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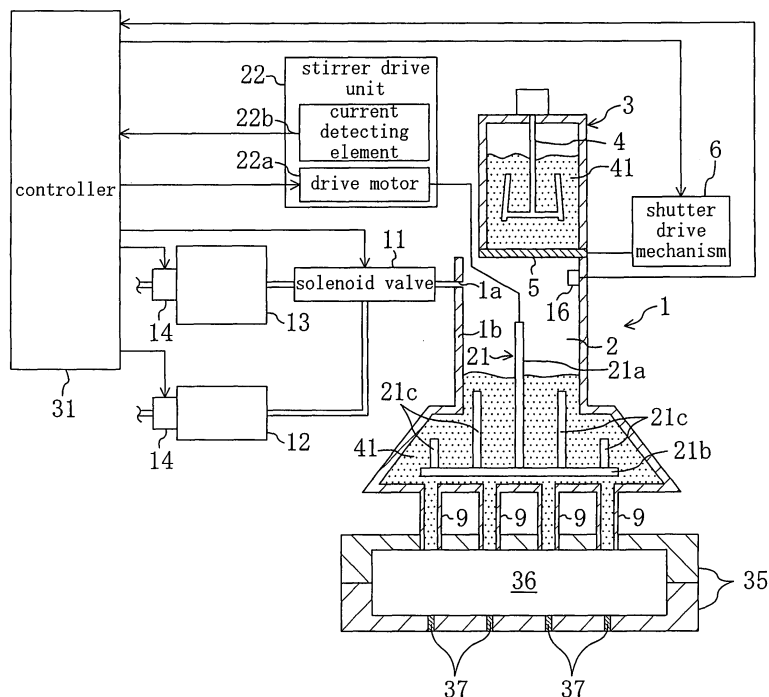
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(54) **Casting mold making system**

(57) In a casting mold making system for blowing and packing casting sand 41 accommodated in a receiver 2 of a blow head 1 into a cavity 36 in molding dies 35 by

feeding pressurized gas into the receiver 2, the pressure of pressurized gas to be fed into the receiver 2 is discontinuously raised at least once in the course of feeding of pressurized gas into the receiver 2.

FIG. 1



**Description**

## BACKGROUND OF THE INVENTION

## (a) Field of the Invention

**[0001]** This invention relates to the technical field of a casting mold making system in which casting sand is blown and packed into a cavity created by molding dies.

## (b) Description of the Related Art

**[0002]** In a well-known casting mold making method, such as disclosed in Published Japanese Patent Application No. H09-141389, gas-curing casting sand is previously accommodated in a receiver of a blow head, the casting sand is blown and packed through the blow nozzles into a cavity in molding dies by feeding pressurized gas into the receiver and a curing gas is then introduced into the cavity to cure the casting sand packed in the cavity, thereby making a casting mold. In another casting mold making method, hot-curing casting sand, instead of gas-curing casting sand, is blown and packed into a cavity in molding dies and the molding dies are heated to cure the casting sand.

**[0003]** In blowing and packing casting sand into a cavity in molding dies using pressurized gas as described above, the most important point is the packability of casting sand into the cavity. In the former technique disclosed in Published Japanese Patent Application No. H09-141389, the packing density for casting sand is increased, after the packing of casting sand into the cavity, by depressurizing the cavity and introducing pressurized air into the depressurized cavity to exert an impact pressure on the casting sand.

**[0004]** However, the above disclosed technique involves a decompressor for depressurizing the cavity and a device for exerting an impact pressure on the casting sand, thereby incurring a larger sized system and significant cost increases.

## SUMMARY OF THE INVENTION

**[0005]** The present invention has been made in view of the foregoing and, therefore, its object is to blow and pack casting sand into a cavity created by molding dies while ensuring good, constant packability with a simple structure.

**[0006]** The inventors conducted intensive studies focusing on the pressure of pressurized gas to be fed into the receiver in the blow head in order to attain the above object and found that the packability of casting sand into the cavity can be enhanced simply by changing the pressure of the pressurized gas. Based on this founding, the present invention is configured to discontinuously raise the pressure of pressurized gas to be fed into the receiver at least once in the course of feeding of pressurized gas into the receiver.

**[0007]** Specifically, a casting mold making system of the present invention includes a blow head having a receiver for accommodating casting sand and a blow nozzle communicating with the receiver and a pressurized gas feed system for feeding pressurized gas into the receiver of the blow head and is configured to feed pressurized gas into the receiver through the pressurized gas feed system and thereby blow the casting sand in the receiver through the blow nozzle into a cavity in molding dies and pack the casting sand into the cavity. Furthermore, the pressurized gas feed system is configured to discontinuously raise the pressure of pressurized gas to be fed into the receiver at least once in the course of feeding of pressurized gas into the receiver.

