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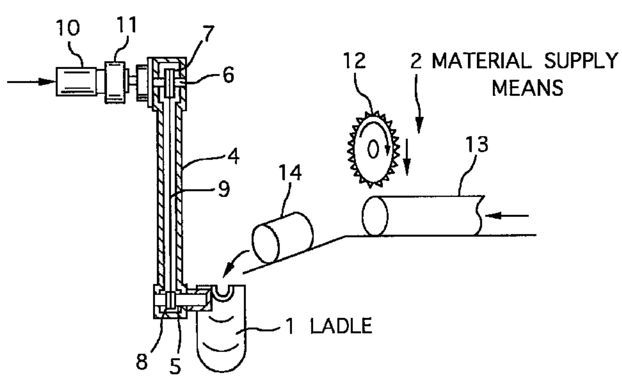
# (54) A method and an apparatus for supplying molten metal

(57) A method and an apparatus for supplying molten metal to a casting machine wherein the amount of molten metal supplied can be controlled precisely and defective castings caused by slag in the molten metal can be prevented. Material supply means (2) supplies a ladle (1) with a suitable amount of a casting material for one shot of casting in a solid state. After the solid casting material (14) is melted into molten metal, the molten metal is supplied from the ladle to the casting machine. By controlling the amount of molten metal supplied by means of the casting material in the solid state, the precision of quantity control of molten metal can be enhanced. In addition, because the molten metal is supplied from the ladle to the casting machine soon after the casting material is melted, the time for molten metal to be exposed to the air can be shortened, and slag generation due to molten metal oxidization can be suppressed.

FIG. 1

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## Description

### BACKGROUND OF THE INVENTION

#### Field of the Invention

This invention relates to a method and apparatus for supplying molten metal to a casting machine by using a ladle.

#### Description of the Related Art

In casting, the operation of supplying molten metal is carried out by scooping up molten metal stored temporarily in a molten metal storage furnace with a ladle, conveying this ladle laden with the molten metal to a casting machine, and tilting the ladle to pour the molten metal in the ladle into a mold.

The amount of molten metal supplied to the mold must be appropriate in accordance with the cavity size of the mold. When the amount of molten metal supplied is too small, in the case of gravity casting, a riser does not function well, and in the case of die casting, a biscuit gets so thin that pressure is not sufficiently transmitted to a product portion, and a good casting cannot be obtained. On the other hand, when the amount of molten metal supplied is too large, in the case of gravity casting, the molten metal overflows from the mold cavity and worsens work environment, and in the case of die casting, a biscuit gets so thick that a chuck for holding the biscuit cannot grip the biscuit appropriately and a casting becomes difficult to be removed. In addition, the thickness of the biscuit will eventually affect the high-speed period and the low-speed period of casting conditions, and some problems occur in quality. It is to be understood that in the field of die casting a biscuit means a portion formed between a plunger tip and a spool core. Before molten metal solidifies, pressure is applied to a product portion by way of molten metal in the biscuit portion. After casting is completed, this biscuit is gripped by a chuck to remove a casting from a mold.

Conventionally, the amount of molten metal supplied has been controlled by adjusting the inclination angle of the ladle, or by utilizing load detecting means such as a load cell when molten metal is scooped with the ladle from the molten metal storage furnace. More specifically, the ladle is inclined at a predetermined angle of inclination, and immersed in and lifted above the molten metal storage furnace with keeping the ladle inclined. Otherwise, the amount of molten metal in the ladle is detected by load detecting means such as a load cell and then excessive molten metal is overflowed by adjusting the inclination angle of the ladle delicately, if necessary. (Refer to Japanese Unexamined Patent Publication (KOKAI) No.sho63-309367.)

However, it is difficult to control the amount of molten metal supplied precisely in the above conventional methods in which the amount of molten metal supplied is controlled by adjusting the inclination angle of the ladle or the amount of molten metal in the ladle is detected by using the load cell. That is to say, in the case where the inclination angle of the ladle is adjusted to control the amount of molten metal supplied, ladle tilting means for varying the inclination angle of the ladle is chronologically changed, and the amount of molten metal supplied becomes inaccurate promptly upon this change. On the other hand, in the case where the load cell detects the amount of molten metal in the ladle, because the ladle is usually fixed at a lower end of a long and slender molten metal feed arm, the molten metal feed arm is often bent delicately in accordance with the inclination angle of the ladle, and this bending of the molten metal feed arm makes it difficult just to measure the amount of molten metal in the ladle with accuracy.

Moreover, in the above conventional methods in which molten metal is temporarily stored in the molten metal storage furnace, the molten metal is exposed to the air for a long time, and oxidization of the molten metal is promoted, so slag easily generates. This slag generation lowers the precision of quantity control of molten metal supplied, and when the slag is supplied together with the molten metal to the casting machine, product defects are caused.

### SUMMARY OF THE INVENTION

The present invention has been conceived in view of the above circumstances.

It is a first object of the present invention to provide a method and an apparatus for supplying molten metal wherein the amount of molten metal supplied can be controlled with high precision.

It is a second object of the present invention to provide a method and an apparatus for supplying molten metal wherein product defects due to slag in molten metal can be prevented.

A method of supplying molten metal according to a first aspect of the present invention, which attains the first and second objects, comprises the steps of supplying a ladle with a suitable amount of a casting material for one shot of casting in a solid state, melting the casting material in the solid state into molten metal, and supplying the molten metal from the ladle to a casting machine.

