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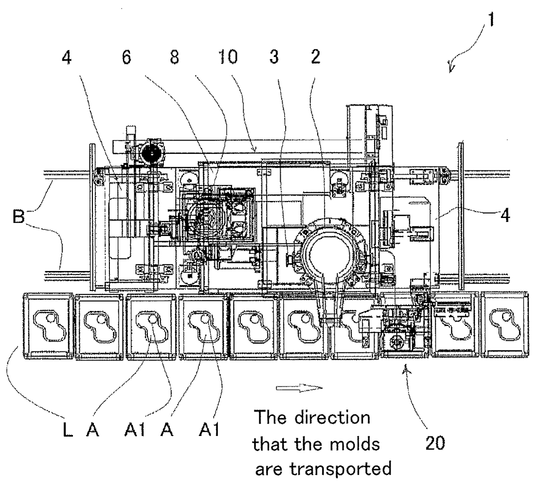
(54) AUTOMATIC MOLTEN METAL POURING DEVICE WITH PRESSURIZING FUNCTION, AND AUTOMATIC MOLTEN METAL POURING METHOD WITH PRESSURIZING FUNCTION

(57) To provide a machine and method for efficiently pouring and definitely filling only a desired cavity with molten metal to cause the molten metal to solidify there. The automatic pouring machine (1) that has an ability to pressurize having a ladle (2) for pouring molten metal into a mold (A) comprises a pouring unit (10) that can move a ladle in the direction parallel to, and in the direction perpendicular to, a line (L) of molds where a plurality of molds are transported and a unit (20) for pressurizing the molten metal that is supported by the pouring unit and that supplies pressurized gas and a granular material to the mold into which molten metal has been poured. The unit (20) supplies the pressurized gas and the granular material to the mold that is next to the mold into which the pouring unit pours molten metal.

Fig. 1



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Description

Technical Field

[0001] The present invention relates to a pouring machine and a method for pouring that are used in a foundry. Specifically, it relates to a pouring machine and method that have the ability to pressurize molten metal in a mold.

Background Art

[0002] In a foundry, molten metal that has melted in a melting furnace and that is at a high temperature is poured into a mold in an area for pouring, to thereby cast a product. When molten metal is poured into a mold, it is poured into the upper end of a pouring cup in consideration of shrinkage during solidification in the mold. After cooling the mold, the mold is shaken out. Then the sprue, the runner, and the riser, which are some of the parts other than the product, are separated from the product so as to be again melted, for return scrap. Among these parts, though the riser is needed during solidification to ensure the soundness of the product, the runner and the sprue are needed only for filling molten metal into a cavity during pouring.

[0003] Conventionally, a casting method has been proposed to fill molten metal only into a desired cavity among the cavities and to solidify it. For example, by a method disclosed in Japanese Patent No. 4150764 pressurized gas is supplied through the sprue to fill molten metal into a desired cavity to cause it to solidify there. Thus the pressure of the gas needs to be maintained until the molten metal solidifies. Further, since the molten metal is confined there by means of pressurized gas, the time to solidify is long and inefficient. By the method disclosed in Japanese Patent Laid-open Publication No. 2010-269345, after pouring molten metal at the same volume as that of a desired cavity, the filling material is supplied to the cavity through the sprue before the cavity is filled with the molten metal, so that the cavities other than the desired cavity are filled with the filling material. However, depending on the arrangement of the cavities or the shapes of the runner and the sprue, heat is transferred to the filling material so that the temperature on the surface of the molten metal becomes low. Then the molten metal may solidify before the desired cavity is filled with it. The resistance to feed the filling material to the cavities may increase. Thus, there are some cases where a desired filling of the molten metal is difficult.

[0004] The present invention aims to provide a machine and method for efficiently pouring and definitely filling only a desired cavity with molten metal among cavities to cause the molten metal to solidify there.

Disclosure of Invention

[0005] An automatic pouring machine 1 that has an ability to pressurize of the present invention comprises, for example, as in Figs. 1, 2, 5, and 6, a pouring unit 10 that has a ladle 2 for pouring molten metal into a mold A and that can be transported along a line L of molds where a plurality of molds A are transported. It also comprises a unit 20 for pressurizing the molten metal that is supported by the pouring unit 10 and that supplies pressurized gas and a granular material to the mold A into which molten metal has been poured from the pouring unit 10. The unit 20 for pressurizing the molten metal has a hopper 22 that stores the granular material and a mouth 26 that connects with a sprue A1 of the mold A that is filled with the molten metal, which mouth 26 feeds the pressurized gas and the granular material to the mold A. It also has a regulating chamber 24 that regulates an amount of the granular material to be supplied from the hopper 22 to the mouth 26. It also has a piping 28 that introduces the pressurized gas to the regulating chamber 24 and a piping 30 that connects with the mouth 26 to introduce the pressurized gas. The unit 20 for pressurizing the molten metal supplies the pressurized gas and the granular material to the mold A(2) among the plurality of molds A that is located next to the mold A(1) into which the pouring unit 10 pours the molten metal. Incidentally, the molds A are individually indicated by a number in parentheses, such as A(1), A(2), ... (see Fig. 6).

[0006] By the above configuration, pressurized gas and a granular material are supplied from the unit for pressurizing the molten metal to a mold into which molten metal has been poured from the pouring unit. Since the pressurized gas is supplied, the molten metal is squeezed into the desired cavity. Since the predetermined amount of the granular material is supplied, the molten metal that has been squeezed into the cavity is plugged. Then heat is transferred to the granular material so that the molten metal at the entrance to the cavity is cooled and solidifies. Thus the automatic pouring machine can efficiently pour molten metal into a mold and definitely fill only a desired cavity among cavities with molten metal so that the molten metal solidifies there. Since the unit for pressurizing the molten metal supplies the pressurized gas and the granular material to the mold that is located next to the mold among the plurality of molds that is poured by the pouring unit, the unit for pressurizing the molten metal can supply the pressurized gas and the granular material immediately after the pouring unit pours the molten metal into the mold.

[0007] In the above-mentioned automatic pouring machine 1 that has the ability to pressurize, for example, as in Fig. 4, the unit 20 for pressurizing the molten metal may be configured to move the mouth 26 in the direction that is parallel to, and in the direction that is perpendicular to, the line L of molds where a plurality of molds A are transported. By the above configuration, if the pouring unit moves to be aligned with a new position of the sprue when the position of the sprue is changed, quickly and easily the mouth can be hermetically connected with the sprue of the mold.

[0008] The above-mentioned automatic pouring machine 1 that has the ability to pressurize, for example, as in Fig. 2, further comprises a position sensor 50 that detects a position of the sprue A1 of the mold A so as to move the mouth 26 to the position of the sprue A1. By the above configuration, since the position of the sprue is detected by means of the position sensor to move the unit for pressurizing the molten metal, the mouth can be rapidly and easily moved to the position of the sprue of the mold to be hermetically connected with it.

[0009] In the above-mentioned automatic pouring machine 1 that has the ability to pressurize, for example, as in Figs. 1 and 2, the pouring unit 10 may have a traversing carriage 4 that moves parallel to the line L of molds. It also has a carriage for moving back and forth 6 that moves perpendicularly to the line L of molds on the traversing carriage 4. The unit 20 for pressurizing the molten metal may be supported by the traversing carriage 4. By the above configuration, since the distance between the position for pouring and the position of the mouth is maintained to be equal to the length of a mold when the position to pour molten metal from the ladle into the mold changes along the line of molds, pouring by the pouring unit and supplying the pressurized gas and the granular material by the unit for pressurizing the molten metal can be simultaneously carried out. Further, when a long time is needed for pouring, the molds are transported while the pouring continues. Even in this case, supplying the pressurized gas and the granular material can be continued because the unit for pressurizing the molten metal moves together with the pouring unit.

[0010] In the above-mentioned automatic pouring machine 1 that has the ability to pressurize, the granular material may be dry silica sand. It has a high fluidity, and so is supplied to a mold so that the runner hardly clogs with it. Further, it hardly deteriorates even when contacting hot molten metal. It is cheap and easy to obtain. Thus the automatic pouring machine is easy to use.