**[0008]** If the pressure of pressurized gas to be fed into the receiver is low, the packability of casting sand into the cavity becomes poor. On the other hand, if the pressure thereof is high, the packability is good but casting sand may blow out through or clog holes in the molding dies, such as ejector pin holes and vents for expelling pressurized gas. However, if the pressure of pressurized gas to be fed into the receiver is low at the beginning of feeding of the pressurized gas into the receiver, casting sand can cover the openings of the ejector pin holes and vents without blowing out through or clogging them. Then, even if in this state the pressure of pressurized gas is discontinuously raised to high pressure, casting sand neither blows out through nor clogs the ejector pin holes and vents since it has already covered their openings. In addition, if the pressure of pressurized gas is raised to a suitable pressure, a good packability can be obtained. Since thus a good packability can be obtained simply by changing the pressure of pressurized gas, the present invention can be realized with a simple structure without incurring a larger sized system and significant cost increases.

**[0009]** In the above casting mold making system, the pressurized gas feed system is preferably configured to discontinuously raise the pressure of pressurized gas to be fed into the receiver from a low pressure to a high pressure once in the course of feeding of pressurized gas into the receiver.

**[0010]** The time taken to pack casting sand into the cavity is normally as short as within one second. Therefore, raising the pressure of pressurized gas twice or more during the packing is itself difficult as compared with the case of raising it just once and involves a complicated structure. In addition, even if the pressure of pressurized gas is discontinuously raised from low to high just once, a sufficiently good packability can be obtained. Hence, according to the above configuration, the packability of casting sand into the cavity can be enhanced with a simpler structure.

**[0011]** In discontinuously raising the pressure of pressurized gas from a low pressure to a high pressure once as described above, the pressurized gas feed system preferably comprises: a low-pressure tank for storing low-pressure pressurized gas; a high-pressure tank for stor-

ing high-pressure pressurized gas; and a feeding device for first feeding the low-pressure pressurized gas in the low-pressure tank into the receiver and then feeding the high-pressure pressurized gas into the receiver.

**[0012]** Thus, the pressure of pressurized gas to be fed into the receiver can be quickly changed, at an appropriate timing and with high response, to a pressure providing a good packability.

**[0013]** Furthermore, in discontinuously raising the pressure of pressurized gas from a low pressure to a high pressure once, the pressurized gas feed system preferably further comprises a pressure changing device for individually changing the pressure levels of the low and high pressures. More preferably, the casting mold making system further comprises a casting sand amount detection device for detecting the amount of casting sand in the receiver, wherein the pressure changing device is configured to individually change the pressure levels of the low and high pressures based on the amount of casting sand detected by the casting sand amount detection device.

**[0014]** Thus, the pressure levels of the low and high pressures can be changed to optimum pressure levels according to the amount of casting sand in the receiver. Specifically, when casting sand is once blown and packed into the cavity, the amount of casting sand in the receiver is reduced by the amount thereof packed in the cavity. If in this state no casting sand is supplementally fed into the receiver, the manner of blowing out casting sand through the blow nozzle and the packability in the next blowing and packing differ from those in the previous blowing and packing, even at the same pressure level, corresponding to the amount of casting sand reduced from that in the receiver by the previous blowing and packing (generally, casting sand in the receiver becomes more likely to be blown out through the blow nozzle as the amount of casting sand in it is smaller). Particularly in the case of feeding pressurized gas from the low-pressure or high-pressure tank into the receiver, the volume of the empty space in the receiver (i.e., the space in which no casting sand exists) increases by the amount of casting sand reduced, which also makes a difference in the manner of blowing out casting sand (generally, casting sand in the receiver becomes less likely to be blown out through the blow nozzle as the amount of casting sand in it is smaller, i.e., as the volume of the empty space increases). Therefore, if an examination is previously made of the relation between the amount of casting sand and the pressure levels of the low and high pressures to provide optimum packability, the pressure levels can be changed to those providing an optimum packability in each blowing and packing according to the amount of casting sand in the receiver. As a result, good packability can be constantly obtained with stability.

**[0015]** In the casting mold making system in which the pressurized gas feed system includes the pressure changing device, it is preferable that the casting mold making system further comprises: a stirrer for stirring the

casting sand in the receiver; a stirrer drive unit for driving the stirrer; and a stirring resistance detection device for detecting the stirring resistance of the stirrer and that the pressure changing device is configured to individually change the pressure levels of the low and high pressures based on the stirring resistance detected by the stirring resistance detection device.

**[0016]** The stirring resistance of the stirrer is in correspondence with the bulk density of casting sand in the receiver. The bulk density increases owing to pressure applied from pressurized gas as the number of times of blowing and packing increases. In the next blowing and packing, the manner of blowing out casting sand through the blow nozzle and the packability differ from those in the previous blowing and packing, even at the same pressure level, corresponding to an increase in bulk density from the previous blowing and packing. Therefore, if an examination is previously made of the relation between the bulk density and the pressure levels of the low and high pressures to provide optimum packability, the pressure levels can be changed to those according to the stirring resistance detected by the stirring resistance detection device, whereby good packability can be constantly obtained with stability.

