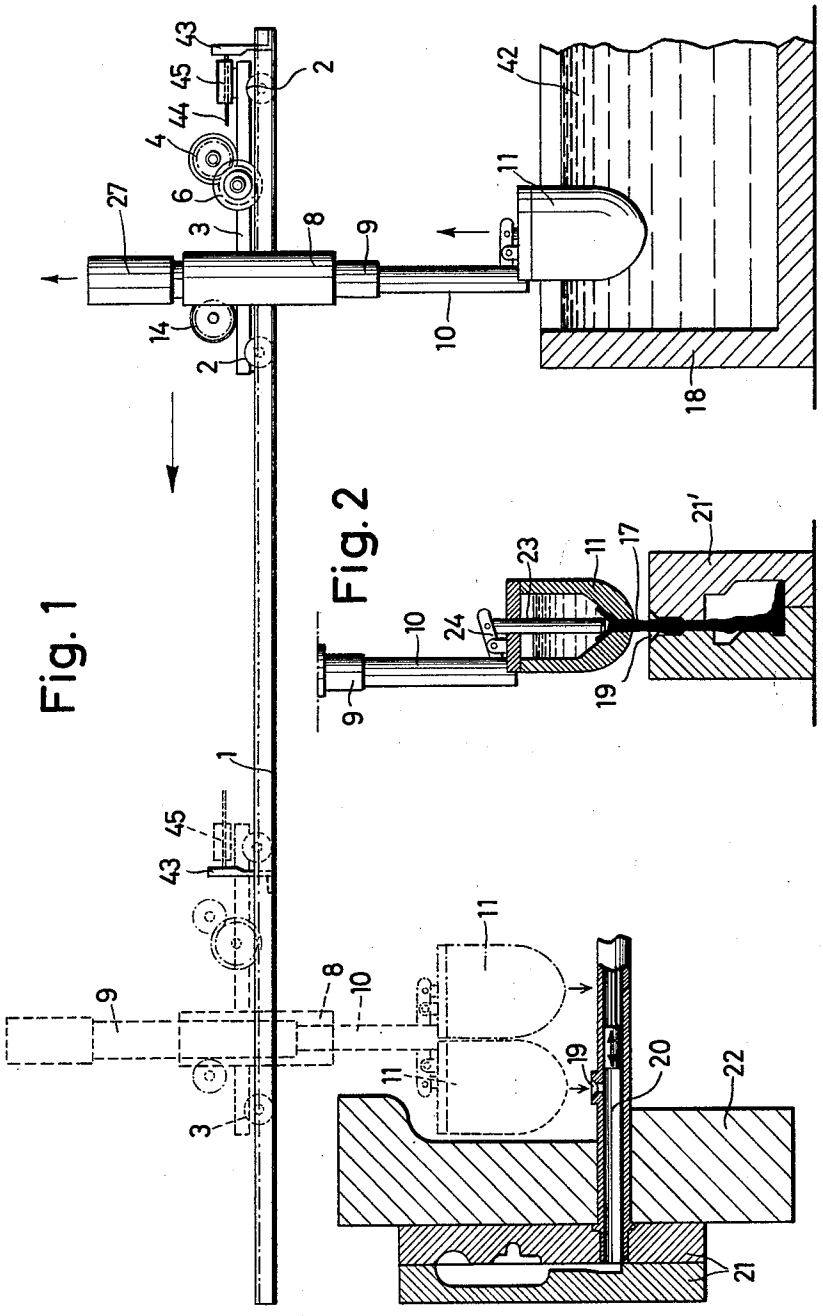
Nov. 24, 1964 F. HODLER 3,157,923

APPARATUS FOR TRANSPORTING MOLTEN METAL

Filed July 31, 1961 2 Sheets-Sheet 1



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Fig. 3

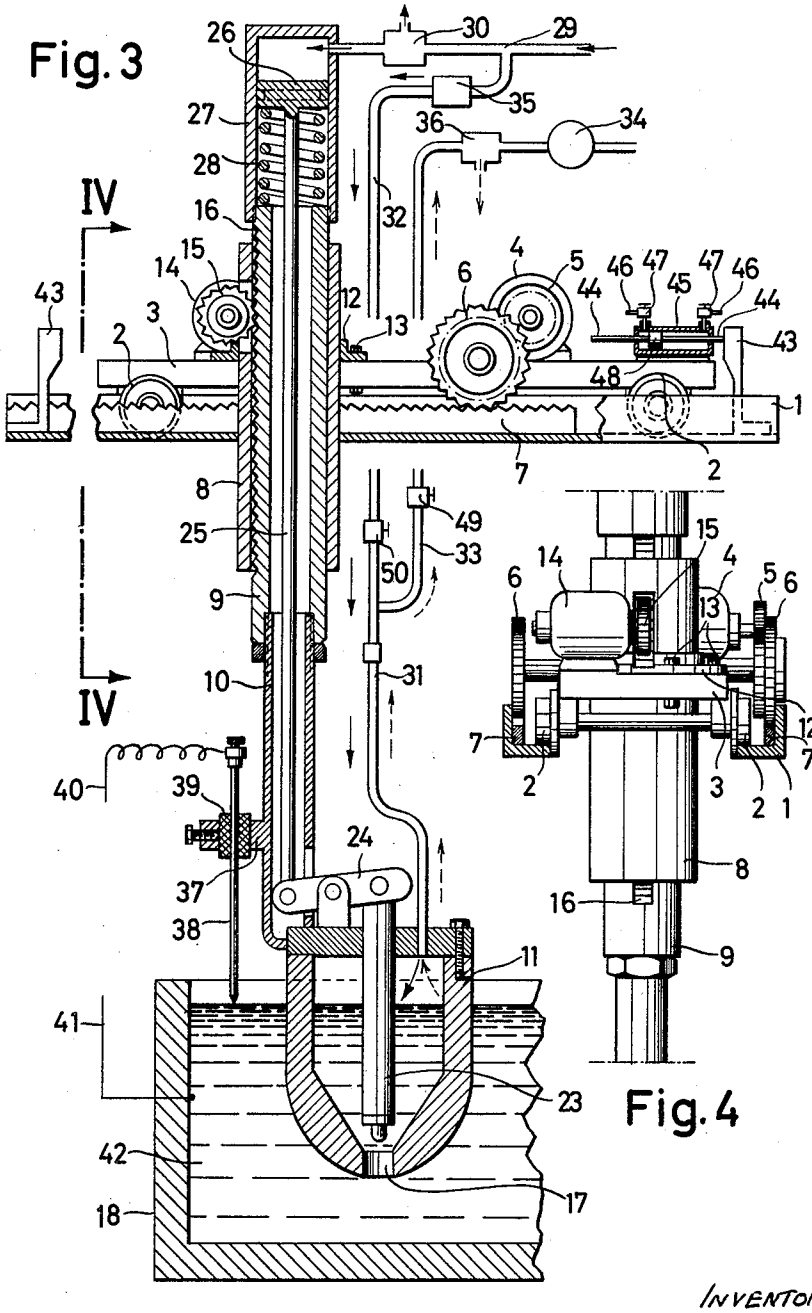


Fig. 4

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APPARATUS FOR TRANSPORTING MOLTEN METAL

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The invention relates to apparatus for transporting molten metal from a melting bath, the top of which is open, to the charging aperture of a casting mold, for example a chill-mold or a casting machine, by means of a charging container adapted to move to and fro, between the bath and the mold, along a guide.