[0011] In a method for automatically pouring that has an ability to pressurize of the present invention, for example, as in Figs. 1, 2, 5, and 6, molten metal is poured from a ladle 2 that is transported along a line L of molds where a plurality of molds A are transported, and pressurized gas and a predetermined amount of a granular material are supplied from a unit 20 for pressurizing the molten metal to the mold A that is filled with the molten metal. The unit 20 has a hopper 22 that stores the granular material. It also has a mouth 26 that hermetically connects with the sprue A1 of the mold A that is filled with the molten metal and which mouth feeds the pressurized gas and the granular material to the mold A. It also has a regulating chamber 24 that regulates an amount of the granular material to be supplied from the hopper 22 to the mouth 26. It also has a first piping 28 that introduces the pressurized gas to the regulating chamber 24 and a second piping 30 that connects with the mouth 26 to introduce the pressurized gas. It is configured to move along the line L of molds together with the ladle 2. The method comprises a step of moving the ladle 2 so that molten metal can be poured into the sprue A1 of a first mold A(1) on the line L of molds where a plurality of molds A are transported. It also comprises a step of pouring molten metal from the ladle 2 to the first mold A(1). It also comprises a step of hermetically connecting the mouth 26 to the sprue A1 of a second mold A(2) that is located next to the first mold A(1) and that is filled with molten metal. It also comprises a step of supplying pressurized gas from the second piping 30 to the second mold A(2) through the mouth 26. It also comprises a step of regulating a predetermined amount of the granular material by the regulating chamber 24, which granular material has been stored in the hopper 22. It also comprises a step of supplying the regulated granular material to the second mold A(2) through the mouth 26 by supplying the pressurized gas from the first piping 28 to the regulating chamber 24.

[0012] By the above configuration, the pressurized gas and the predetermined amount of the granular material are supplied from the unit for pressurizing the molten metal to a mold into which molten metal has been poured from a ladle. Since the pressurized gas is supplied to the mold, the molten metal is squeezed into a desired cavity. Since the predetermined amount of the granular material is supplied to the mold, the molten metal that has been squeezed into the cavity is plugged. Since the heat is transferred to the granular material, the molten metal at the entrance to the cavity is cooled, and it solidifies. Thus the method for automatically pouring can efficiently pour molten metal into a mold and definitely fill only the desired cavity, among the cavities, with molten metal so that the molten metal solidifies there.

[0013] The above-mentioned method for automatically pouring that has the ability to pressurize, for example, as in Fig. 2, may further comprise a step of detecting a position of the sprue A1 of the second mold A(2) by means of a position sensor 50 and a step of moving the mouth 26 based on the detected position. By the above configuration, the mouth is quickly and accurately moved to the position of the sprue of the mold based on the detected position by the sensor, to be hermetically connected to the sprue.

[0014] In the above-mentioned method for automatically pouring that has the ability to pressurize, a time when pouring molten metal into the first mold A(1) is completed may coincide with a time when supplying the pressurized gas and the granular material to the second mold A(2) is completed. Further, the times may coincide with a time when the plurality of molds A on the line L of molds start to be transported. By the above configuration, immediately after a mold into which molten metal was just poured from a ladle is transported, the pressurized gas and the granular material can be supplied from the unit for pressurizing the molten metal. Thus the molten metal in the mold is squeezed into the desired cavity before it solidifies. Thus the method for automatically pouring enables only the desired cavity to be definitely filled with the molten metal, so that the molten metal solidifies there.

[0015] In the above-mentioned method for automatically pouring that has the ability to pressurize, if a position of the sprue A1 of the first mold A(1) is changed from a position of the sprue A1 of the second mold A(2), the ladle 2 may be moved so as to pour molten metal into the sprue A1 of the first mold A(1). Then in the unit 20 for pressurizing the molten metal that has been moved together with the ladle 2 the mouth 26 may be moved so as to be hermetically connected with the sprue A1 of the second mold A(2). By the above configuration even when the pouring unit is moved so that molten metal can be poured from the ladle into the sprue, the distance between the pouring unit and the unit for pressurizing the molten metal is maintained to be equal to the length of a mold. Then, if needed, the mouth may be moved to the position of the sprue. Thus the movement of the mouth can be suppressed to be small and the mouth can be quickly moved to the position of the sprue.

[0016] In the above-mentioned method for automatically pouring that has the ability to pressurize, the granular material may be dry silica sand. If so, it has a high fluidity, and so is supplied to a mold so that the runner hardly clogs with it. Further, it hardly deteriorates even when contacting hot molten metal. It is cheap and easy to obtain. Thus the method for automatically pouring is easy to use.

Brief Description of the Drawings

[0017]

[Fig. 1]
Fig. 1 shows a plan view of the automatic pouring machine that has the ability to pressurize, as an embodiment of the present invention.

[Fig. 2]
Fig. 2 shows a front view of the automatic pouring machine that has the ability to pressurize, as an embodiment of the present invention.

[Fig. 3]
Fig. 3 shows a plan view of an embodiment of the unit for pressurizing the molten metal.

[Fig. 4]
Fig. 4 shows a side view of an embodiment of the unit for pressurizing the molten metal.

[Fig. 5]
Fig. 5 shows a diagram of a system for pressurization of an embodiment of the unit for pressurizing the molten metal.

[Fig. 6]
Fig. 6 shows a plan view of an embodiment of the automatic pouring machine that has the ability to pressurize at the step of pouring.

[Fig. 7]
Fig. 7 shows a side view of an embodiment of the automatic pouring machine that has the ability to pressurize at the step of pressurizing.

[Fig. 8]
Fig. 8 shows a side view of an embodiment of the automatic pouring machine that has the ability to pressurize that has returned to the original position after pressurizing.

Mode for Carrying Out the Invention

[0018] Below, an automatic pouring machine equipped with a unit for pressurizing the molten metal, which machine is an embodiment of the present invention, is discussed with reference to the drawings. Fig. 1 shows a plan view of the automatic pouring machine 1, which is an embodiment of the present invention. It is equipped with the unit 20 for pressurizing the molten metal. As in Fig. 1, the automatic pouring machine 1 is configured to move on a rail B that is disposed to be parallel to the line L of molds on which the molds are transported.

[0019] Fig. 2 is a front schematic view of the automatic pouring machine 1 as in Fig. 1. As in Fig. 2, a traversing carriage 4 is placed on the rail B so that it runs on it. The rail B is placed on the floor. A carriage for moving back and forth 6 is placed on the traversing carriage 4 so as to move perpendicularly to the rail B. Specifically, a rail (not shown) is placed on the upper plane of the traversing carriage 4 in the direction that is perpendicular to the rail B. The carriage for moving back and forth 6 runs on that rail. A device 8 for vertically moving the ladle is disposed on the carriage for moving back and forth 6. The device 8 for vertically moving the ladle 2 moves a device 3 for tilting the ladle. The device 3 for tilting the ladle tilts the ladle 2 that stores molten metal. Thus, the ladle 2 can be moved in three dimensions. The device 3 for tilting the ladle tilts the ladle 2 so as to pour the molten metal in the ladle 2 into the mold A.

[0020] The unit 20 for pressurizing the molten metal is disposed on the traversing carriage 4 of the automatic pouring machine 1. On the traversing carriage 4, the unit 20 for pressurizing the molten metal is located at a position so as to supply pressurized gas or a granular material to a mold A(2) on the line L of molds that is located downstream of, and next to, a mold A(1) into which molten metal is poured from the ladle 2 by means of the automatic pouring machine 1. By disposing the unit 20 for pressurizing the molten metal on the traversing carriage 4 as discussed above, the unit 20 for pressurizing the molten metal can be easily installed in an existing pouring machine. Further, it does not interrupt the movement of the pouring unit 10.

[0021] Fig. 3 is a plan view that shows only the unit 20 for pressurizing the molten metal in the automatic pouring machine 1 that is disposed along the line L of molds. Fig. 4 is a schematic side view of the automatic pouring machine 1, which is seen from the side of the unit 20 for pressurizing the molten metal. In the unit 20 for pressurizing the molten metal, a supporting structure 12 is disposed on the traversing carriage 4. The upper part of the supporting structure 12 is structured by beams. Each of them has an axial direction that is perpendicular to the line L of molds. On the supporting structure 12, a device 14 for moving the unit for pressurizing the molten metal back and forth is provided so as to move in the direction that is perpendicular to the line L of molds. On the device 14, a device 16 for traversing the unit for pressurizing the molten metal is provided so as to move in parallel to the line L of molds. On the device 16, a device 18 for vertically moving the unit for pressurizing the molten metal is provided.