**[0017]** Furthermore, in the casting mold making system in which the pressurized gas feed system includes the pressure changing device, it is more preferable that the casting mold making system further comprises: a casting sand amount detection device for detecting the amount of casting sand in the receiver; a stirrer for stirring the casting sand in the receiver; a stirrer drive unit for driving the stirrer; and a stirring resistance detection device for detecting the stirring resistance of the stirrer and that the pressure changing device is configured to individually change the pressure levels of the low and high pressures based on the amount of casting sand detected by the casting sand amount detection device and the stirring resistance detected by the stirring resistance detection device.

**[0018]** Thus, the pressure levels can be changed to optimum levels according to the amount of casting sand and the stirring resistance of the stirrer, thereby surely providing an optimum packability.

#### BRIEF DESCRIPTION OF THE DRAWINGS

##### **[0019]**

Figure 1 is a schematic block diagram showing a casting mold making system according to an embodiment of the present invention.

Figure 2 is a flowchart showing a processing procedure of a controller.

Figure 3 is a graph showing an example of a pattern of changes in the internal pressure of a receiver.

Figure 4 is a diagram showing a casting mold actually made.

Figure 5 is a graph showing changes in the internal

pressure of a receiver in Working Example.

Figure 6 is a graph showing changes in the internal pressure of a receiver in Comparative Example 1.

Figure 7 is a graph showing changes in the internal pressure of a receiver in Comparative Example 2.

Figure 8 is a graph showing changes in the internal pressure of a receiver in Comparative Example 3.

Figure 9 is a graph showing measurement results on the amounts of casting sand packed and the amounts of casting sand blown out in Working Example and Comparative Examples 1 to 3.

#### DETAILED DESCRIPTION OF THE INVENTION

**[0020]** An embodiment of the present invention will be described below with reference to the drawings.

**[0021]** Figure 1 schematically shows a casting mold making system according to an embodiment of the present invention. The casting mold making system is a cold box casting mold making system including a blow head 1 with a receiver 2 for accommodating gas-curing casting sand 41. The casting sand 41 contains a binder composed of a phenol resin and a polyisocyanate compound and a solvent so that the surfaces of sand particles are coated with the binder and the solvent. Examples of the phenol resin in the binder include phenol resins having at least one benzyl ether group in its molecule, novolak resins and their derivative resins. Examples of the polyisocyanate compound include diphenylmethane diisocyanate, hexamethylene diisocyanate and 4,4'-dicyclohexylmethane diisocyanate. The solvent is an organic solvent including aliphatic hydrocarbons, alicyclic hydrocarbons, aromatic hydrocarbons, halogenated hydrocarbons, ketones, esters, ethers and alcohols, or their mixtures.

**[0022]** The casting sand 41 is fed from a kneading unit 3 disposed above the receiver 2 to the receiver 2. Specifically, the binder, the solvent and sand are charged into the kneading unit 3 and uniformly kneaded by a kneader 4 driven into rotation in the kneading unit 3, thereby providing casting sand 41 in which sand particles are coated with the binder and the solvent as described above. A shutter 5, opened and closed by a shutter drive mechanism 6, is disposed between the receiver 2 and the kneading unit 3. The operation of the shutter drive mechanism 6 is controlled by a controller 31. When the shutter 5 is opened by the shutter drive mechanism 6, the casting sand 41 falls down from the kneading unit 3 by its own weight and is fed to the receiver 2.

**[0023]** The bottom of the blow head 1 is provided with a plurality of blow nozzles 9, communicated with the receiver 2, for blowing out casting sand 41 in the receiver 2 therethrough. The blow nozzles 9 are presented to a cavity 36 created by a plurality of molding dies 35 set up below the casting mold making system. Casting sand 41 blown out through the blow nozzles 9 is packed into the cavity 36 to have a shape of a casting mold to be made by the casting mold making system. Casting molds made

by the casting mold making system include casting molds for cylinder blocks or cylinder heads and cores for water jackets of the cylinder heads.

**[0024]** An upper portion of any one of the side walls defining the receiver 2 in the blow head 1 is formed with an air feed port 1a through which pressurized air serving as pressurized gas is fed into the receiver 2. The air feed port 1a is connected to a first air tank 12 and a second air tank 13 through a solenoid valve 11 whose actuation is controlled by the controller 31. The first and second air tanks 12 and 13 are supplied with air in the factory while each air to the air tanks 12 and 13 is kept at a constant pressure by a regulator (not shown). The airs supplied are stored as pressurized airs in the air tanks 12 and 13. The first air tank 12 stores pressurized air at a low pressure (e.g., about 0.2 MPa), while the second air tank 13 stores pressurized air at a higher pressure (e.g., about 0.4 MPa) than the first air tank 12. Thus, the first air tank 12 corresponds to a low-pressure tank and the second air tank 13 corresponds to a high-pressure tank.