Devices of this kind have already been proposed, wherein the charging container consists of a bucket which is adapted to move to and fro, between the melting bath or melting furnace and the casting mold, along a gantry. In this known device, the charging bucket is filled by placing it beneath an outlet duct of the melting bath and it is then moved until its outlet aperture, which is disposed at the bottom, is situated above the charging aperture of the casting mold, by means of a crane hook hanging from a travelling carriage. This known device has the disadvantage that automatic operation is not possible. One or more operators are required to fill the charging container, to move it to and fro between the melting bath and the casting mold, and to pour the metal into the charging aperture of the mold. In particular, manual operation is required for accurate alignment of the outlet aperture of the charging container above the charging aperture of the casting mold.

Another device for transporting molten metal from the melting bath to the charging aperture of a casting mold has been disclosed wherein the charging container is not only movable to and fro along a horizontal guide, but is also movable up and down a vertical guide automatically within exact adjustable limits. In this arrangement, however, the charging container consists of a pivoting ladle, such as is frequently used for carrying molten metal. The pivoting movement of this ladle requires a complicated drive mechanism. Moreover, when the metal is poured out by pivoting the ladle, it is not possible to ensure that the metal is poured with absolute accuracy into the charging aperture, which is usually small, if the device is to be operated completely automatically. Moreover, such a pivoting ladle has the disadvantage that, with each pouring operation, a thin layer of metal becomes deposited on its inner wall and on the outlet spout or duct which is usually provided to improve the charging process, so that the outlet becomes increasingly restricted with continuing use of these casting ladles, and pouring of the molten metal cannot be satisfactorily ensured.

Furthermore as a result of the pivoting movement, which takes up a certain amount of space, the outlet of such a pivoting ladle frequently cannot completely reach the mold charging duct or mold charging aperture which is usually not completely exposed, particularly in the case of casting machines, so that an additional connecting duct is often required between the pivoting ladle outlet and the charging aperture, to enable the pouring operation to be performed satisfactorily. Such connecting ducts have the same disadvantage as the outlet spouts or ducts on the pivoting ladles.

Furthermore, with the above-described known device comprising a pivoting ladle which is movable horizontally and vertically, special apparatus is necessary to fill the ladle. To obviate this, it has been proposed to arrange the melting bath above the floor at a level such that the pivoting ladle can be brought beneath an outlet aperture situated at the bottom of the melting bath. This is complicated, however, and usually requires conversion of existing plants in which the melting bath is usually supported directly on the ground.

The object of the invention is to provide apparatus for transporting molten metal, which apparatus requires no conversion of the melting bath and casting mold and requires no additional attached fittings to be provided thereon, yet guarantees fully automatic transportation of metal from the melting bath to the casting mold in a satisfactory manner with the simplest possible means, and without having the abovementioned disadvantages. Such apparatus, which comprises a charging container adapted to move to and fro between the bath and the mold along a guide, is characterised, according to the invention, in that the bottom of the charging container has a closable outlet aperture for the metal, said aperture being adapted to the charging aperture of the mold or a charging duct of the mold; in that the charging container is movable along its guide non-pivotally in the direction of movement in such manner that it can be brought with its outlet aperture immediately above the charging aperture; and in that, for filling purposes, it is adapted to be lowered into the melting bath so that the outlet aperture in the bottom of the container serves also as an inlet aperture for the metal. Not only does this construction of apparatus for transporting metal to casting molds ensure completely satisfactory fully automatic operation together with an increased number of mold charging operations per unit of time, but also the molten metal is made to flow accurately into the charging aperture and deposition of layers of metal on the charging container or other spillage of the molten metal is obviated.

As a result of the provision of the outlet aperture in the bottom of the charging container, pivoting of the container for the pouring out of the metal is unnecessary. Complicated devices which would otherwise be required to pivot the container are rendered unnecessary. Another advantage of providing the outlet aperture in the bottom of the charging container arises from the fact that the molten metal flows from such aperture into the charging aperture in a closed stream, while in the case of pivoting ladles there is usually a turbulent flow of metal into the mold, and this results in the inclusion of air in the metal and hence the formation of cavities in castings made therefrom.