[0022] The devices for supplying the pressurized gas and the granular material from the unit 20 for pressurizing the molten metal to the mold A are supported by the device 18 for vertically moving the unit for pressurizing the molten metal so as to move in three dimensions. The unit 20 for pressurizing the molten metal has a hopper 22 that stores the granular material. It also has a mouth 26 that is hermetically connected to the sprue A1 of the mold A into which the molten metal has been poured, so as to feed the pressurized gas and the granular material to the mold A. It also has a piping 44 that connects the hopper 22 with the mouth 26. Further, as in Fig. 5, the unit 20 for pressurizing the molten metal has on the piping 44 a regulating chamber 24 that regulates the amount of the granular material to be supplied from the hopper 22 to the mouth 26, and a first ball valve 32 and a second ball valve 34 that act as on-off valves. Further, it has a second piping 30 that is connected to the mouth 26 to introduce the pressurized gas. It also has a first piping 28 that introduces the pressurized gas into the regulating chamber 24. The first piping 28 is equipped with a first on-off valve 36 that starts and stops the supply of the pressurized gas to the regulating chamber 24. The second piping 30 is equipped with a second on-off valve 38 that starts and stops the supply of the pressurized gas to the mouth 26. The second piping 30 is also equipped with a flow control valve 40 that controls the flow of the pressurized gas to be supplied. The mouth 26 is equipped with a pressure sensor 42 that measures the pressure of the pressurized gas so as to supply the pressurized gas to the mold A. The hopper 22, the piping 44, the regulating chamber 24, and the mouth 26 constitute the pressurizing device 46 that supplies the pressurized gas and the pressurized granular material to the mold A. Incidentally, the wording "the second piping 30 is connected to the mouth 26 to introduce the pressurized gas" means not only the case where the second piping 30 is directly connected to the mouth 26, but also the case where the second piping 30 is connected to the piping 44 to be indirectly connected to the mouth 26.

[0023] As in Fig. 4, the unit 20 for pressurizing the molten metal has also a member 48 for constraining the mold, which member constrains the mold A not to misalign while the pressurized gas or the granular material is supplied by the unit 20 for pressurizing the molten metal. The member 48 for constraining the mold has an air cylinder, and a constraining plate (not shown) that is attached to the air cylinder. It presses the mold A by means of the constraining plate to fix the mold A during the operation of the unit 20 for pressurizing the molten metal. Since the mold A is not misaligned, the mouth 26 is facilitated to be hermetically connected with the sprue A1. Incidentally, besides an air cylinder, the constraining plate may be pressed by any other known means.

[0024] Any of the traversing carriage 4, the carriage for moving back and forth 6, the device 8 for vertically moving the ladle, the device 14 for moving the unit for pressurizing the molten metal back and forth, the device 16 for traversing the unit for pressurizing the molten metal, and the device 18 for vertically moving the unit for pressurizing the molten metal, is preferably moved by a servomotor, since it can thus be definitely moved to an accurate position. However, any known means other than a servomotor may be used to move any of them.

[0025] Next, with reference to Figs. 6, 7, and 8, the operation of the automatic pouring machine 1, which has the above-mentioned configuration, is discussed. A plurality of molds A line up on the line L of molds. The ladle 2 of the pouring unit 10 is filled with molten metal that is poured from a melting furnace, and so on. First, the filled ladle 2 is moved by means of the traversing carriage 4 and the carriage for moving back and forth 6 to a horizontal position to pour the molten metal into the mold A on the line L of molds. After molten metal is once poured from the ladle 2 into the mold A, it can be poured into the sprue A1 of any mold A that has the sprue A1 at the same position, without moving the ladle 2, by means of the traversing carriage 4 or the carriage for moving back and forth 6. When pouring the molten metal into a mold A that has the sprue A1 at the same position, pouring molten metal starts at a predetermined time after the mold A is transported on the line L of molds by a distance that is equal to the length of the mold A. The predetermined time may be 0 sec. When the position of the sprue A1 changes, the ladle 2 is moved by means of the traversing carriage 4 and the carriage for moving back and forth 6 to the position for pouring molten metal, based on the position of the sprue A1 that is detected by the position sensor 50. If the direction to pour molten metal changes because of any deterioration of the nozzle of the ladle 2 for pouring molten metal, the ladle 2 is moved by means of the traversing carriage 4 and the carriage for moving back and forth 6, even when no position of the sprue A1 changes, so as to accurately pour molten metal into the sprue A1.

[0026] The ladle 2 is elevated by means of the device 8 for vertically moving the ladle and tilted by means of the device 3 for tilting the ladle to start pouring molten metal into the sprue A1 of an empty mold A. The amount of molten metal that has been poured is measured by a device for weighing, which is not shown. When a predetermined amount of molten metal has been measured and then poured, the pouring operation is completed. Incidentally, to increase the accuracy of the amount to be poured, the flow of molten metal is preferably decreased before the predetermined amount of molten metal has been poured (the tilting angle is gradually decreased) so that the pouring operation is stopped just when the predetermined amount has been poured. Incidentally, the predetermined amount of molten metal is an amount of molten metal that is required to cast a product, i.e., a product that is cast by the mold A. It is an amount of molten metal that is equal to the volume of a desired cavity plus the volume that will be caused by shrinkage plus an allowance. When the predetermined amount of molten metal has been poured, a part of the molten metal may remain in the runner so that a space exists in an upper part of the desired cavity.

[0027] At the same time the molten metal is poured into the empty ladle A, by the unit 20 for pressurizing the molten metal the pressurized gas and the granular material are supplied to the mold A(2) into which the molten metal has been poured. The position of the mold A(2) is detected by means of the position sensor 50. The mouth 26 is moved to a position right above the sprue A1 by means of the device 14 for moving the unit for pressurizing the molten metal back and forth and the device 16 for traversing the unit for pressurizing the molten metal. After the pressurized gas and the granular material are once supplied, it can be supplied to the sprue A1 of any mold A that has the sprue A1 at the same position, without moving the mouth 26 by means of the device 14 for moving the unit for pressurizing the molten metal back and forth or by means of the device 16 for traversing the unit for pressurizing the molten metal. When supplying the pressurized gas and the granular material to the mold A that has the sprue A1 at the same position, supplying them starts at a predetermined time after a mold A is transported on the line L of molds by the distance that is equal to the length of the mold A. The predetermined time may be 0 sec. When the position of the sprue A1 changes, the mouth 26 is moved again to a position right above the sprue A1. In this case, to align the position of the ladle 2 of the pouring unit 10, which position is upstream of the unit 20 for pressurizing the molten metal, with the position of the sprue A1, the traversing carriage 4 and the carriage for moving back and forth 6 may move. Thus the unit 20 for pressurizing the molten metal may move before supplying the pressurized gas and the granular material to the mold A that has the sprue A1 at the same position. Since the position of the sprue is detected by means of the position sensor 50, the position of the mouth 26 can be quickly and accurately aligned with the position of the sprue A1. If the position of the ladle 2 for pouring is moved by moving the pouring unit 10, even if no position of the sprue A1 changes, the mouth 26 is moved right above the sprue A1 based on the position of the sprue A1 that is detected by the position sensor 50.

[0028] As in Fig. 7, the pressurizing device 46, i.e., the mouth 26, is lowered by means of the device 18 for vertically moving the unit for pressurizing the molten metal. When the force of the device 18 for vertically moving the unit for pressurizing the molten metal to lower the mouth 26, for example, the torque of the servomotor, reaches a predetermined value, the lowering operation is completed. Namely, the pressing force between the mouth 26 and the sprue A1 is caused to be equal to the predetermined value. So, the mouth 26 contacts the sprue A1 at an appropriate force. Thus the mouth 26 hermetically contacts the sprue A1. Further, neither the mold A nor the mouth 26 should be damaged. Incidentally, a load sensor, such as a load cell, which does not measure the force of the device 18 for vertically moving the unit for pressurizing the molten metal to lower the mouth 26, may be used to measure the force of the mouth 26 to press the mold A to complete the lowering operation. The member 48 for constraining the mold lowers the constraining plate to fix the mold A(2).

[0029] When the mouth 26 covers the sprue A1 to hermetically connect with the sprue A1 of the mold A(2), the second on-off valve 38 is opened to supply the pressurized gas from the second piping 30 into the mold A(2) via the mouth 26. Further, the first on-off valve 36 is opened to introduce the pressurized gas from the first piping 28 to the regulating chamber 24. Thus the granular material in the regulating chamber 24 is supplied to the mold A(2) via the mouth 26. The molten metal in the mold A(2) is squeezed into the desired cavity by means of the pressurized gas and the granular material.

[0030] Now, a method for pressurizing the mold A by using the pressurizing device 46 as in Fig. 5 is discussed. When the mouth 26 is to be connected with the mold A, the first ball valve 32, the second ball valve 34, the first on-off valve 36, and the second on-off valve 38, are all closed. When the mouth 26 has been completely lowered, the second on-off valve 38 is opened. While the flow control valve 40 is controlled to cause the detection by the pressure sensor 42 to be equal to a predetermined pressure, the pressurized gas is supplied by the second piping 30 to the mold A. The predetermined pressure is a pressure by which molten metal is squeezed into the cavity. This pressure is maintained for a predetermined period of time. Thus air that remains in the upper part of the cavity flows out of the cavity because of the permeability of the sand mold, so that the cavity is filled with the molten metal.