**[0025]** The solenoid valve 11 is selectively put, under the control of the controller 31, into any one of three positions, a position to communicate the first air tank 12 with the receiver 2, a position to communicate the second air tank 13 with the receiver 2 and a position not to communicate both the first and second air tanks 12 and 13 with the receiver 2. When the solenoid valve 11 is put into a position to communicate the first or second air tank 12 or 13 with the receiver 2, pressurized air is fed into the receiver 2, whereby casting sand 41 in the receiver 2 is blown through the blow nozzles 9 into the cavity 36 in the molding dies 35 and packed into the cavity 36. Thus, the solenoid valve 11, the first and second air tanks 12 and 13 and the controller 31 constitute a pressurized gas feed system for feeding pressurized gas into the receiver 2. The pressurized air, blown into the cavity 36 together with the casting sand 41, is vented out of the cavity 36 through air vents 37 attached to the bottom of the molding die 35.

**[0026]** The pressurized air feed system is configured to discontinuously raise the pressure of pressurized air to be fed into the receiver 2 at least once in the course of feeding of pressurized air into the receiver 2. In this embodiment, the pressure of pressurized air to be fed into the receiver 2 is discontinuously raised from a low pressure to a high pressure just once in the course of feeding of pressurized air into the receiver 2. Specifically, at the beginning of feeding of pressurized air into the receiver 2, the solenoid valve 11 is put into a position to communicate the first air tank 12 with the receiver 2 by the controller 31. When a first predetermined time passes since the start of feeding of a low-pressure pressurized air into the receiver 2, the solenoid valve 11 is put into a position to communicate the second air tank 13 with the receiver 2 by the controller 31. Thereby, partway through the feeding of pressurized air into the receiver 2, pressurized air to be fed into the receiver 2 is changed from the low-pressure pressurized air in the first air tank 12 to

a high-pressure pressurized air in the second air tank **13**. Thus, the solenoid valve **11** and the controller **31** constitute a feeding device for first feeding the low-pressure pressurized gas in the low-pressure tank into the receiver **2** and then feeding the high-pressure pressurized gas into the receiver **2**. Then, when a second predetermined time (longer than the first predetermined time) passes since the start of feeding of the low-pressure pressurized air into the receiver **2**, the solenoid valve **11** is put into a position not to communicate both the first and second air tanks **12** and **13** with the receiver **2** by the controller **31**.  
**[0027]** The first predetermined time, which is the timing of changing the pressure of pressurized air to be fed into the receiver **2**, is previously set at such a time period that casting sand **41** neither blows out through nor clogs ejector pin holes (not shown) and the air vents **37** and that good packability can be obtained. The first predetermined time is normally about 0.2 to 0.3 seconds. The second predetermined time is previously set at a slightly longer time period than the time period taken to fully pack casting sand **41** into the cavity **36** and varies depending upon the volume of the cavity **36**.

**[0028]** The first and second air tanks **12** and **13** are provided with their respective pressure intensifying valves **14** whose actuation is controlled by the controller **31**. Through the control of each of the pressure intensifying valves **14**, the low-pressure and high-pressure pressurized airs in the first and second air tanks **12** and **13** can be individually changed in pressure. Thus, the pressure intensifying valves **14** and the controller **31** constitute a pressure changing device for individually changing the pressure levels of the low and high pressures. It should be noted that even when the pressurized airs in the first and second air tanks **12** and **13** are individually changed, the pressure magnitude relation between the pressurized airs in the first and second air tanks **12** and **13** does not change.

**[0029]** An upper part of the interior of the receiver **2** of the blow head **1** is provided with a casting sand amount sensor **16** serving as a casting sand amount detection device for detecting the amount of casting sand **41** in the receiver **2**. In this embodiment, the casting sand amount sensor **16** is configured to emit infrared rays downward, receive infrared rays reflected from the top surface of the casting sand **41** and detect the amount of casting sand **41** in the receiver **2** based on the intensity of the reflected infrared rays. However, any appropriate sensors having other configurations can also be employed. Data on the amount of casting sand **41** in the receiver **2** detected by the casting sand amount sensor **16** is input to the controller **31**.

**[0030]** Furthermore, a lower part of the interior of the receiver **2** of the blow head **1** is provided with a stirrer **21** for stirring casting sand **41** in the receiver **2**. The stirrer **21** is an element for detecting the bulk density of casting sand **41** in the receiver **2** as described later. The stirrer **21** is composed of a rotary shaft **21a** vertically extending and rotatably supported, a base plate **21b** fixed to the

lower end of the rotary shaft **21a** and extending horizontally, and a plurality of stirring bars **21c** disposed on the base plate **21b**. The upper end of the rotary shaft **21a** is connected to the stirrer drive unit **22**. The stirrer drive unit **22**, whose detailed configuration is not described here, includes a drive motor **22a**, a connecting member made, for example, of flexible wire and connecting the rotary shaft of the drive motor **22a** to the rotary shaft **21a**, and a drive circuit for driving the drive motor **22a**. The drive circuit includes a current detecting element **22b** for detecting the value of current flowing into the drive motor **22a**. The current detecting element **22b** constitutes a stirring resistance detection device for detecting the stirring resistance of the stirrer **21**.