In the method according to the first aspect of the present invention, because a suitable amount of a casting material for one shot of casting is supplied in the solid state to the ladle, the amount of molten metal supplied can be precisely controlled by means of the casting material in the solid state, and the precision of quantity control of molten metal supplied can be enhanced. In the conventional methods, because molten metal is temporarily stored in a molten metal storage furnace, the molten metal is exposed to the air for a long time and slag tends to generate due to oxidization. In the method according to the first aspect of the present invention, however, these problems do not occur: Since molten metal can be supplied from the ladle to the casting machine soon after the casting material is melted, the time for the molten metal to be exposed to the air can be shortened, and slag generation due to oxidization of molten metal can be suppressed. In addition, since only heat at a level necessary and sufficient to melt the suitable amount of the casting material for one shot of casting need be applied in melting the casting material in the solid state, there is also an advantage in which the ladle and the like are hardly heat degraded.

A method for supplying molten metal from a ladle to a casting machine according to a second aspect of the present invention, which attains the first object of the present invention, is characterized in vibrating the ladle which holds molten metal, detects vibration frequency of the ladle at this time, and controlling the amount of molten metal supplied on the base of the detected vibration frequency.

The method according to the second aspect of the present invention includes vibrating the ladle which holds molten metal, detecting vibration frequency of the ladle at this time, and controlling the amount of molten metal supplied on the base of the detected vibration frequency. In other words, the amount of molten metal in the ladle can be measured by detecting a variation in vibration frequency which is influenced by a variation in mass of molten metal held in the ladle, and thus the amount of molten metal in the ladle can be controlled with high precision.

In a preferred embodiment of the methods according to the first and second aspects of the present invention, the ladle is vibrated in supplying molten metal to the casting machine. By thus vibrating the ladle in supplying molten metal, fluidity of molten metal is improved so that the time to supply molten metal can be shortened. In addition, when a suitable amount of molten metal for one shot of casting is contained in the ladle, the entire molten metal can be securely supplied to the casting machine, and accordingly a suitable amount of molten metal for one shot of casting can be securely supplied. Moreover, it is possible to prevent molten metal from dropping on the periphery of a supply port of the casting machine and dropped metal from depositing.

A method of supplying molten metal according to a fourth aspect of the present invention, which attains the first and second objects, is a method of supplying a casting machine with molten metal scooped from a molten metal storage furnace, by using a ladle which comprises a container part which molten metal is supplied to and held in, an air port which makes an upper part of the container part communicate with the external environment and can be opened and closed, a supply and exhaust port which is provided at a lower portion of the container part for supplying molten metal to the container part or exhausting molten metal from the container part, wherein this method comprises the step of supplying molten metal from the molten metal storage furnace to the container part through the supply and exhaust port by immersing the ladle in the molten metal storage furnace with the air port open to the air, and closing the air port, when the molten metal supplied to the container part reaches a predetermined amount, in order to hold the predetermined amount of molten metal in the container part, and the step of supplying the molten metal held in the container part through the supply and exhaust port to the casting machine by opening the air port to make the upper portion of the container part open to the air after the ladle is conveyed to the casting machine with the air port closed.

In the method according to the fourth aspect of the present invention, by immersing the ladle in the molten metal storage furnace with the air port open to the air, molten metal is supplied from the molten metal storage furnace to the container part through the supply and exhaust port. When molten metal supplied to the container part reaches a predetermined amount, the air port is closed to hold the predetermined amount of molten metal in the container part. Then, after the ladle is conveyed to a predetermined position in the casting machine with the air port closed, the air port is opened to expose the upper portion of the container part to the air, so that the molten metal held in the container part can be supplied to the casting machine through the supply and exhaust port. Thus, without tilting the ladle, a predetermined amount of molten metal can be supplied to and held in the ladle, and the predetermined amount of molten metal in the ladle can be supplied to the casting machine, so the amount of molten metal supplied can be controlled with high precision. In addition, although slag exists around the surface of molten metal in the molten metal storage furnace, slag-free molten metal which exists in a deep portion of the molten metal storage furnace can be supplied to the container part through the supply and exhaust port. Moreover, while the ladle is conveyed from the molten metal storage furnace to the casting machine, the molten metal supplied in the container part contacts the air only through the supply and exhaust port and the contact area with the air is small, so slag hardly generates.

An apparatus according to a fifth aspect of the present invention, which attains the first and second objects, is an apparatus used in carrying out the method according to the first aspect of the present invention. In an apparatus for supplying molten metal from a ladle to a casting machine, this apparatus is characterized in comprising material supplying means for supplying the ladle with a suitable amount of a casting material for one shot of casting in a solid state, and melting means for melting the casting material in the solid state into molten metal.

An apparatus according to a sixth aspect of the present invention, which attains the first object, is an apparatus used in carrying out the method according to the second aspect of the present invention. In an apparatus for supplying molten metal from a ladle to a casting machine, this apparatus is characterized in comprising vibrating means for vibrating the ladle, vibration frequency detecting means for detecting vibration frequency of the ladle vibrated by the vibrating means, and control means for controlling the amount of molten metal supplied on the base of the vibration frequency detected by the vibration frequency detecting means.

An apparatus according to a seventh aspect of the present invention, which attains the first and second objects, is an apparatus used in carrying out the method according to the fourth aspect of the present invention. In an apparatus for supplying a casting machine with molten metal scooped from a molten metal storage furnace by using a ladle, the ladle characteristically comprises a container part which molten metal is supplied to and held in, an air port which makes an upper portion of the container part communicate with the external environment and can be opened and closed, and a supply and exhaust port which is provided at a lower portion of the container part for supplying the molten metal to the container part or exhausting the molten metal from the container part, and molten metal quantity detecting means for detecting a predetermined amount of molten metal having been supplied in the container part.

Now, advantages of the present invention will be described.