[0031] Next, a method for blowing the granular material into the mold A is discussed. First, a predetermined amount of the granular material is stored in the regulating chamber 24 for the granular material. After the mouth 26 is completely lowered, the second ball valve 34 and the first on-off valve 36 are opened to feed the pressurized gas from the first piping 28. Since in this way the pressurized gas and the granular material are fed, the granular material accumulates at the end of the runner, to become a plug.

[0032] After the predetermined period of time passes, the end part of the molten metal, which contacts the granular material, starts to solidify. Then the second ball valve 34, the first on-off valve 36, and the second on-off valve 38, are closed. The unit 20 for pressurizing the molten metal is elevated so that the mouth 26 is separated from the mold A as in Fig. 8. At the same time, the constraining plate of the member 48 for constraining the mold is elevated.

[0033] After the second ball valve 34 is closed, the first ball valve 32 is opened so that the granular material in the hopper 22 is introduced into the regulating chamber 24. After a predetermined period of time passes, the first ball valve 32 is closed so that a predetermined amount of the granular material are stored in the regulating chamber 24. Since the granular material is introduced from the hopper 22 to the regulating chamber 24 over a predetermined period of time, the predetermined amount of the granular material is regulated. The amount of the granular material that is stored in the regulating chamber 24, i.e., the combined weight of them, may be measured so that the first ball valve 32 is closed when the amount becomes equal to the predetermined amount. The predetermined amount of the granular material is an amount of the granular material in the runner that prevents the molten metal that has been squeezed into the desired cavity from flowing back to the runner.

[0034] After pouring the molten metal and supplying the pressurized gas and the granular material are completed, the molds A on the line L of molds are transported for the distance that is equal to the length of the molds A. Namely, as in Fig. 6, the mold A(2), which is located in front of the pouring unit 10, is transported to the position in front of the unit 20 for pressurizing the molten metal and a new and empty mold A(1) is transported to the position in front of the pouring unit 10. In the pouring unit 10, molten metal is poured from the ladle 2 into the empty mold A(1). In the unit 20 for pressurizing the molten metal the pressurized gas and the granular material are supplied to the mold A(2) into which molten metal has just been poured by means of the pouring unit 10.

[0035] In the automatic pouring machine 1 the pressurized gas and the granular material are preferably supplied by means of the unit 20 for pressurizing the molten metal immediately after molten metal is poured into the mold A by means of the pouring unit 10. Before the molten metal that has been poured into the mold A starts to solidify, it is squeezed into the desired cavity by means of the pressurized gas and the granular material. If supplying the pressurized gas and the granular material by means of the unit 20 for pressurizing the molten metal takes longer than pouring molten metal by means of the pouring unit 10, the time when pouring molten metal into the first mold A(1) by the pouring unit 10 is completed is controlled to coincide with the time when supplying the pressurized gas and the granular material to the second mold A(2) by the unit 20 is completed, and the time when the plurality of molds A on the line L of molds start to be transported is controlled to coincide with these times. Here the wording "the time ... is controlled to coincide with" includes the case where the times do not coincide with each other because of a lag between the devices, and the case where they do not do so as to allow for the initiation of the operation of the respective units 10, 20 or the operation of the line L of molds.

[0036] The pressurized gas that is used by the automatic pouring machine 1 is typically air, but is not limited to air. The granular material that is used by the automatic pouring machine 1 is preferably heat-resistant granular material, such as refractory granular material, or sand, or steel balls, but are not limited to those items.

[0037] As discussed above, immediately after molten metal is poured into the mold A the mouth 26 is hermetically connected with the sprue A1 so as to pressurize the mold A by means of the pressurized gas and to supply the granular material to it. Thus the molten metal is squeezed into the desired cavity before it starts to solidify.

[0038] After the cavity is filled with the molten metal the granular material that has been put into the runner functions as a plug. Thus the molten metal is prevented from flowing back to the runner, etc. Thus the cavity can be quickly and definitely filled with molten metal. Since the granular material functions as a plug, the molten metal is prevented from flowing back. Thus a cast product, after being shaken out, has no part that corresponds to the runner or the sprue.

[0039] Further, the mold in which the granular material functions as a plug is transported from the unit 20 for pressurizing the molten metal, i.e., the automatic pouring machine 1, to cause the molten metal to solidify. That is, the automatic pouring machine 1 can promptly handle the next mold A. Thus the efficiency is good.

[0040] Further, the molten metal that has been poured is squeezed into the cavity by means of the unit 20 for pressurizing the molten metal, which unit 20 is separated from the pouring unit 10. Thus pouring molten metal by means of the pouring unit 10 and supplying the pressurized gas and the granular material by means of the unit 20 can be simultaneously carried out. That is, the casting operation can be efficient.

[0041] Since pressurizing by means of the pressurized gas and supplying the granular material is simultaneously carried out, both the power of pressurizing and the power of supplying the granular material are used to squeeze the molten metal into the cavity. Thus the molten metal can be quickly and definitely squeezed into the cavity. When pressurizing by means of the pressurized gas is carried out before supplying the granular material, the molten metal is prevented from being cooled by the granular material. Thus, the molten metal is not cooled by the granular material. Since the molten metal is prevented from solidifying because of being cooled, it is quickly and easily squeezed into the cavity.

[0042] In the automatic pouring machine 1 the unit 20 for pressurizing the molten metal is located so as to supply the pressurized gas and the granular material to the mold A(2) that is downstream of, and next to, the mold A(1) into which molten metal is poured from the ladle 2 of the pouring unit 10 on the line L of molds. Thus the unit for pressurizing the molten metal is easily added to an existing pouring unit so that the existing one is converted to an automatic pouring machine that has the ability to pressurize. Further, the unit 20 for pressurizing the molten metal supplies the pressurized gas and the granular material to the mold A(2) that is next to the mold A(1) into which molten metal is poured. Thus the pressurized gas and the granular material are supplied immediately after molten metal is poured into the mold A(2) by means of the pouring unit 10. Thus the molten metal in the mold A(2) can be squeezed into the desired cavity before it starts to solidify. That is, the pressure of the pressurized gas can be low and the amount of the granular material to be supplied can be small.

[0043] In the automatic pouring machine 1 the unit 20 for pressurizing the molten metal is supported by the traversing carriage 4 of the pouring unit 10. When the position of the sprue A1 of the mold A is changed or when the nozzle of the ladle 2 deteriorates, the pouring unit 10 is moved by means of the traversing carriage 4 and the carriage for moving back and forth 6 to align the ladle 2 with the sprue A1. Then, if needed, the device 14 for moving the unit for pressurizing the molten metal back and forth and the device 16 for traversing the unit for pressurizing the molten metal of the unit 20 for pressurizing the molten metal are moved to align the mouth 26 with the sprue A1. So the distance between the ladle 2 and the mouth 26 is maintained to be equal to the length of a mold so that the movement of the mouth 26 can be shortened. Thus the unit 20 for pressurizing the molten metal can be quickly and definitely moved and continuous operations can be conducted. Incidentally, the unit 20 for pressurizing the molten metal may be located at a position other than on the traversing carriage 4 of the pouring unit 10. It may also be located on a supporting structure that is separate from the pouring unit 10.

[0044] In the above detailed description, we do not discuss the following matters: the device 3 for tilting the ladle, the traversing carriage 4, the carriage for moving back and forth 6, the device 8 for vertically moving the ladle, the device 14 for moving the unit for pressurizing the molten metal back and forth, the device 16 for traversing the unit for pressurizing the molten metal, the device 18 for vertically moving the unit for pressurizing the molten metal, the member 48 for constraining the mold, the first ball valve 32, the second ball valve 34, the first on-off valve 36, the second on-off valve 38, the flow control valve 40, and so on, may be automatically operated. Alternatively, they may be operated by means of a controller (not shown) based on the input by a user.

[0045] In the above discussion the mouth 26 is moved, by means of the device 14 for moving the unit for pressurizing the molten metal back and forth and by means of the device 16 for traversing the unit for pressurizing the molten metal. It may be moved by having a part of the piping 44 be flexible. The part of the piping 44 may be downstream of the second ball valve 34. In this case, if the mouth 26 is largely moved by means of the flexibility of the piping 44, the curvature of the piping 44 becomes large, so that the granular material can hardly pass through it. Thus even though the piping 44 is flexible, the device 14 for moving the unit for pressurizing the molten metal back and forth and the device 16 for traversing the unit for pressurizing the molten metal are preferably provided.

[0046] The present invention is not limited to any specific embodiment to carry out the invention. Various possible changes and modifications will be apparent to those of ordinary skill in the art that are within the scope of the technical ideas that are defined in the claims.