**[0031]** The operation of the drive motor **22a** of the stirrer drive unit **22** is controlled by the controller **31**. During operation of the drive motor **22a**, data on the value of current detected by the current detecting element **22b** is input to the controller **31**.

**[0032]** The controller **31** is configured to operate the drive motor **22a** prior to the blowing and packing of casting sand **41** in the receiver **2** into the cavity **36**. The controller **31** is also configured to allow the pressure intensifying valves **14** to individually change the pressures of the pressurized airs in the first and second air tanks **12** and **13** based on the value of current detected by the current detecting element **22b** during operation of the drive motor **22a** and the amount of casting sand **41** detected by the casting sand amount sensor **16**.

**[0033]** Specifically, when casting sand **41** is once blown and packed into the cavity **36**, the amount of casting sand **41** in the receiver **2** is reduced by the amount thereof packed in the cavity **36**. If in this state no casting sand **41** is supplementally fed into the receiver **2**, the manner of blowing out casting sand **41** through the blow nozzles **9** and the packability in the next blowing and packing differ from those in the previous blowing and packing, even at the same pressure level, corresponding to the amount of casting sand **41** reduced from that in the receiver **2** by the previous blowing and packing. Particularly in the case of feeding pressurized air from the first or second air tank **12** or **13** into the receiver **2** as in this embodiment, the volume of the empty space in the receiver **2** (i.e., the space in which no casting sand **41** exists) increases by the amount of casting sand **41** reduced, which also makes a difference in the manner of blowing out casting sand **41**. In the former ordinary case, the pressurized airs in the first and second air tanks **12** and **13** are changed to lower pressure levels because casting sand **41** in the receiver **2** becomes more likely to be blown out through the blow nozzles **9** as the amount of casting sand **41** in it is smaller. In the latter particular case, however, the increase in the volume of the empty space lowers the internal pressure of the receiver **2** and therefore weakens the effect of ease of blowing out casting sand **41**. Therefore, the pressurized airs are changed in pressure by a smaller amount of pressure reduction than that corresponding to the amount of casting sand

41 reduced.

[0034] On the other hand, the value of current is in correspondence with the motor torque required to rotate the stirrer 21, i.e., the stirring resistance of the stirrer 21, and the stirring resistance of the stirrer 21 is in correspondence with the bulk density of casting sand 41 in the receiver 2. In other words, as the value of current of the drive motor 22a increases, the bulk density increases. Furthermore, the bulk density increases owing to pressure applied from pressurized air as the number of times of blowing and packing increases. In the next blowing and packing, the manner of blowing out casting sand 41 through the blow nozzles 9 and the packability differ from those in the previous blowing and packing, even at the same pressure level, corresponding to an increase in bulk density from the previous blowing and packing.

[0035] Therefore, an examination is previously made of the relation of the pressures of pressurized airs in the first and second air tanks 12 and 13 with the value of current (the stirring resistance of the stirrer 21, i.e., the bulk density) and the amount of casting sand 41 to provide optimum packability, the examination results are mapped in a table and the table is stored in the controller 31. When receiving data on the value of current and the amount of casting sand 41 from the current detecting element 22b and the casting sand amount sensor 16, respectively, during operation of the casting mold making system, the controller 31 sets, by reference to the table, the pressures of pressurized airs in the first and second air tanks 12 and 13 that will provide an optimum packability and controls the pressure intensifying valves 14 to reach the pressures.

[0036] The pressures of pressurized airs in the first and second air tanks 12 and 13 may be set based on only the amount of casting sand 41 detected by the casting sand amount sensor 16. In this case, the stirrer 21 and the stirrer drive unit 22 can be dispensed with. Alternatively, the pressures of pressurized airs in the first and second air tanks 12 and 13 may be set based on only the value of current detected by the current detecting element 22b (the stirring resistance of the stirrer 21).

[0037] The interior of the receiver 2 may be provided with a pressure sensor for detecting the internal pressure of the receiver 2 and the pressures of pressurized airs in the first and second air tanks 12 and 13 may be set based on, in addition to the value of current and the amount of casting sand 41, the internal pressure of the receiver 2 detected by the pressure sensor. Thus, changes in the internal pressure of the receiver 2 can be approximated to an optimum pattern of changes.

[0038] Furthermore, the first predetermined time, which is the timing of changing the pressure of pressurized air to be fed into the receiver 2, may be changed based on the amount of casting sand 41 detected by the casting sand amount sensor 16 (or also based on the value of current detected by the current detecting element 22b and/or the internal pressure of the receiver 2 detected by the pressure sensor).

[0039] When the amount of casting sand 41 detected by the casting sand amount sensor 16 reaches below a predetermined amount, i.e., when the remaining amount of casting sand 41 gets too low to provide enough to pack casting sand 41 into the cavity 36, the controller 31 actuates the shutter drive mechanism 6 to feed casting sand 41 from the kneading unit 3 into the receiver 2.

[0040] Next, a processing procedure of the controller 31 is described with reference to the flowchart of Figure 2.