In the method according to the first aspect of the present invention or the apparatus according to the fifth aspect of the present invention, by supplying the ladle with a suitable amount of casting material for one shot of casting in a solid state, the amount of molten metal supplied can be controlled precisely by means of the casting material in the solid state, and thus precision of quantity control of molten metal supplied can be enhanced. In addition, because molten metal can be supplied from the ladle to the casting machine soon after the casting material is melted, the time for molten metal to be exposed to the air can be shortened, and slag generation due to oxidization of the molten metal can be suppressed. Therefore, this invention contributes to quality improvement in castings.

In the method according to the second aspect of the present invention or the apparatus according to the sixth aspect of the present invention, by detecting a variation in vibration frequency which is influenced by a variation in the mass of molten metal held in the ladle, the amount of molten metal in the ladle can be controlled precisely, and the precision of quantity control of the molten metal supplied can be enhanced. Therefore, this invention contributes to quality improvement in castings.

In the method according to the fourth aspect of the present invention or the apparatus according to the seventh aspect of the present invention, by conducting simple operations such as lifting or lowering the ladle and opening or closing the air port, a predetermined amount of molten metal can be precisely held in and supplied to the casting machine, the construction of the apparatus can be simplified and at the same time precise quantity control of molten metal supplied can be achieved. In addition, slag-free molten metal which exists in a deep portion of the molten metal storage furnace can be supplied to the container part through the supply and exhaust port, and at the same time by limiting the contact area with the air during the conveyance of the ladle, slag generation can be suppressed. Accordingly, product defects due to slag can be prevented. Therefore, this invention contributes to a decrease in production expenses and quality improvement in castings.

## BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, in which:

Figure 1 is a side view showing that a suitable amount of a casting material for one shot of casting is supplied in a solid state from material supplying means to a ladle in Example 1;
Figure 2 is a cross sectional view showing that the solid casting material supplied to the ladle is melted into molten metal in Example 1;
Figure 3 is a cross sectional view showing that the molten metal in the ladle is poured into a casting machine in Example 1;
Figure 4 is a side view showing that a suitable amount of a casting material for one shot of casting is supplied in a solid state from material supply means to a ladle in Example 2;
Figure 5 is a side view showing that a suitable amount of a casting material for one shot of casting is supplied in a solid state from material supply means to a ladle in Example 3;
Figure 6 is a side view showing that the amount of molten metal in a ladle is controlled in Example 4;
Figure 7 is a cross sectional view showing that a predetermined amount of molten metal is supplied to a ladle in Example 5; and
Figure 8 is a cross sectional view showing that the molten metal in the ladle is poured into a casting machine in Example 5.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Having generally described this invention, a further understanding can be obtained by reference to certain specific examples which are provided herein for purposes of illustration only and are not intended to be limiting unless otherwise specified.

### The First Preferred Embodiment

The first preferred embodiment relates to the method according to the first aspect of the present invention and the apparatus according to the fifth aspect of the present invention.

In the method according to the first aspect of the present invention or the apparatus according to the fifth aspect of the present invention, a preferred embodiment of supplying a suitable amount of a casting material for one shot of casting in a solid state is to cut a bar having a constant diameter and formed of a casting material into a predetermined length of billets, so that each billet has suitable mass for one shot of casting, or to count and supply a predetermined number of billets (balls, square bars, or the like) formed of a casting material and having constant mass respectively so that the predetermined number of billets have suitable mass for one shot of casting. It is also possible to prepare plural kinds of billets having constant mass respectively and supply a predetermined number of billets by combining the plural kinds. It is also possible to weigh one or more kinds of billets such as balls and square bars so that the weighed billets have suitable mass for one shot of casting. In such an embodiment, a casting material with suitable mass for one shot of casting can be supplied in a solid state with ease and high accuracy.

In the method according to the first aspect of the present invention or the apparatus according to the fifth aspect of the present invention, a preferred embodiment of melting a solid casting material into molten metal is to employ electromagnetic induction heating means which serves as melting means. In this preferred embodiment, by setting appropriate conditions of an induction coil as electromagnetic induction heating means, heat at a level necessary and sufficient to melt the suitable amount of the casting material for one shot of casting can be applied with ease, and a ladle and the like can be prevented from being heat degraded in melting the casting material. In addition, molten metal at a desired and constant temperature can be easily obtained.

(Example 1)

In Example 1, the present invention is applied to die casting of an aluminum alloy.

The apparatus of Example 1 comprises a ladle 1, material supply means 2 for supplying the ladle 1 with a suitable amount of a casting material for one shot of casting in a solid state, and electromagnetic induction heating means 3 as melting means for melting the solid casting material held in the ladle 1 into molten metal.

Referring to Figure 1, the ladle 1 is rotatably held by a lower end of a molten metal supply arm 4 by way of a supporting shaft 5. The ladle 1 is fixed to the supporting shaft 5, and the supporting shaft 5 is rotatably held by the molten metal supply arm 4 by way of a bearing not shown. A driving shaft 6 is rotatably held by an upper end of the molten metal supply arm 4 by way of a bearing not shown. A sprocket 7 and a sprocket 8 are respectively fixed to the driving shaft 6 and the supporting shaft 5, and a chain 9 connects the both sprockets 7 and 8. Owing to this construction, rotation is transmitted from the driving shaft 6 to the supporting shaft 5 by way of the chain 9. The driving shaft 6 is connected through a speed reducer 11 to a motor (a pulse motor) 10 which serves as ladle driving means for changing the inclination angle of the ladle 1. The ladle 1 together with the molten metal supply arm 4 and the motor 10 can be conveyed by conveying means not shown.