Furthermore, the apparatus according to the invention provides for simple automatic operation, the rigid mounting of the charging container on its guide ensuring an exact end position of the charging container above the charging aperture of the mold. The lowering of the charging container into the melting bath, which latter is open at the top, for the purpose of filling the said container is a contributory factor in providing for fully automatic transport of metal, without the need for conversion, where the invention is being applied to already existing melting baths and casting machines. It ensures, particularly simply and advantageously, filling of the charging container without it being necessary to equip the melting bath with any special device for the automatic control or operation of valves for outlet apertures.

Furthermore, the apparatus according to the invention has absolute machine freedom, i.e. it is completely independent and without any mechanical connection with the melting bath and the casting mold. Assembly and dismantling of the apparatus, for example for the purpose of servicing parts of a casting machine, are therefore unnecessary. If required, the apparatus according to the invention can also readily be replaced.

With the exception of the metal inlet/outlet aperture provided in the bottom of the charging container, such charging container is advantageously completely closed on all sides, i.e. including its top. The effect of this is that the molten metal in the metal bath does not flow

into the charging container from the surface of said metal bath, but only through the aperture provided at the bottom of the charging container. Thus, entry of slags and oxide layers floating on the surface of the metal melt into the charging container is minimised.

At least in its bottom region, the charging container preferably has a drop-shape, or is of globular shape, which ensures that the container may be immersed in and removed from the metal bath without any turbulent flow being produced in the melt and which prevents layers of metal from becoming deposited both on the inside and on the outside of the container wall.

Furthermore, a quantity-regulating device may be provided for regulating the amount of metal entering the charging container and such device may consist of an electrode which is fastened on the container so as to be adjustable vertically in relation thereto and which, by the making of contact in a control circuit by way of the metal bath, limits the depth to which the charging container is immersed. The quantity-regulating device may alternatively consist of a device for keeping the level of the bath constant, so that the depth of immersion into the bath can be kept at a constant value by constant depth of lowering of the charging container into the bath. To vary the depth of immersion, the amount by which the charging container is lowered into the bath may be variable appropriately. The adjustability of such quantity-regulating devices enables different quantities of metal to be charged into the mold, using one and the same charging container, only different fillings of the charging container being necessary for this purpose. Even in the case of casting molds having mold cavities of different sizes, it is not necessary to change the charging container.

The invention will be described further, by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a part-sectional side elevation showing an embodiment of the device according to the invention in relation to a melt bath and a casting machine,

FIG. 2 is a part-sectional elevation showing the charging container of the arrangement of FIG. 1 during pouring of the metal into a chill-mold,

FIG. 3 is an enlarged fragmentary cross-sectional view showing the charging container, and its associated mechanism, of the arrangement of FIG. 1, and

FIG. 4 is a cross-sectional end view taken on the line IV—IV of FIG. 3.

As will be apparent from FIGS. 1, 3 and 4 of the drawings, the embodiment illustrated comprises a pair of horizontal guide rails **1**, on which wheels **2** of a carriage **3** are guided. The carriage carries a first motor **4**, the shaft of which bears a gearwheel **5** which drives a pair of driving gearwheels **6** mounted on a horizontal shaft. Each of the two gearwheels **6** engages with a respective rack **7**, and the carriage **3** is moved along the guide rails **1** when the driving gearwheels **6** are driven by the motor **4**.

The carriage **3** also fixedly carries a guide tube **8** for a vertical carrier rod **9** which is mounted so as to be movable up and down in the guide tube **8** and on the bottom end of which a charging container **11** is fastened interchangeably by means of a connecting rod **10**. The guide tube **8** has a flange **12** by which it is fastened to the carriage **3** by means of screws **13** so as to be detachable. A second motor **14**, also mounted on the carriage **3**, serves for effecting the up and down movement of the vertical carrier rod **9** and drives a gearwheel **15** meshing with a row of teeth **16** arranged on the vertical carrier rod **9**. By appropriate rotation of the gearwheel **15** by the second motor **14**, the up and down movement of the vertical carrier rod **9** in the guide tube **8**, and hence of the charging container **11**, is obtained.