[0041] In the first step S1, the drive motor 22a of the stirrer drive unit 22 is operated until the stirrer 22 reaches a predetermined number of rotations. In the next step S2, the pressures of pressurized airs in the first and second air tanks 12 and 13 are individually set by reference to the table based on the value of current detected by the current detecting element 22b during the operation of the drive motor 22a and the amount of casting sand 41 detected by the casting sand amount sensor 16 and the pressurized airs are changed to the set pressures by the associated pressure intensifying valves 14.

[0042] In the next step S3, the solenoid valve 11 is put into a position to communicate the first air tank 12 with the receiver 2 to feed a low-pressure pressurized air in the first air tank 12 into the receiver 2. Subsequently, it is determined in step S4 whether the first predetermined time has passed since the start of feeding of the low-pressure pressurized air.

[0043] If the determination in step S4 is NO, the procedure goes back to step S3. If the determination in step S4 is YES, the procedure goes to step S5 to put the solenoid valve 11 into a position to communicate the second air tank 13 with the receiver 2, thereby feeding a high-pressure pressurized air from the second air tank 13 into the receiver 2. Subsequently, it is determined in step S6 whether the second predetermined time has passed since the start of feeding of the low-pressure pressurized air.

[0044] If the determination in step S6 is NO, the procedure goes back to step S5. If the determination in step S6 is YES, the procedure goes to step S7 to put the solenoid valve 11 into a position not to communicate both the first and second air tanks 12 and 13 with the receiver 2, thereby stopping the feeding of pressurized air.

[0045] In the next step S8, it is determined whether the amount of casting sand 41 detected by the casting sand amount sensor 16 is smaller than the predetermined amount. If the determination in step S8 is NO, the procedure ends. If the determination in step S8 is YES, the procedure goes to step S9 to actuate the shutter drive mechanism 6 and then ends.

[0046] Next, a description is given of a method for making a casting mold using the above casting mold making system.

[0047] First, the molding dies 35 are set up in the casting mold making system. Then, when the casting mold making system is activated by switch operation or in other manners, the stirrer 21 is rotated a predetermined number of rotations by the drive motor 22a of the stirrer

drive unit **22** and the value of current of the drive motor **22a** in operation is detected. Then, based on the value of current of the drive motor **22a** thus detected and the amount of casting sand **41** detected by the casting sand amount sensor **16**, the pressures of pressurized airs in the first and second air tanks **12** and **13** are changed to individual suitable pressures by the associated pressure intensifying valves **14**.

**[0048]** Subsequently, pressurized air starts to be fed into the receiver **2**. At the beginning of feeding of pressurized air, a low-pressure pressurized air in the first tank **12** is fed into the receiver **2**. Thus, such as shown in Figure **3**, the internal pressure of the receiver **2** is gradually raised and casting sand **41** in the receiver **2** then starts to be blown through the blow nozzles **9** into the cavity **36** in the molding dies **35** when the internal pressure reaches a certain pressure. At the time, since low-pressure pressurized air is fed into the receiver **2**, the internal pressure of the receiver **2** is not raised so much, so that the pressure on casting sand **41** in the receiver **2** is not so large. Therefore, casting sand **41** blown into the cavity **36** can cover the openings of the ejector pin holes and the air vents **37** without blowing out through or clogging them. When the first predetermined time passes since the start of feeding of the low-pressure pressurized air, casting sand **41** in the cavity **36** fully covers all the openings of the ejector pin holes and the air vents **37**.

**[0049]** Next, when the first predetermined time has passed since the start of feeding of the low-pressure pressurized air, pressurized air to be fed into the receiver **2** is changed from the low-pressure pressurized air in the first air tank **12** to a high-pressure pressurized air in the second air tank **13**, thereby feeding the high-pressure pressurized air from the second air tank **13** into the receiver **2**. Thus, as shown in Figure **3**, the internal pressure of the receiver **2** abruptly rises. As a result, a large pressure acts on casting sand **41** in the receiver **2**, whereby the casting sand **41** rushes out through the blow nozzles **9** and becomes swiftly packed into the cavity **36**. Since casting sand **41** in the cavity **36** has already covered all the openings by the time, casting sand **41** being blown can be packed into the cavity **36** with high packability without blowing out through or clogging the ejector pin holes and the air vents **37**.

**[0050]** If the packing of casting sand **41** into the cavity **36** is completed before the second predetermined time passes since the start of feeding of the low-pressure pressurized air and the second predetermined time then passes, the feeding of pressurized air is stopped. As shown in Figure **3**, the internal pressure of the receiver **2** increases during a short period of time after the stop of feeding of pressurized air but then gradually reduces because the pressurized air gradually flows through between casting sand particles and the air vents **37** away to the outside of the molding dies **35**. Note that, in the casting mold making system used for the measurement of Figure **3**, an exhaust valve is provided for exhausting

pressurized air from the receiver **2** and operated during the measurement and, therefore, the rate of reduction in the pressure in the receiver **2** is considerably high.

