponding to the number of molds, a displacer body operative within said receptacle and of a size sufficient to occupy a substantial portion of the space therein when in its lowermost position, and elevating means attached to said displacer body to raise and lower the same.

References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
655,296	Collins	Aug. 7, 1900
1,983,579	Ennor et al.	Dec. 11, 1934
1,983,580	Nock	Dec. 11, 1934
2,135,183	Junghans	Nov. 1, 1938
2,218,171	Junghans	Oct. 15, 1940
2,290,083	Webster	July 14, 1942
2,301,027	Ennor	Nov. 3, 1942
2,356,013	Spooner	Aug. 15, 1944
2,399,634	Holland et al.	May 7, 1946
2,509,079	Trewin et al.	May 23, 1950