At its lower part, the charging container **11** has substantially the shape of a drop, that is to say it is globular-

shaped or domed, and, except for an aperture **17** provided at its lowest point, it is completely closed on all sides. This aperture **17** serves both for the entry of molten metal from a crucible or melting bath **18** into the charging container **11** and for the discharge of metal from said container into a mold to be charged. The aperture **17**, is therefore an inlet/outlet aperture. FIG. 1 of the drawings illustrates, in phantom, the pouring position of the charging container **11** above a charging aperture **19** of a feed pipe **20** of a mold **21** of a casting machine **22** which has been illustrated purely diagrammatically.

A valve rod **23** mounted pivotally on a pivoting lever **24** serves for the closing of the inlet/outlet aperture **17**. This pivoting lever **24**, which is pivoted on the top of the charging container **11**, can be so pivoted, by means of an operating rod **25** which is adapted to move up and down inside the hollow connecting rod **10** and the vertical carrier rod **9**, which is also hollow, as to ensure opening or closing of the aperture **17** by means of the valve rod **23**. The operating rod **25** is connected, at its top end, to a working piston **26** which is displaceable in a cylinder **27** fitted to the top end of the carrier rod **9**. Between the piston **26** and the top end of the carrier rod is a compression spring **28** which tends to hold the piston **26**, and hence the operating rod **25**, in the top end position. In this position, the aperture **17** of the charging container **11** is closed.

A compressed air conduit **29** leads into the cylinder **27** above the piston **26** and compressed air can be supplied through such conduit **29** to act on the top of the piston **26** to produce a downward movement of the piston in the cylinder **27** and of the operating rod **25** in the rods **9** and **10**. The aperture **17** of the charging container **11** is thus opened. If a three-way valve **30** is operated to discharge compressed air from the cylinder **27** to atmosphere, the spring **28** presses the piston **26** and the piston rod **25** upwards, so that the aperture **17** is closed again.

Another conduit **31** leads into the charging container **11**. This conduit **31** branches into two branch conduits **32** and **33**, of which the conduit **32** is connected to the compressed air conduit **29** and the conduit **33** is connected to a negative pressure or suction source **34**. By operation of a valve **35**, compressed air can be fed to the charging container **11** in order to assist emptying of the charging container **11** as required and to adapt the speed of exit of the metal to the absorption capacity of the mold.

It is also possible to produce a reduced or sub-atmospheric pressure in the charging container **11** by operation of a three-way valve **36**, which is also connected to atmosphere, disposed in the branch conduit **33**, this reduced pressure serving to ensure that during transportation of molten metal to the charging aperture **19** of the mold **21** no metal can escape from the container **11**, even if the closure of the aperture **17** by the valve rod **23** is incomplete, before such escape is desired. This reduced pressure may be set to any desired value by means of a regulating valve **49**, but is preferably set to a somewhat higher value than the pressure which can be exerted by the molten metal in the charging container **11** upon the cross-sectional area of the aperture **17**. The effect of this is that, even if the aperture **17** is incompletely closed by the valve rod **23**, the molten metal cannot escape from the charging container **11**. On the other hand, however, the reduced pressure in the container **11** should not be so high as to allow a relatively large amount of air to flow into the container **11**, since this would result in considerable cooling of the molten metal.

The solid-line arrows in FIG. 3 indicate the direction of pressure of the compresed air, while the broken-line arrows indicate the direction of the suction air.

A holder **37** for a rod-like sensing electrode **38** is fastened on the connecting rod **10** and is adjustable in an insulated part **39** on the holder **37** to different vertical positions with respect to the charging container **11**. This elec-

trode 38 extends in the vertical direction and is connected, by an electrical lead 40 to an electric control circuit (not shown in full) for switching the electric motor 14 on and off, the said circuit including a lead 41 to the electrically conductive molten metal 42 in the melting bath 18. The control circuit is so energised that, as the charging container 11 is lowered into the metal bath, it stops the second motor 14 as soon as the bottom end of the electrode 38 comes into contact with the surface of the metal 42, and hence closes the control circuit.