**[0051]** After the blowing and packing, in this embodiment, the molding dies **35** are moved to an unshown curing gas introduction device disposed separately from the blow head **1** in order to introduce curing gas into the cavity **36** in the molding dies **35**, and placed in the curing gas introduction device. Then, curing gas (such as triethylamine gas) is introduced into the cavity **36** to cure the casting sand **41** packed in the cavity **36**, thereby completing the making of a high-quality casting mold.

**[0052]** Then, if the molding dies **35** are set up again in the casting mold making system in order to make another casting mold and the casting mold making system is activated again, the processing procedure of the controller **31** is carried out similarly and casting sand **41** in the receiver **2** is packed into the cavity **36** in the molding dies **35**. In this blowing and packing, the amount of casting sand **41** generally becomes smaller than that in the previous blowing and packing (but becomes larger when casting sand **41** is fed from the kneading unit **3** into the receiver **2**). In other words, the volume of the space in the receiver **2** where no casting sand **41** exists increases.

In addition, the bulk density of casting sand **41** in the receiver **2** becomes higher than that in the previous blowing and packing owing to pressure applied from pressurized air in the previous blowing and packing. However, since in this embodiment the pressures of pressurized airs in the first and second air tanks **12** and **13** are individually changed based on the bulk density of casting sand **41** (the value of current detected by the current detecting element **22b**) and the amount of casting sand **41** detected by the casting sand amount sensor **16**, casting sand **41** can be well packed into the cavity **36** also in this blowing and packing. After the blowing and packing, the casting sand **41** in the cavity **36** is cured similarly. If the above processing procedure and curing of casting sand **41** are repeated in this manner, a large number of casting molds can be made.

**[0053]** When the amount of casting sand **41** in the receiver **2** becomes smaller than the predetermined amount after the blowing and packing, the shutter drive mechanism **6** is actuated to put the shutter **5** to an open position, whereby casting sand **41** is fed from the kneading unit **3** into the receiver **2**.

**[0054]** As described above, in this embodiment, the pressure of pressurized air to be fed into the receiver **2** is discontinuously raised from a low pressure to a high pressure once in the course of feeding of pressurized air into the receiver **2**. Therefore, the packability of casting sand **41** into the cavity **36** can be enhanced with a simple structure. In addition, casting sand **41** can be prevented from blowing out through or clogging the ejector pin holes and the air vents **37**, thereby preventing the ejector pin holes from wearing owing to clogging of casting sand **41**.

**[0055]** Although in the above embodiment the pressure of pressurized air to be fed into the receiver **2** is

discontinuously raised from a low pressure to a high pressure just once in the course of feeding of pressurized air into the receiver 2, the number of times to discontinuously raise the pressure of pressurized air may be two or more. However, raising the pressure of pressurized air twice or more during the packing is itself difficult as compared with the case of raising it just once and involves a complicated structure because the time taken to pack casting sand 41 is as short as within one second. In addition, even if the pressure of pressurized air is raised from low to high just once, a sufficiently good packability can be obtained. Therefore, considering that the structure of the casting mold making system should be simpler, the pressure of pressurized air is preferably raised from low to high just once as in the above embodiment.

[0056] Although in the above embodiment the pressurized gas feed system includes first and second air tanks 12 and 13 for storing pressurized air and is configured to feed pressurized air from the first and second air tanks 12 and 13 into the receiver 2, the pressurized gas feed system may be instead configured to provide two pressurized air sources containing airs of different pressures and feed into the receiver 2 first a low-pressure pressurized air from one pressurized air source and then a high-pressure pressurized air from the other.

[0057] Furthermore, although in the above embodiment the amount of casting sand 41 is detected by the casting sand amount sensor 16, the casting sand amount sensor 16 may not be used, for example, in the case of making a large number of casting molds of the same configuration. Specifically, in this case, the amount of casting sand 41 reduced in a single blowing and packing is substantially constant. On the basis of this fact, if after every given times of the blowing and packing a given amount of casting sand 41 (i.e., the given times multiplied by the amount of casting sand reduced in a single blowing and packing) is fed from the kneading unit 3 into the receiver 2, individual amounts of casting sand 41 in the receiver 2 for the respective blowing and packing times can be determined. Therefore, if the controller 31 stores the individual amounts of casting sand 41 determined, a large number of casting molds of the same configuration can be made without using the casting sand amount sensor 16.

[0058] Although the above embodiment shows an example in which the present invention is applied to a cold box casting mold making system, the present invention is applicable to a shell mold making system for blowing and packing hot-curing casting sand into a cavity in molding dies and heating the molding dies to cure the casting sand.

[0059] A casting mold making system as in the above embodiment was used to make a plate casting mold having approximately the shape of the letter U. In order to make the casting mold, the casting mold making system has blow nozzles provided at its points corresponding to both ends of the casting mold and an air vent provided at its point corresponding to the middle of the casting

mold.