[0047] Below, the main reference numerals and symbols that are used in the detailed description and drawings are listed.

A. the mold
A1. the sprue
B. the rail
L. the line of molds
1. the automatic pouring machine
2. the ladle
3. the device for tilting the ladle
4. the traversing carriage
6. the carriage for moving back and forth
8. the device for vertically moving the ladle
10. the pouring unit
12. the supporting structure
14. the device for moving the unit for pressurizing the molten metal back and forth
16. the device for traversing the unit for pressurizing the molten metal
18. the device for vertically moving the unit for pressurizing the molten metal
20. the unit for pressurizing the molten metal
22. the hopper
24. the regulating chamber
26. the mouth
28. the first piping
30. the second piping
32. the first ball valve
34. the second ball valve
36. the first on-off valve
38. the second on-off valve
40. the flow control valve
42. the pressure sensor
44. the piping
46. the pressurizing device
48. the member for constraining the mold
50. the position sensor

Claims

1. An automatic pouring machine that has an ability to pressurize comprising:

a pouring unit that has a ladle for pouring molten metal into a mold and that can be transported along a line of molds where a plurality of molds are transported; and
a unit for pressurizing the molten metal that is

supported by the pouring unit and that supplies pressurized gas and a granular material to the mold into which molten metal has been poured from the pouring unit;
wherein the unit for pressurizing the molten metal has a hopper that stores the granular material, a mouth that hermetically connects with a sprue of the mold that is filled with the molten metal and which mouth feeds the pressurized gas and the granular material to the mold, a regulating chamber that regulates an amount of the granular material to be supplied from the hopper to the mouth, a piping that introduces the pressurized gas to the regulating chamber, and a piping that connects with the mouth to introduce the pressurized gas; and
wherein the unit for pressurizing the molten metal supplies the pressurized gas and the granular material to the mold among the plurality of molds that are located next to the mold into which the pouring unit pours the molten metal.

2. The automatic pouring machine that has the ability to pressurize of claim 1, wherein the unit for pressurizing the molten metal is configured to move the mouth in the direction that is parallel to, and in the direction that is perpendicular to, the line of molds where a plurality of molds are transported.

3. The automatic pouring machine that has the ability to pressurize of claim 2, further comprising a position sensor that detects a position of the sprue of the mold so as to move the mouth to the position of the sprue.

4. The automatic pouring machine that has the ability to pressurize of claim 1, wherein the pouring unit has a traversing carriage that moves parallel to the line of molds and a carriage for moving back and forth that moves perpendicularly to the line of molds on the traversing carriage, and
wherein the unit for pressurizing the molten metal is supported by the traversing carriage.

5. The automatic pouring machine that has the ability to pressurize of any of claims 1 to 4, wherein the granular material is dry silica sand.

6. A method for automatically pouring that has an ability to pressurize, wherein molten metal is poured from a ladle that is transported along a line of molds where a plurality of molds are transported, and wherein pressurized gas and a predetermined amount of a granular material are supplied from a unit for pressurizing the molten metal to the mold that is filled with the molten metal, wherein the unit for pressurizing the molten metal has a hopper that stores the granular material, a mouth that hermetically connects with the sprue of the mold that is filled with the molten metal and which mouth feeds the pressurized gas and the granular material to the mold, a regulating chamber that regulates an amount of the granular material to be supplied from the hopper to the mouth, a first piping that introduces the pressurized gas to the regulating chamber, and a second piping that connects with the mouth to introduce the pressurized gas, and wherein the unit for pressurizing the molten metal is configured to move along the line of molds together with the ladle, the method comprising the steps of:

moving the ladle so that molten metal can be poured into the sprue of a first mold on the line of molds where a plurality of molds are transported;
pouring molten metal from the ladle to the first mold;
hermetically connecting the mouth to the sprue of a second mold that is located next to the first mold and that is filled with molten metal;
supplying pressurized gas from the second piping to the second mold through the mouth;
regulating a predetermined amount of the granular material by the regulating chamber, which granular material has been stored in the hopper; and
supplying the regulated granular material to the second mold through the mouth by supplying the pressurized gas from the first piping to the regulating chamber.

7. The method for automatically pouring that has the ability to pressurize of claim 6 further comprising the steps of:

detecting a position of the sprue of the second mold by means of a position sensor; and
moving the mouth based on the detected position.

8. The method for automatically pouring that has the ability to pressurize of claim 6, wherein a time when pouring molten metal into the first mold is completed coincides with a time when supplying the pressurized gas and the granular material to the second mold is completed, and wherein the times coincide with a time when the plurality of molds on the line of molds start to be transported.

9. The method for automatically pouring that has the ability to pressurize of claim 6, wherein, if a position of the sprue of the first mold is changed from a position of the sprue of the second mold, the ladle is moved so as to pour molten metal into the sprue of the first mold, and then in the unit for pressurizing the molten metal that has been moved together with

the ladle the mouth is moved so as to be hermetically connected with the sprue of the second mold.

10. The method for automatically pouring that has the ability to pressurize of any of claims 6 to 9, wherein the granular material is dry silica sand.