The material supply means 2 serves to supply the ladle 1 with a suitable amount of a casting material for one shot of casting in a solid state. Specifically, the material supply means 2 is provided with a sawing machine not shown, and by using a saw blade 12 of this sawing machine, a predetermined length of billets 14 are cut out from a bar 13 having a constant diameter and formed of a casting material (an aluminum alloy in this example), in order to have suitable mass for one shot of casting respectively. Then each of the billets 14 is supplied to the ladle 1.

The electromagnetic induction heating means 3 as melting means is installed in a melting chamber 16 and serves to melt one billet 14, i.e., the casting material in the solid state into molten metal 15. This electromagnetic induction heating means 3 can easily change a heating temperature by setting conditions of an induction coil, and can easily apply heat at a level necessary and sufficient to melt one billet 14 in accordance with the mass and melting temperature of the billet 14 held in the ladle 1.

A method of supplying molten metal using the apparatus with the above construction will be described hereinafter.

After the ladle 1 is conveyed to a predetermined position in the material supply means 2, the material supply means 2 is actuated to supply the ladle 1 with one billet 14 as a suitable amount of a casting material for one shot of casting. Then the ladle 1 holding the billet 14 is conveyed to the melting chamber 16, and there the electromagnetic induction heating means 3 melts the billet 14 into molten metal 15. The ladle 1 which holds the suitable amount of the molten metal 15 for one shot of casting is conveyed to a die casting machine, and the motor 10 is actuated to tilt the ladle 1 so that the entire molten metal 15 held in the ladle 5 is poured to a supply port 17a of a plunger sleeve 17.

In the method of supplying molten metal according to this example, the amount of molten metal supplied is controlled by cutting the bar 13 having a constant diameter and formed of a casting material into a predetermined length of billets 14, so that each billet 14 has suitable mass for one shot of casting. Therefore, the amount of molten metal supplied can be controlled with ease and high precision.

In the conventional method of supplying molten metal, since molten metal is temporarily stored in a molten metal storage furnace, the molten metal is exposed to the air for a long time and slag tends to generate due to oxidization. This slag causes problems such as inaccurate quantity control of molten metal supplied and product defects. In the method of supplying molten metal of this example, however, these problems do not occur: Since molten metal 15 can be supplied from the ladle 1 to the plunger sleeve 17 soon after one billet 14 as a casting material in a solid state is melted in the melting chamber 16, the time for the molten metal 15 to be exposed to the air can be shortened and slag generation due to oxidation of the molten metal 15 can be prevented.

Moreover, in this example, since the electromagnetic induction heating means 3 is employed as melting means, heating temperature can be easily changed by setting conditions of the induction coil, and heat at a level necessary and sufficient to melt the billet 14 can be applied easily in accordance with the mass, melting temperature and the like of the billet 14 held in the ladle 1. Although in the conventional method there is a problem in which the ladle 1 and the like are easily degraded by the heat of the molten metal storage furnace, in the method of this example such a problem does not occur, so the maintenance expenses of the ladle 1 and the like can be reduced.

(Example 2)

The apparatus of this example has the same construction as the apparatus of Example 1, except that the construction of the material supply means 2 of this example is different from that of Example 1. As shown in Figure 4, the material supply means 2 of this example serves to prepare a large number of first billets 18 which are in the form of balls with constant mass and second billets 19 which are in the form of balls having smaller constant mass than that of the first billets 18 and count a predetermined number of billets 18 and 19 so as to have suitable mass for one shot of casting. Also by using this material supply means 2, a casting material with suitable mass for one shot of casting can be supplied in a solid state with ease and high precision.

(Example 3)

As shown in Figure 5, the apparatus of this example has the same construction as the apparatus of Example 2, except the construction of the material supply means 2. The material supply means 2 of this example serves to prepare a number of first billets 18 in the form of balls with constant mass, and second billets 19 in the form of balls which respectively have smaller constant mass than the first billets 18, weigh the first and second billets so as to have suitable mass in total for one shot of casting by using a weighing machine 20, and supply the weighed billets 18 and 19 to the ladle 1. Also by using this material supply means 2, a casting material with suitable mass for one shot of casting can be supplied in a solid state with ease and high precision.

<u>The Second Preferred Embodiment</u>

The second preferred embodiment relates to the method according to the second aspect of the present invention and the apparatus according to the sixth aspect of the present invention.

(Example 4)

Referring now to Figure 6, the apparatus of this example comprises a vibrator 21 as vibrating means for vibrating a ladle 1, a vibration sensor 22 as vibration frequency detecting means for detecting vibration frequency of the ladle 1, and control means 23 for controlling the amount of molten metal supplied on the base of the vibration frequency detected by the vibration sensor 22. The control means 23 also controls a motor 10 which serves as ladle driving means for changing the inclination angle of the ladle 1.

The vibrator 21 as vibrating means serves to give a predetermined vibration to the ladle 1. Upon actuation of the vibrator 21, the ladle 1 is vibrated, and vibration frequency at this time is detected by the vibration sensor 22, and the detected vibration frequency f is sent to the control means 23. In the control means 23, reference vibration frequency $f_0$ is input beforehand. The reference vibration frequency $f_0$ is the frequency of the ladle 1 when the vibrator 21 gives a predetermined vibration to the ladle 1 which holds a suitable amount of molten metal for one shot of casting. The control means 23 compares the detected vibration frequency f with the reference vibration frequency $f_0$ and controls the motor 10 to change the inclination angle of the ladle 1 so that the detected vibration frequency f becomes equal to the reference vibration frequency $f_0$.