In this way, even if the level of the molten metal 42 varies, the charging container 11 is always filled with metal to a certain constant level. The depth of immersion of the charging container 11 and hence the amount by which the container 11 is filled can be varied as required by vertical adjustment of the electrode 38 on the charging container 11.

In order that the horizontal movement of the charging container 11 may be arrested in the required position exactly above the melting bath 18 or above the charging aperture 19 of the mold 21 or feed pipe 20, stops 43 are provided on the guide rails 1 for the carriage 3 and these cooperate with piston rods 44 of a brake cylinder 45 on the carriage 3. The horizontal movement of the carriage 3 can be braked slowly by means of this brake cylinder 45. To this end, compressed air conduits 46 lead into the brake cylinder 45 at both ends of the latter and these conduits 46 can be closed by valves 47. Thus, a certain pressure can be produced on one or other side of a braking piston 48 disposed in the cylinder 45 and carrying the piston rods 44 so that the rate of braking and the braking path can be exactly adjusted. It is thus possible to fix the end positions of the charging container 11 in such manner that in these positions respectively: the charging container 11 is properly disposed above the melting bath 18; and the charging container 11 is arrested when the aperture 17 is situated exactly above the charging aperture 19 of the mold 21.

The mode of operation of the appartus according to the invention will be described hereinbelow, it being assumed that the charging container 11 is initially situated in its end position and lowered into the metal 42 as shown in solid-lines in FIG. 1. In this end position, one piston rod 44 of the brake cylinder 45 bears against the right-hand stop 43. By appropriate operation of the three-way valve 30 compressed air is brought into the cylinder 27 and hence the aperture 17 is opened. Consequently, the metal 42 enters into the interior of the charging container 11 until the level of metal in the container 11 has risen to the height of the level of metal 42 outside the container 11. During filling of the charging container 11 the air contained therein can escape to atmosphere through the conduits 31 and 33, if the three-way valve 30 is in an appropriate position. The valve 30 is changed over so that the compressed air passes from the cylinder 27, whereupon the compression spring 28 relaxes and causes the aperture 17 to be closed by the lifting of the working piston 26. At the same time, a negative pressure or suction is produced in the charging container 11 by operation of the valve 36.

The second motor 14 is then put into operation so that the gearwheel 15 moves the vertical carrier rod 9, together with the connecting rod 10, upwards in the guide tube 8 and hence raises the charging container 11 out of the bath 18. When this has been done sufficiently, a switching operation serves to stop the second driving motor 14 and switches on the first driving motor 4 so that the carriage 3 is moved in the direction of the casting mold 21 by roation of the driving gearwheels 6. A cut-out (not shown) which is fastened on the guide tube 8 may serve to switch the second driving motor 14 off when the charging container has moved upwards sufficiently, the said cut-out being operable by a nosepiece (not shown) which is disposed on the carrier rod 9 or on the connecting rod 10, and ensuring that the motor 14 is put out of operation when the said nosepiece strikes against the cut-out.

When the carriage 3 with the charging container 11 reaches or has reached the required end position above the charging aperture 19 of the mold 21, the first driving motor 4 for the carriage 3 is put out of operation. By contact of the other piston rod 44 against the left-hand stop 43 provided at this end position, the movement of the carriage 3 is braked, so that the latter stops in exactly the position in which the charging container 11 is situated with its aperture 17 exactly above the charging aperture 19 of the mold 21. The charging container 11 can then be lowered towards the charging aperture 19 vertically, if necessary, by switching on the second motor 14. The inlet/outlet aperture 17 of the charging container 11 is then opened by operation of the three-way valve 30 and at the same time the charging container 11 is disconnected from the negative-pressure source 34 and is connected to the compressed-air conduit 29 so that compressed air is introduced into the container 11, this being effected by appropriate operation of the valves 35 and 36. By appropriate throttling of the compressed air by means of a regulating valve 50 in the branch conduit 32, the discharge of molten metal from the aperture 17 of the container 11 into the charging aperture 19 of the casting mold 21 can be controlled and effected within the required interval of time.