Fig. 1

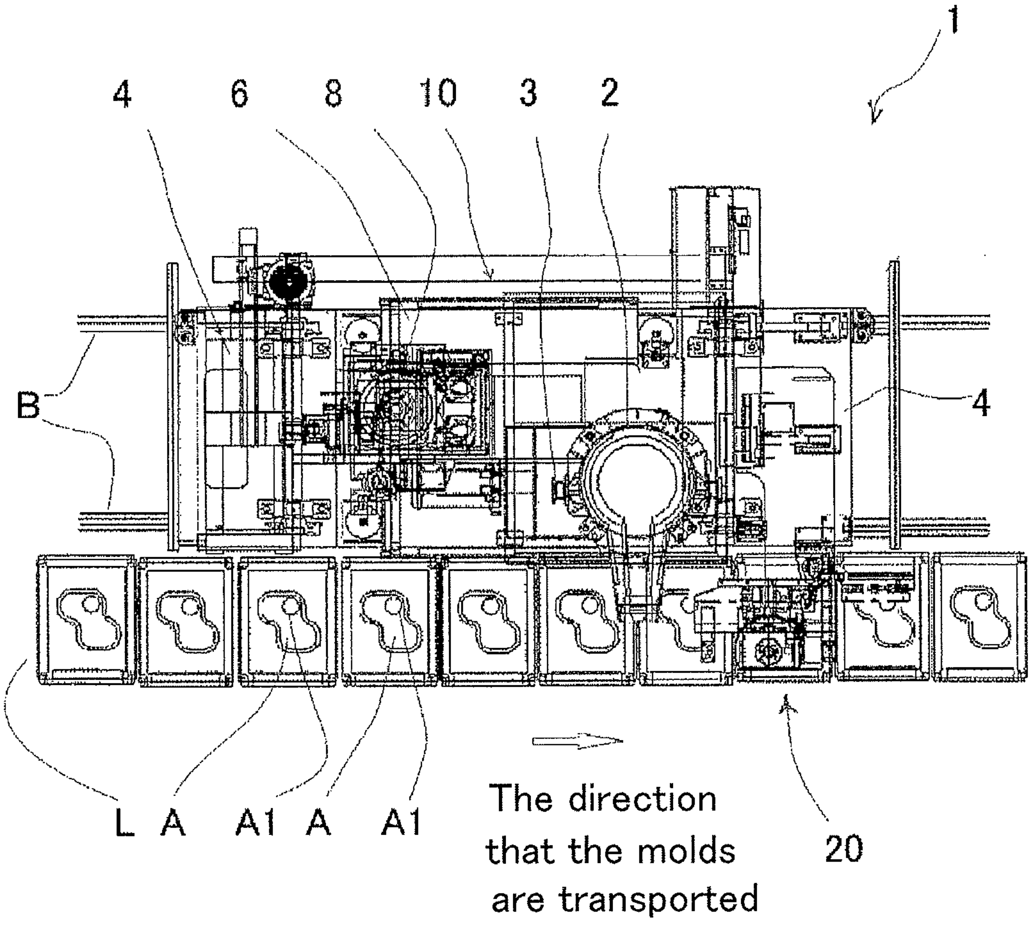

1
4
6
8
10
3
2
B
4
L
A
A1
A
A1
The direction that the molds are transported
20

Fig. 2

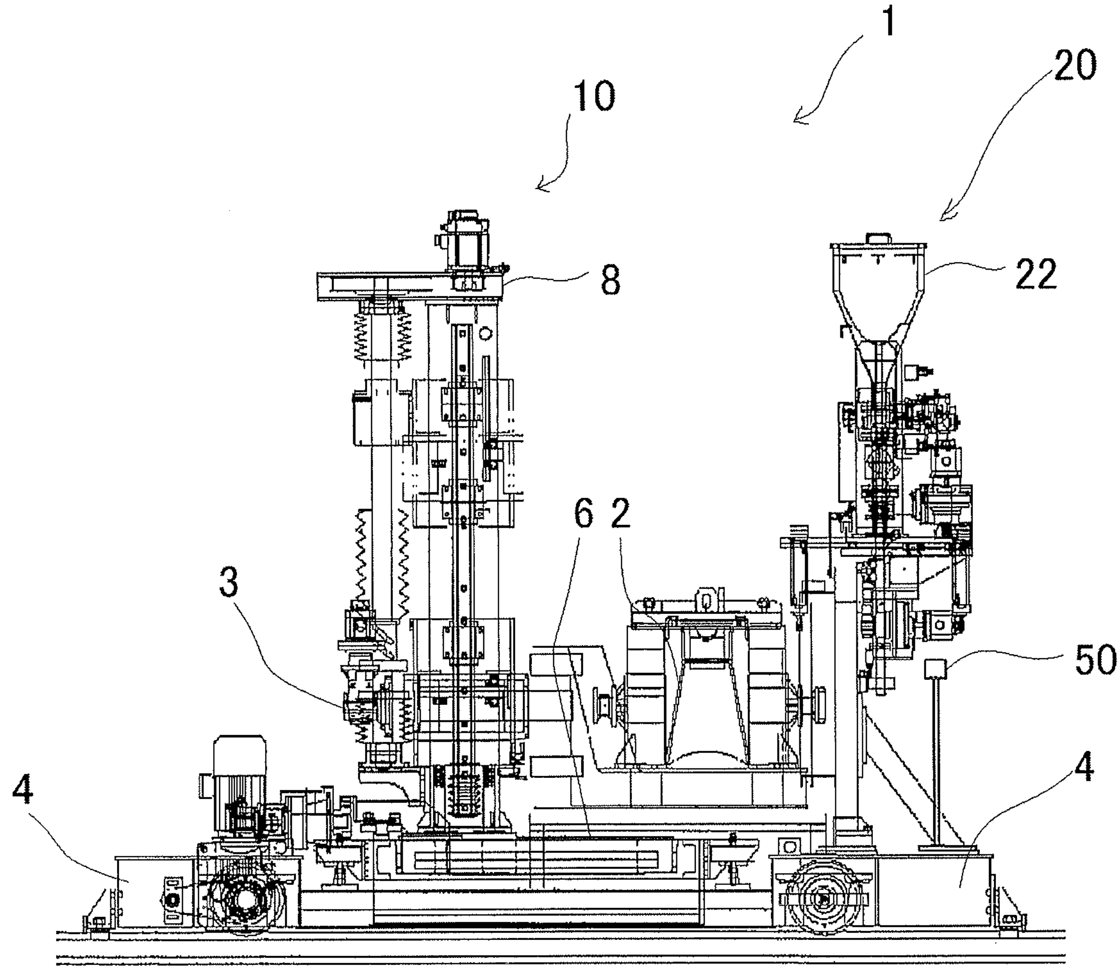


Fig. 3

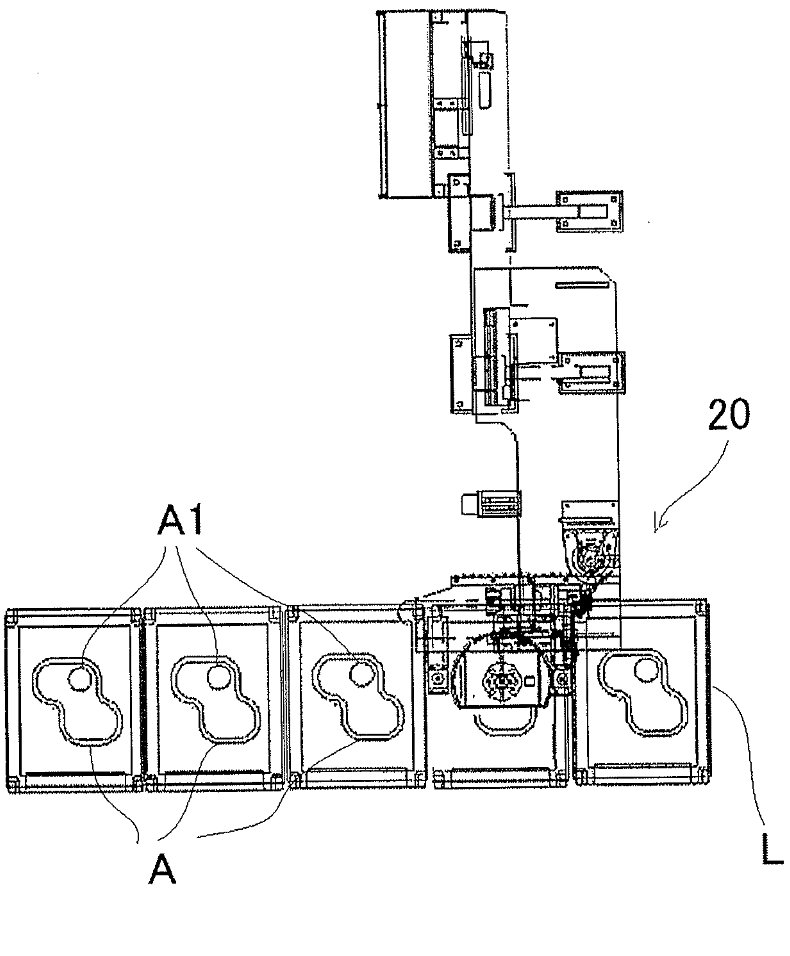


Fig. 4

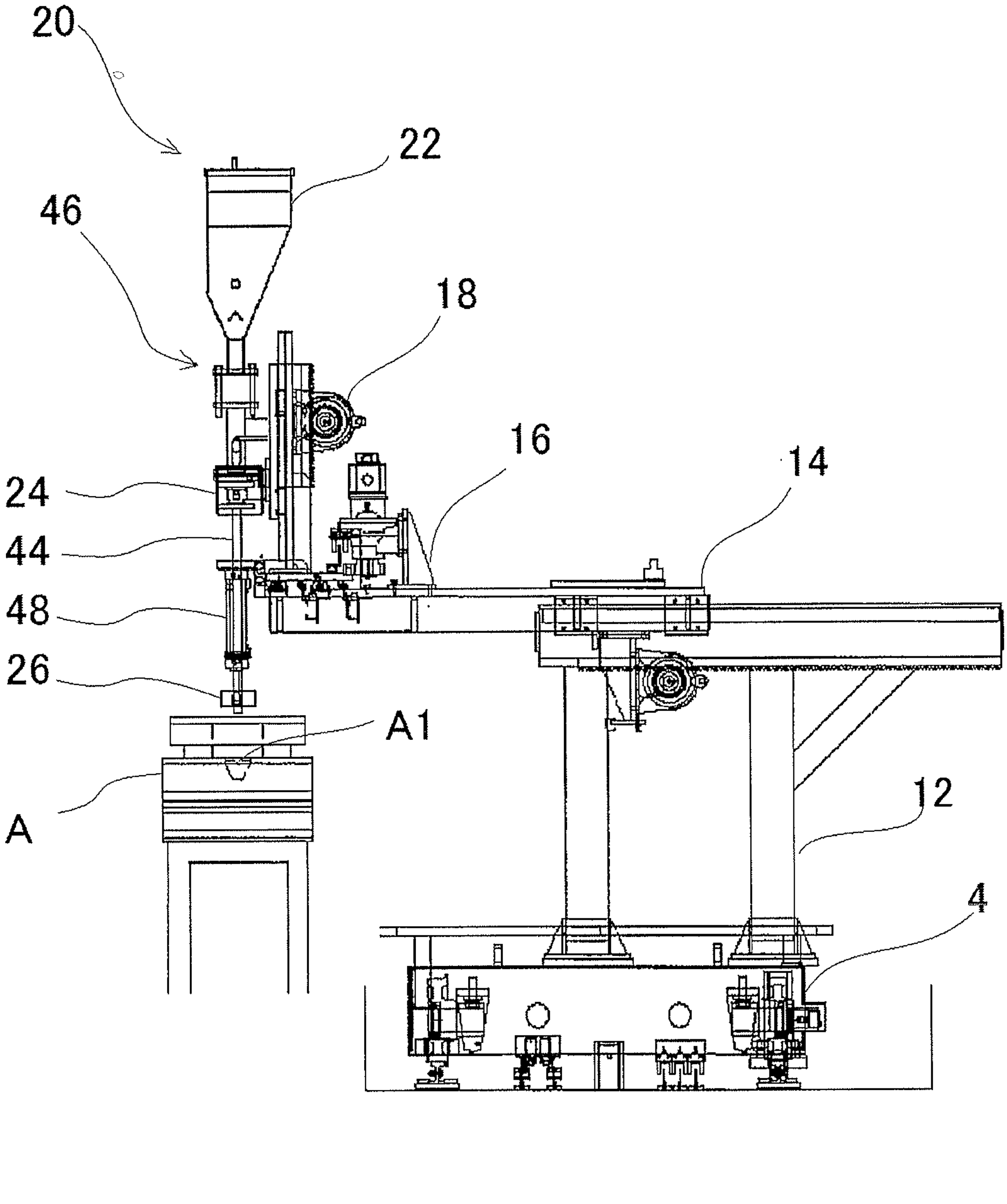


Fig. 5

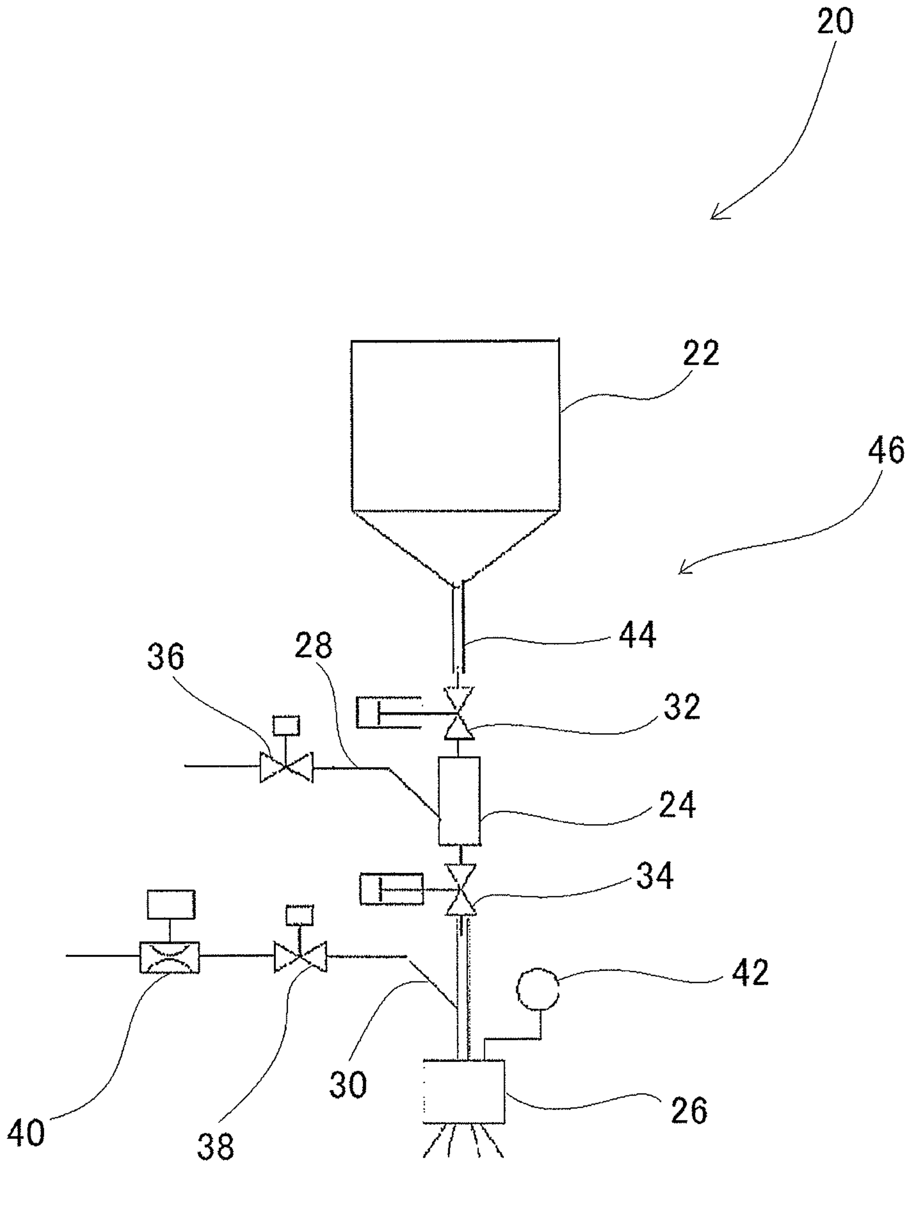


Fig. 6

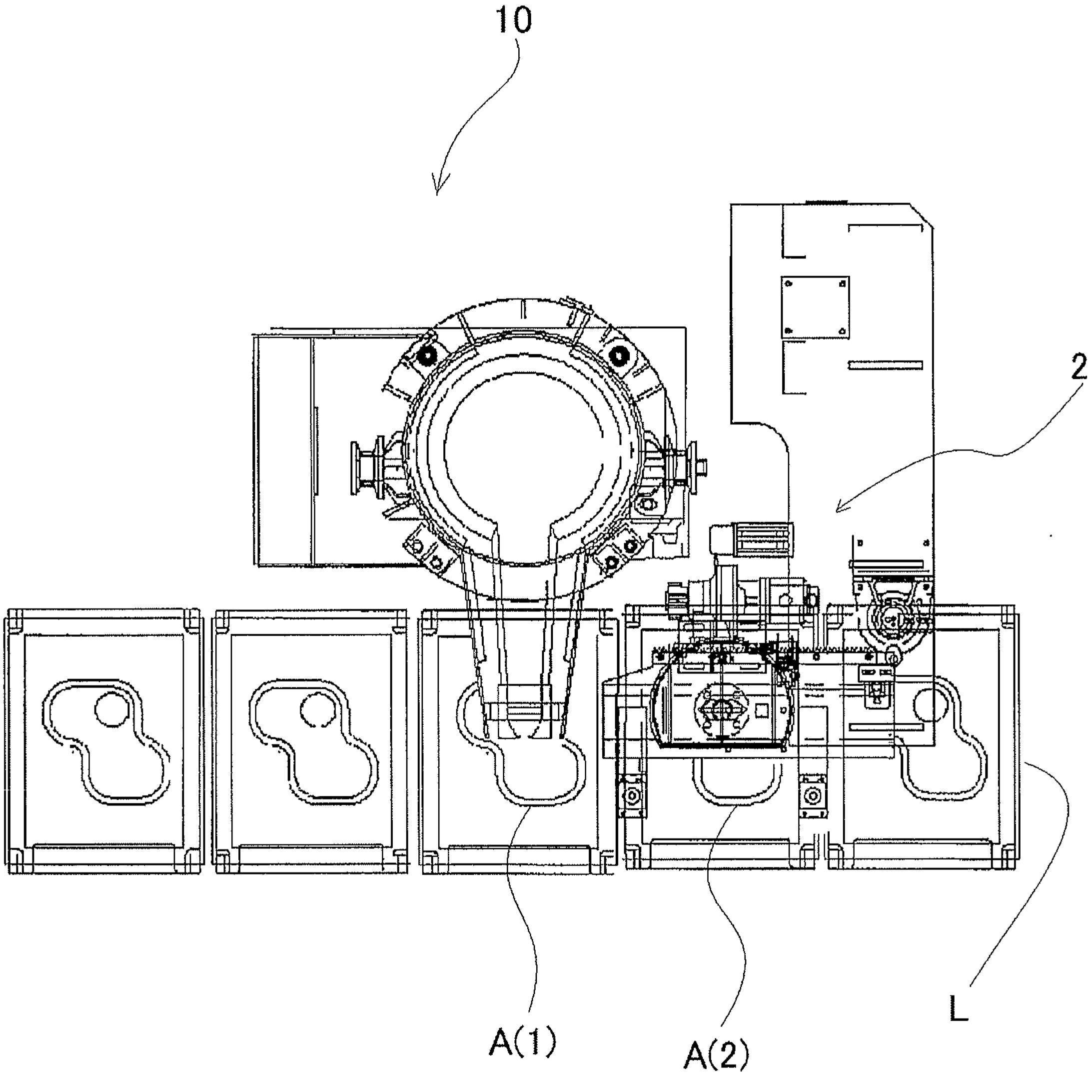


Fig. 7

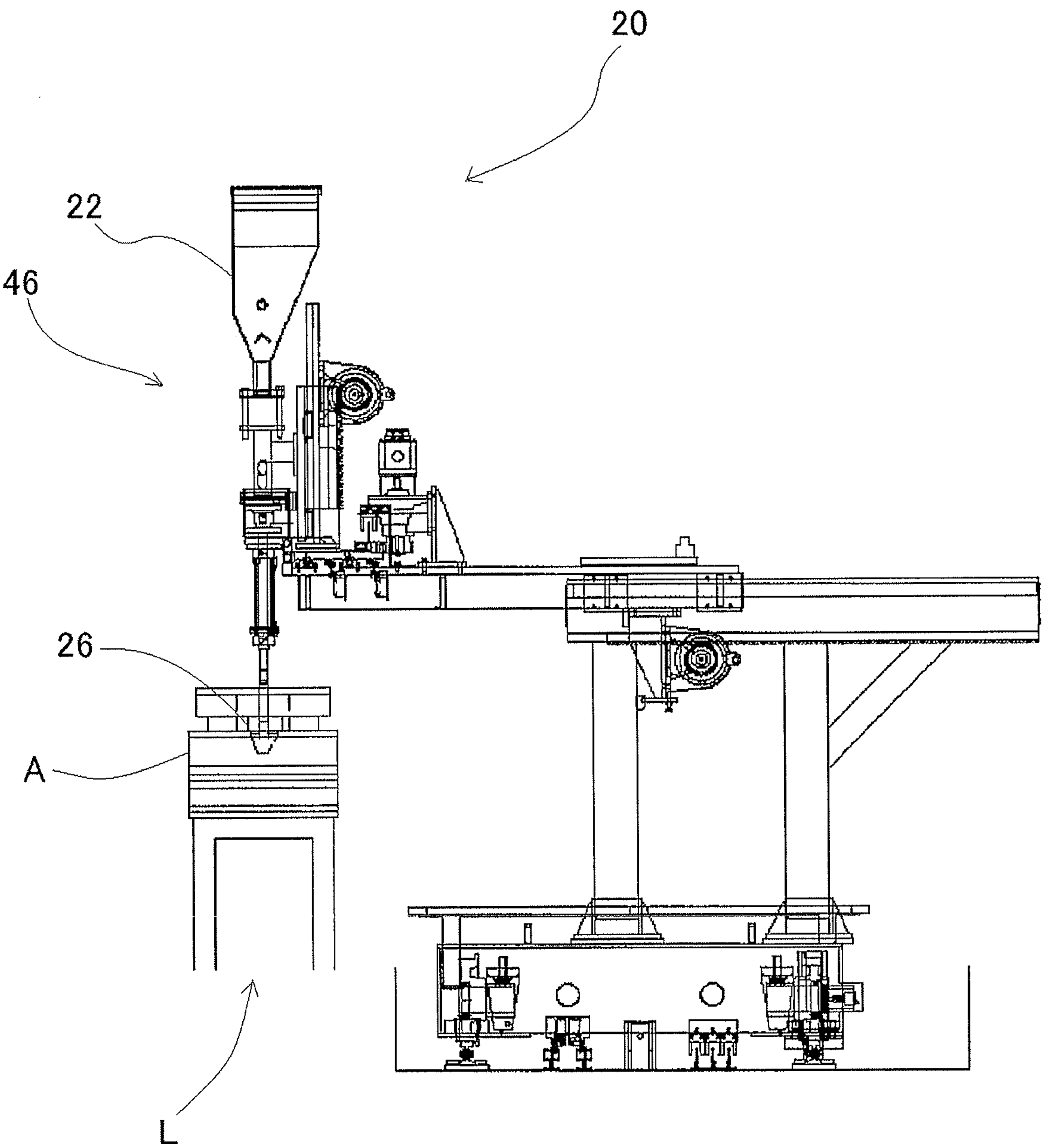
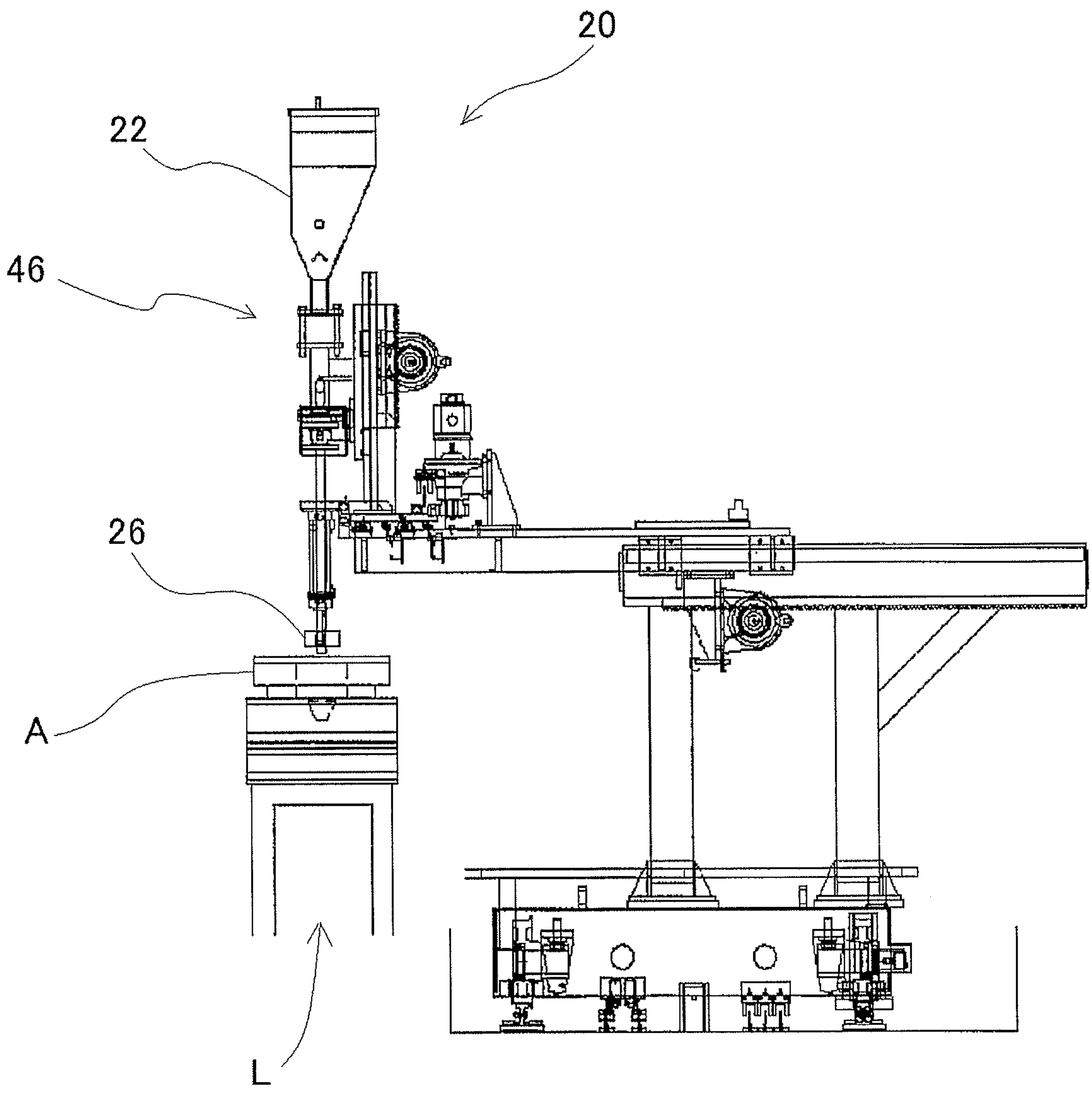


Fig. 8



INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2014/081199

A. CLASSIFICATION OF SUBJECT MATTER