In operation, a slightly larger amount of molten metal than a suitable amount of molten metal for one shot of casting is scooped from a molten metal storage furnace not shown by the ladle 1, and the vibrator 21 is actuated to give a predetermined vibration to the ladle 1. At this time, vibration frequency f of the ladle 1 is detected by the vibration sensor 22 and the detected vibration frequency f is sent to the control means 23. The control means 23 compares the detected vibration frequency f with the previously input reference vibration frequency $f_0$, and controls the motor 10 to increase the inclination angle of the ladle 1 gradually and continuously so as to drop molten metal little by little from the ladle 1 until the detected vibration frequency f becomes equal to the previously input reference vibration frequency $f_0$. Accordingly, the amount of molten metal in the ladle 1 can be controlled precisely so as to become a suitable amount of molten metal for one shot of casting.

Therefore, in this example, the amount of molten metal supplied can be controlled with ease and high precision.

In this example, if the ladle 1 is vibrated by the vibrator 21 in supplying molten metal from the ladle 1 to the casting machine, fluidity of the molten metal is improved and the time to supply molten metal can be shortened. In addition, since the suitable amount of molten metal for one shot of casting is held by the ladle 1 and the entire molten metal can be securely supplied to the casting machine, the suitable amount of molten metal for one shot of casting can be securely supplied. Besides, the molten metal can be prevented from dropping on the periphery of the supply port of the casting machine and the dropped molten metal from depositing.

Also in Examples 1 to 3, similar effects to the above can be obtained, if a vibrator 21 is provided to the ladle 1 and vibrates the ladle 1 in supplying molten metal from the ladle 1 to the casting machine.

## The Third Preferred Embodiment

The third preferred embodiment relates to the method according to the fourth aspect of the present invention or the apparatus according to the seventh aspect of the present invention.

(Example 5)

In the apparatus of this example, referring now to Figures 7 and 8, molten metal 15 scooped from a molten metal storage furnace 25 is supplied into a plunger sleeve 17 by using a ladle 24.

The ladle 24 comprises a container part 26 which the molten metal 15 is supplied to and held in, an air port 27 which makes an upper portion of the container part 26 communicate with the external environment and can be opened and closed, a supply and exhaust port 28 for supplying the molten metal 15 to the container part 26 or exhausting the molten metal 15 from the container part 26, and a touch sensor 29 which serves as molten metal quantity detecting means for detecting a predetermined amount of molten metal having been supplied to the container part 26.

The container part 26 of the ladle 24 can be lifted and lowered in a vertical direction by lifting and lowering means not shown, and can be conveyed from the molten metal storage furnace 25 to the plunger sleeve 17 by conveying means not shown. The capacity of the container part 26 is designed so that the amount of molten metal in the ladle 24 is equal to a suitable amount of molten metal for one shot of casting, when the molten metal has been supplied to the whole of the container part 26 and the supply and exhaust port 28.

The air port 27 of the ladle 24 can be opened and closed by a closing board 30, and the touch sensor 29 is fixed at the fore end of the closing board 30. This closing board 30 can be reciprocated in a horizontal direction by way of a hydraulic cylinder not shown by the control of a control part 31 to which signals detected by the touch sensor 29 are output. The lower end of the touch sensor 29 is designed to be on the same horizontal surface with the inner top surface of the container part 26.

The supply and exhaust port 28 of the ladle 24 has a slant portion 28a which extends in an obliquely downward direction from the center of the lower end of the container part 26, and a vertical opening portion 28b which is integrally formed at the fore end of the slant portion 28a. The vertical opening portion 28b exists at a certain horizontal distance from the container part 26.

In this apparatus, the closing board 30 is moved forward in a horizontal direction (in the left direction in Figure 7) by the control of the control part 31, so the air port 27 is opened to the air. Then, the ladle 24 is lowered by operating the lifting and lowering means not shown and immersed in the molten metal storage furnace 15. The molten metal is thus supplied from the molten metal storage furnace 25 into the container part 26 through the supply and exhaust port 28. When the molten metal supplied reaches the inner top surface of the container part 26, the touch sensor 29 contacts the molten metal in the molten metal storage furnace 25 and outputs a signal to the control part 31. The control part 31 which has received this signal controls the closing board 30 to move backward in a horizontal direction (in the right direction in Figure 7) so as to close the air port 27. Thus, the suitable amount of molten metal for one shot of casting can be precisely held in the ladle 24. With keeping the molten metal in the ladle 24, the ladle 24 is conveyed to the plunger sleeve 17 by the conveying means not shown, and the vertical opening portion 28b of the supply and export port 28 is placed at a supply port 17a of the plunger sleeve 17. Then, by the control of the control part 31, the closing board 30 is moved forward in the horizontal direction (in the left direction in Figure 7) to make the air port 30 open to the air, whereby the entire molten metal 15 held in the container part 26 can be supplied from the supply and exhaust port 28 to the supply port 17a.

As mentioned above, only by lowering or lifting the ladle 24 and moving the closing board 30 horizontally, the predetermined amount of molten metal can be supplied to and held in the ladle 24 and the molten metal held in the ladle 24 can be supplied into the plunger sleeve 17, and the amount of molten metal supplied can be controlled with high precision.

In addition, there is no need to tilt the ladle 24 in controlling the amount of molten metal in the ladle 24 or in supplying molten metal in the ladle 24 to the plunger sleeve 17. Therefore, a mechanism for tilting the ladle 24 is not required, and the construction of the apparatus can be simplified.

Moreover, in the molten metal storage furnace 25, slag exists around the surface of the molten metal 15, but the vertical opening portion 28b of the supply and exhaust port 28 reaches near the bottom of the molten metal storage furnace 25, and slag-free molten metal which exists in the deep portion can be supplied to the container part 26 through this supply and exhaust port 28. In addition, while the ladle 24 is conveyed from the molten metal storage furnace 25 to the plunger sleeve 17, the molten metal 15 held in the container part 26 contacts the air only through the vertical opening portion 28b of the supply and exhaust port 28. Since the contact area with the air is small, slag hardly generates. As a result, molten metal containing little slag can be supplied from the ladle 24 to the plunger sleeve 17, and product defects caused by slag can be prevented.