Emptying of the container 11 may be carried out in a completely closed stream of metal as a result of the charging container design according to the invention and the use of compressed air, so that air inclusions in the metal—which would result in the formation of cavities—are avoided.

After emptying, the container 11 is returned to its original position above the metal bath 18 by the motors 4 and 14, in which position the brake cylinder 45 brakes the horizontal movement of the carriage 3. The second motor 14 is then put into operation and the container 11 lowered into the metal melt 42, with the inlet aperture 17 open, until the bottom end of the electrode 38 meets the metal surface. At that moment, the second motor 14 is put out of operation and the downward movement of the charging container 11 is stopped. The cycle of operations just described is then repeated for filling a fresh mold.

The charging container 11 is advantageously not submerged to the bottom of the bath 18, so that if the molten metal is a light-metal alloy the charging container 11 does not become filled with metal incorporating iron-containing alloys which, as is well known, gravitate towards the bottom of the bath 18, as a result of their greater density.

Control of the movement of the charging container 11 and of the valves may be carried out fully automatically. To this end, the valves 34, 35, 36 may be electromagnetic valves which can be appropriately connected for fully automatic operation.

The apparatus according to the invention may advantageously be provided with a delay device which keeps the charging container 11 immersed in the metal melt for a certain period after the electrode 38 has come into contact with the molten metal, so that adequate heat exchange can take place between it and the metal melt. In this way, the wall of the container 11 can be brought to a temperature such that excessively rapid cooling of the metal disposed therein is prevented during its movement to the mold.

It is also advantageous, as in the exemplified embodiment illustrated, to dispose the pneumatic working cylinder 27 and the electromagnetic control elements as far away as possible from the charging container 11, for example in the region of the top end of the carrier rod 9, so as to avoid any harmful temperature influence on these sensitive elements on the lowering of the container 11 and during the period when the charging container 11 is in the metal bath 18, which latter may, for example, be at a temperature of about 600°.

Moreover, the provision of these operating elements at the top end of the carrier rod **9** ensures that the charging container **11** can be moved as close as may be necessary to the casting machine **22** so that its aperture **17** comes to lie exactly above the charging aperture **19**. This is particularly important in pressure casting machines. In such machines, in fact, the feed pipe inlet aperture is usually situated at a location such that said aperture can be reached only with difficulty. Moreover, with the apparatus according to the invention it is easily possible for the charging container **11** to be mounted eccentrically on the carrier rod **9** and arranged so as to pivot in the horizontal plane about said carrier rod **9** or about the axis of its mounting on the carriage, in such manner that the outlet aperture **17** of the charging container **21** can be adjusted to lie exactly above the charging aperture **19** of the casting machine **22**, as shown diagrammatically in FIG. 1, with the most diverse types of casting machines.

The apparatus according to the invention may also be used in cases in which a plurality of molds have to be filled successively. It is also possible to use a plurality of these devices simultaneously in conjunction with a single melt bath.

I claim:

1. An apparatus for transporting molten metal from an open-topped melting bath to a mold charging aperture horizontally spaced from said bath a predetermined distance, said apparatus comprising, in combination:

(*a*) elongated stationary guide means adapted to extend from a first location adjacent the open top of said melting bath over said distance to a second location adjacent said mold charging aperture;

(*b*) a carriage mounted on said guide means for movement thereon between said two locations in said direction;

(*c*) rigid carrier means slidably guided on said carriage for vertical movement in a fixed path relative to said carriage;

(*d*) moving means on said carriage for vertically moving said carrier means in said path;

(*e*) a charging container rigidly mounted on said carrier means, said container having a bottom portion and being formed with an outlet aperture in said bottom portion thereof; and

(*f*) closing means for selectively closing said outlet aperture.