B22D27/13(2006.01)i, *B22D18/04*(2006.01)i, *B22D27/09*(2006.01)i, *B22D39/02*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B22D27/13, B22D18/04, B22D27/09, B22D39/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2015
Kokai Jitsuyo Shinan Koho	1971-2015	Toroku Jitsuyo Shinan Koho	1994-2015

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2010-269345 A (Yugen Kaisha Foundry Tech Consulting), 02 December 2010 (02.12.2010), claims; paragraphs [0068] to [0084]; fig. 1 to 3 (Family: none)	1-10
Y	JP 2011-206785 A (Sinto Kogyo Ltd.), 20 October 2011 (20.10.2011), claims; paragraphs [0009] to [0014]; fig. 1 to 4 (Family: none)	1-10

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 February 2015 (16.02.15)	24 February 2015 (24.02.15)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3,Kasumigaseki,Chiyoda-ku, Tokyo 100-8915,Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/081199

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2007-75862 A (Masahito GOKA), 29 March 2007 (29.03.2007), entire text & US 2009/0151887 A1 & EP 1944105 A1 & WO 2007/032174 A1 & CN 101262968 A	1-10
A	JP 2-303671 A (Mazda Motor Corp.), 17 December 1990 (17.12.1990), entire text & US 5297610 A	1-10

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 4150764 B **[0003]**
- JP 2010269345 A **[0003]**