Besides, since the supply and exhaust port 28 exists at a horizontal distance from the container part 26 and there is no need to tilt the ladle 24 in supplying molten metal, there is little fear that the ladle 24 damages casting machine members such as a fixed platen 32 in supplying molten metal. Therefore, the supply port 17a of the plunger sleeve 17 can be placed near the fixed platen 32, and this allows the plunger sleeve 17 to have a larger diameter and a smaller length.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

A method and an apparatus for supplying molten metal to a casting machine wherein the amount of molten metal supplied can be controlled precisely and defective castings caused by slag in the molten metal can be prevented. Material supply means supplies a ladle with a suitable amount of a casting material for one shot of casting in a solid state. After the solid casting material is melted into molten metal, the molten metal is supplied from the ladle to the casting machine. By controlling the amount of molten metal supplied by means of the casting material in the solid state, the precision of quantity control of molten metal can be enhanced. In addition, because the molten metal is supplied from the ladle to the casting machine soon after the casting material is melted, the time for molten metal to be exposed to the air can be shortened, and slag generation due to molten metal oxidization can be suppressed.

## Claims

1. A method of supplying molten metal, comprising the steps of:

    supplying a ladle with a suitable amount of a casting material for one shot of casting in a solid state;
    melting said casting material in said solid state into molten metal; and
    supplying said molten metal from said ladle to a casting machine.

2. A method of supplying molten metal from a ladle to a casting machine, including vibrating said ladle which holds said molten metal, detecting vibration frequency of said ladle at this time, and controlling the amount of molten metal supplied on the base of said detected vibration frequency.

3. A method of supplying molten metal according to claim 1 or 2, including vibrating said ladle in supplying said molten metal to said casting machine.

4. A method of supplying a casting machine with molten metal scooped from a molten metal storage furnace, by using a ladle which comprises a container part which molten metal is supplied to and held in, an air port which makes an upper portion of said container part communicate with the external environment and can be opened and closed, and a supply and exhaust port which is provided at a lower portion of said container part for supplying molten metal to said container part or exhausting molten metal from said container part, said method comprising the steps of:

    supplying molten metal from said molten metal storage furnace to said container part through said supply and exhaust port by immersing said ladle in said molten metal storage furnace with said air port open to the air, and closing said air port, when said molten metal supplied to said container part reaches a predetermined amount, in order to hold said predetermined amount of molten metal in said container part; and
    supplying said molten metal held in said container part through said supply and exhaust port to said casting machine by opening said air port to make said upper portion of said container part open to the air after said ladle is conveyed to said casting machine with said air port closed.

5. An apparatus for supplying molten metal from a ladle to a casting machine, comprising:

    material supply means for supplying said ladle with a suitable amount of a casting material for one shot of casting in a solid state; and
    melting means for melting said casting material in said solid state into molten metal.

6. An apparatus for supplying molten metal from a ladle to a casting machine, comprising:

    vibrating means for vibrating said ladle;
    vibration frequency detecting means for detecting vibration frequency of said ladle vibrated by said vibrating means; and
    control means for controlling the amount of molten metal supplied on the base of said vibration frequency detected by said vibration frequency detecting means.

7. An apparatus for supplying a casting machine with molten metal scooped from a molten metal storage furnace, by using a ladle comprising a container part which said molten metal is supplied to and held in, an air port which makes an upper portion of said container part communicate with the external environment and can be opened and closed, a supply and exhaust port which is provided at a lower portion of said container part for supplying said molten

metal to said container part or exhausting said molten metal from said container part, and molten metal quantity detecting means for detecting a predetermined amount of said molten metal having been supplied to said container part.

FIG. 1

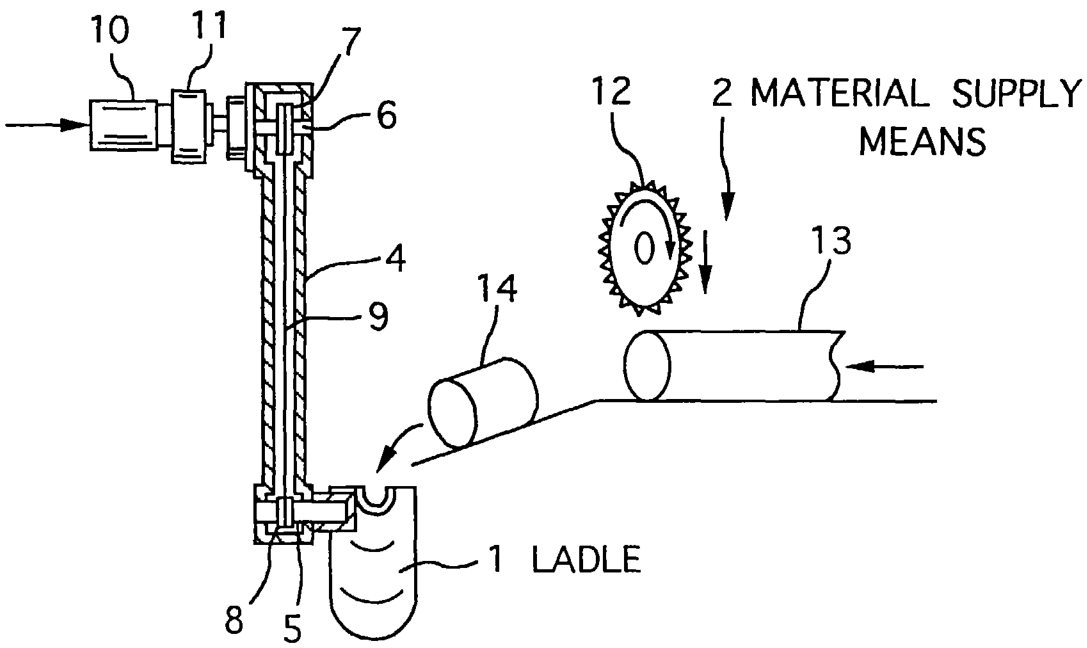
10
11
7
6
12
2 MATERIAL SUPPLY MEANS
4
13
14
9
1 LADLE
8
5