2. An apparatus as set forth in claim 1, wherein said carriage fixedly supports a tubular guide member having a vertically extending axis, said carrier means includes a rod member axially slidable in said tubular member and fixedly fastened to said container, said moving means being adapted to move said members relative to each other in an axial direction.

3. An apparatus as set forth in claim 1, wherein said moving means include a motor mounted on said carriage and gear wheel means driven by said motor, and said carrier means has a plurality of vertically spaced teeth meshingly engaging said gear wheel means.

4. An apparatus as set forth in claim 1, further comprising a rack on said guide means, said rack being elongated in a direction from said first to said second location, a motor on said carriage, a gear wheel on said carriage and driven by said motor, said gear wheel engaging said rack for actuating movement of said carriage between said locations.

5. An apparatus as set forth in claim 1, further comprising drive means for moving said carriage from one of said locations toward the other location, and brake means for arresting movement of said carriage at said other location.

6. An apparatus for transporting molten metal from an open-topped melting bath to a mold charging aperture horizontally spaced from said bath a predetermined distance, said apparatus comprising, in combination:

(*a*) elongated stationary guide means adapted to extend from a first location adjacent the open top of said melting bath over said distance to a second location adjacent said mold charging aperture;

(*b*) a carriage mounted on said guide means for movement between said two locations in said directions;

(*c*) carriare means rigidly mounted on said carriage for vertical movement;

(*d*) moving means on said carriage for vertically moving said carrier means;

(*e*) a charging container rigidly mounted on said carrier means, said container having a bottom portion and being formed with an outlet aperture in said bottom portion thereof;

(*f*) closing means for selectively closing said outlet aperture;

(*g*) drive means for moving said carriage from one of said locations toward the other location; and

(*h*) brake means for arresting movement of said carriage at said other location, said brake means including

(1) a stop on said guide means,

(2) a brake cylinder on said carriage, and

(3) a brake piston slidable in said brake cylinder and abuttingly engageable with said stop when said carriage reaches said other location.

7. An apparatus for transporting molten metal from an open-topped melting bath to a mold charging aperture horizontally spaced from said bath a predetermined distance, said apparatus comprising, in combination:

(*a*) elongated stationary guide means adapted to extend from a first location adjacent the open top of said melting bath over said distance to a second location adjacent said mold charging aperture;

(*b*) a carriage mounted on said guide means for movement thereon between said two locations in said direction;

(*c*) rigid carrier means slidably guided on said carriage for vertical movement in a fixed path relative to said carriage;

(*d*) moving means on said carriage for vertically moving said carrier means in said path, said moving means including an electric motor;

(*e*) a charging container rigidly mounted on said carrier means, said container having a bottom portion, and being formed with an outlet aperture in said bottom portion thereof;

(*f*) closing means for selectively closing said outlet aperture;

(*g*) sensing contact means on said carrier means for sensing the level of molten metal in said melting bath; and

(*h*) conductor means attached to said sensing means for connecting said sensing means to said electric motor.

8. An apparatus for transporting molten metal from an open-topped melting bath to a mold charging aperture horizontally spaced from said bath a predetermined distance, said apparatus comprising, in combination:

(*a*) elongated stationary guide means adapted to extend from a first location adjacent the open top of said melting bath over said distance to a second location adjacent said mold charging aperture;

(*b*) a carriage mounted on said guide means for movement thereon between said two locations in said direction;

(*c*) rigid carrier means slidably guided on said carriage for vertical movement in a fixed path relative to said carriage;

(*d*) moving means on said carriage for vertically moving said carrier means in said path;

(*e*) a charging container rigidly mounted on said carrier means, said container having a substantially closed top and a bottom portion, and being formed with an outlet aperture in said bottom portion thereof;

(*f*) closing means for selectively closing said outlet aperture; and

(*g*) means for controlling gas pressure within said container.

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