FIG. 2

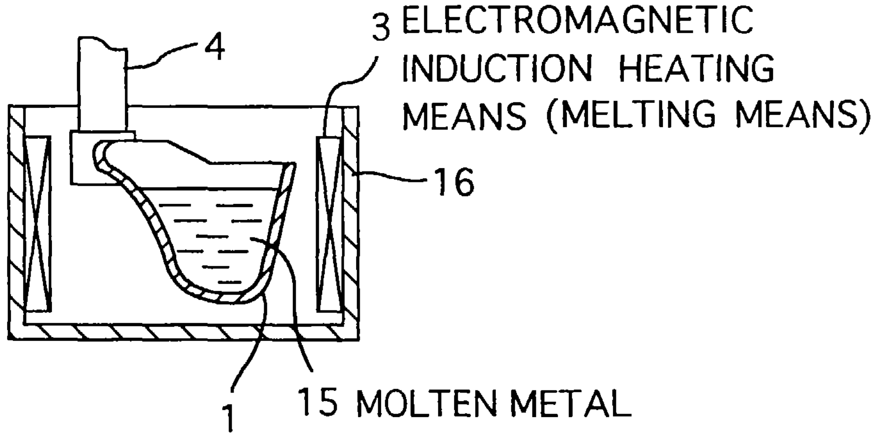
4
3 ELECTROMAGNETIC INDUCTION HEATING MEANS (MELTING MEANS)
16
1
15 MOLTEN METAL

FIG. 3

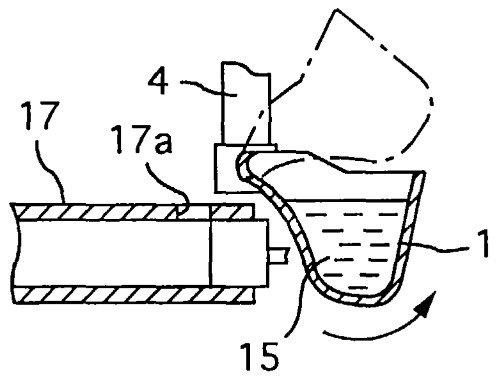


FIG. 4

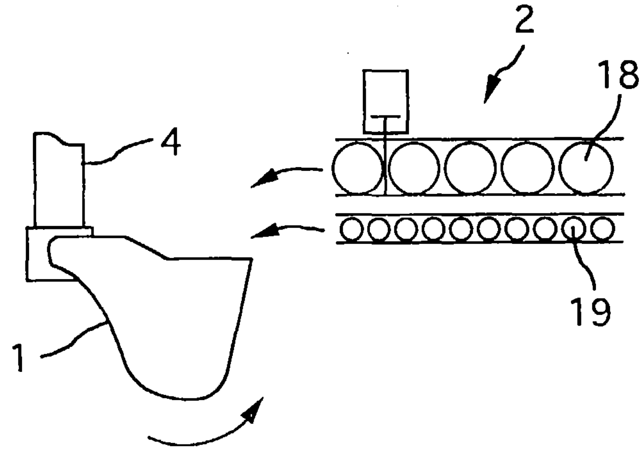


FIG. 5

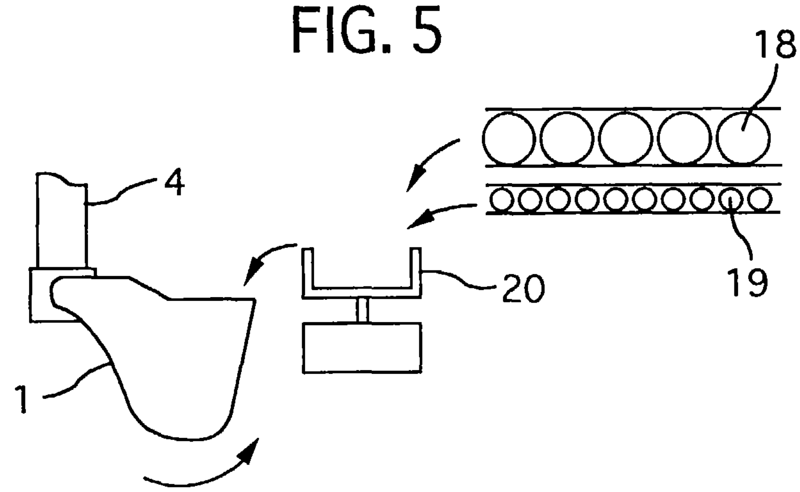

FIG. 6

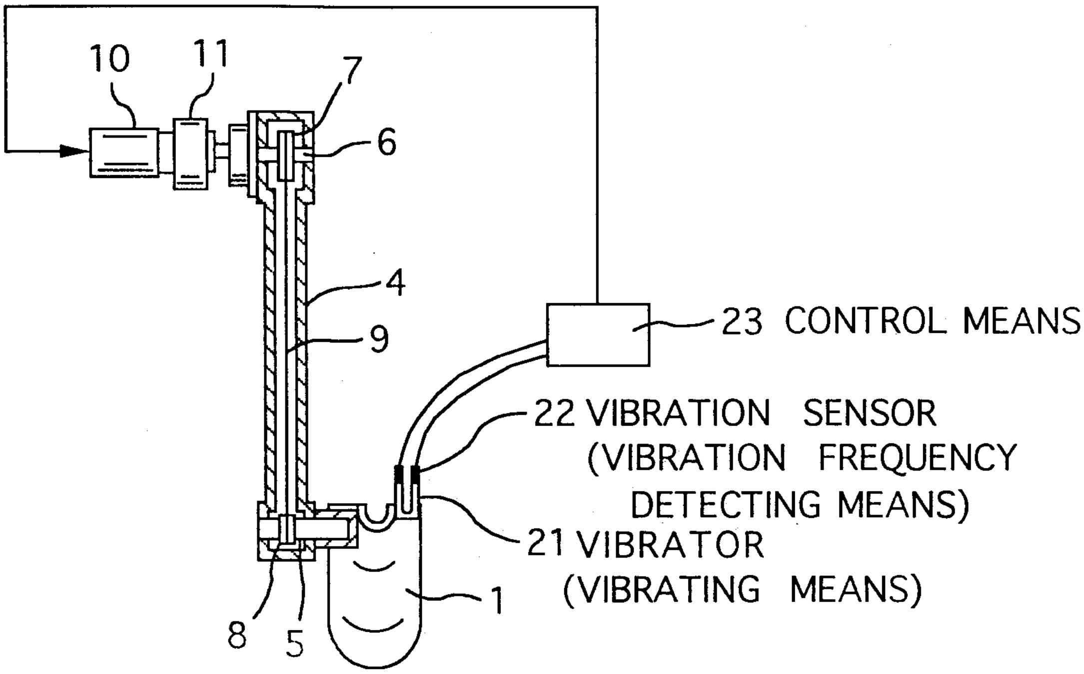
10
11
7
6
4
9
23 CONTROL MEANS
22 VIBRATION SENSOR (VIBRATION FREQUENCY DETECTING MEANS)
21 VIBRATOR (VIBRATING MEANS)
1
8
5

FIG. 7

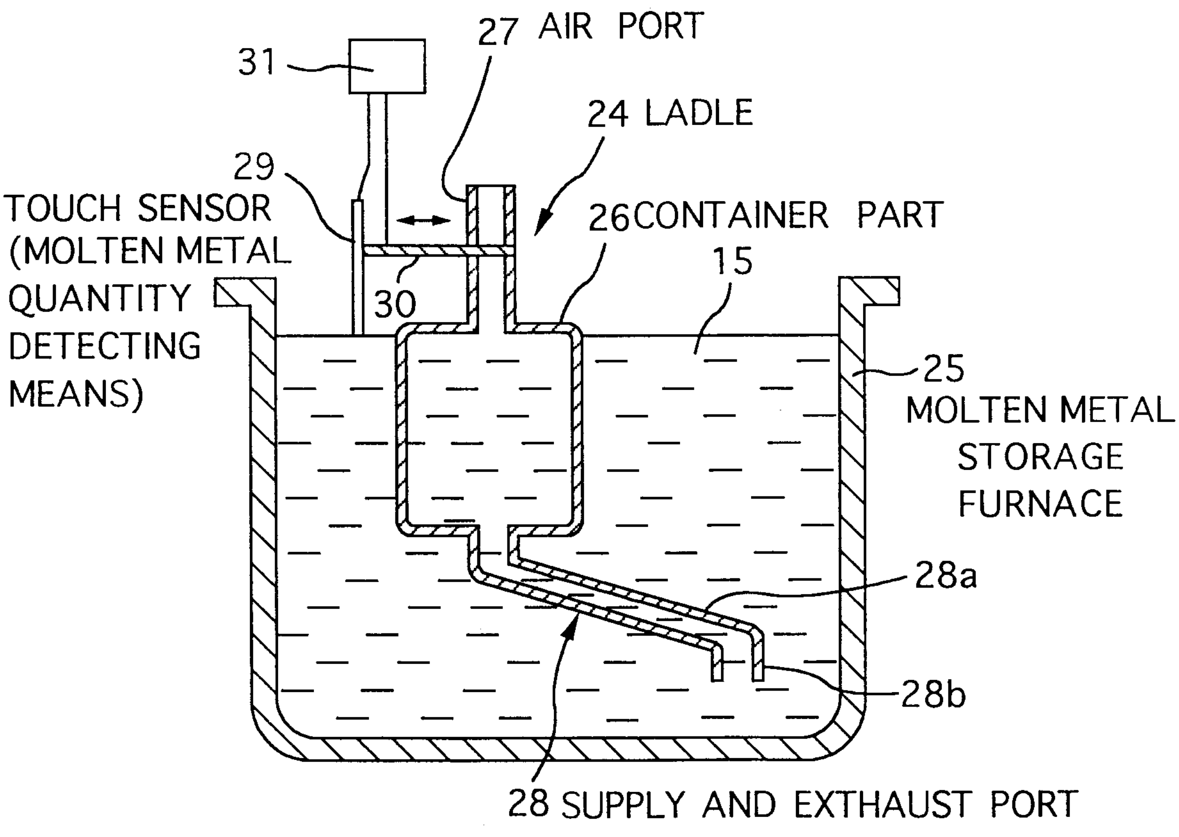
31
27 AIR PORT
24 LADLE
29
TOUCH SENSOR (MOLTEN METAL QUANTITY DETECTING MEANS)
26 CONTAINER PART
15
30
25
MOLTEN METAL STORAGE FURNACE
28a
28b
28 SUPPLY AND EXHAUST PORT

FIG. 8