[0060] Measurement was made in terms of the internal pressure of the receiver, the weights of casting molds produced (i.e., the amounts of casting sand packed) and the weights of casting sand blown out through the air vent (i.e., the amounts of casting sand blown out) in the case of changing the pressure of pressurized air to be fed into the receiver from low to high once in the course of feeding of pressurized air (Working Example) as in the above embodiment, the case of feeding pressurized air while keeping it at a constant low pressure (Comparative Example 1), the case of feeding pressurized air while keeping it at a constant high pressure (Comparative Example 2) and the case of changing the pressure of pressurized air from high to low once in the course of feeding of pressurized air (Comparative Example 3). The pressure levels of low and high pressures in Comparative Examples 1 to 3 are the same as in Working Example.

[0061] Figure 5 shows a pattern of changes in the internal pressure of the receiver in Working Example. The pressure changes in this case are approximately the same as those in Figure 3. Figures 6 to 8 shows patterns of changes in the internal pressure of the receiver in Comparative Examples 1 to 3, respectively.

[0062] Figure 9 shows measurement results on the amounts of casting sand packed and the amounts of casting sand blown out in Working Example and Comparative Examples 1 to 3. Reference to Figure 9 indicates that when the pressure of pressurized air being fed was kept at a constant low pressure as in Comparative Example 1, the amount of casting sand packed became considerably small. This is because the molded product did not have a full shape of a casting mold but lacked both ends of the shape. On the other hand, the amount of casting sand blown out was very small and, therefore, Comparative Example 1 was good in this respect. When the pressure of pressurized air being fed was kept at a constant high pressure as in Comparative Example 2, casting sand was fully packed but the amount of casting sand blown out became considerably large. When the pressure of pressurized air was changed from high to low as in Comparative Example 3, the molded product had a full shape of the casting mold but caused defects due to air entrainment (had a slightly smaller amount of casting sand packed than that of Comparative Example 2 because of low rate of packing). On the other hand, the amount of casting sand blown out in Comparative Example 3 was smaller than that in Comparative Example 2 but cannot be said to be larger and more excellent than that in Comparative Example 1.

[0063] In contrast, when the pressure of pressurized air was changed from low to high as in Working Example, casting sand was fully packed as in Comparative Example 2 and the amount of casting sand blown out was nearly as low as in Comparative Example 1.

[0064] Therefore, it can be seen from the above results that if the pressure of pressurized air to be fed into the receiver is changed from low to high during feeding of

pressurized air into the receiver, the packability of casting sand into the cavity can be enhanced while the amount of casting sand blown out through holes in the molding dies is minimized.

### Claims

1. A casting mold making system including a blow head (1) having a receiver (2) for accommodating casting sand (41) and a blow nozzle (9) communicating with the receiver and a pressurized gas feed system (11, 12, 13, 31) for feeding pressurized gas into the receiver of the blow head and configured to feed pressurized gas into the receiver through the pressurized gas feed system and thereby blow the casting sand in the receiver through the blow nozzle into a cavity (36) in molding dies (35) and pack the casting sand into the cavity, wherein the pressurized gas feed system is configured to discontinuously raise the pressure of pressurized gas to be fed into the receiver at least once in the course of feeding of pressurized gas into the receiver.
2. The casting mold making system of claim 1, wherein the pressurized gas feed system is configured to discontinuously raise the pressure of pressurized gas to be fed into the receiver from a low pressure to a high pressure once in the course of feeding of pressurized gas into the receiver.
3. The casting mold making system of claim 2, wherein the pressurized gas feed system comprises: a low-pressure tank (12) for storing low-pressure pressurized gas; a high-pressure tank (13) for storing high-pressure pressurized gas; and a feeding device (11, 31) for first feeding the low-pressure pressurized gas in the low-pressure tank into the receiver and then feeding the high-pressure pressurized gas into the receiver.
4. The casting mold making system of claim 2 or 3, wherein the pressurized gas feed system further comprises a pressure changing device (14, 31) for individually changing the pressure levels of the low and high pressures.
5. The casting mold making system of claim 4, further comprising a casting sand amount detection device (16) for detecting the amount of casting sand in the receiver, wherein the pressure changing device is configured to individually change the pressure levels of the low and high pressures based on the amount of casting sand detected by the casting sand amount detection device.

6. The casting mold making system of claim 4, further comprising:

a stirrer (21) for stirring the casting sand in the receiver;  
a stirrer drive unit (22) for driving the stirrer; and  
a stirring resistance detection device (22b) for detecting the stirring resistance of the stirrer,

wherein the pressure changing device is configured to individually change the pressure levels of the low and high pressures based on the stirring resistance detected by the stirring resistance detection device.

7. The casting mold making system of claim 4, further comprising:

a casting sand amount detection device (16) for detecting the amount of casting sand in the receiver;  
a stirrer (21) for stirring the casting sand in the receiver;  
a stirrer drive unit (22) for driving the stirrer; and  
a stirring resistance detection device (22b) for detecting the stirring resistance of the stirrer,

wherein the pressure changing device is configured to individually change the pressure levels of the low and high pressures based on the amount of casting sand detected by the casting sand amount detection device and the stirring resistance detected by the stirring resistance detection device.

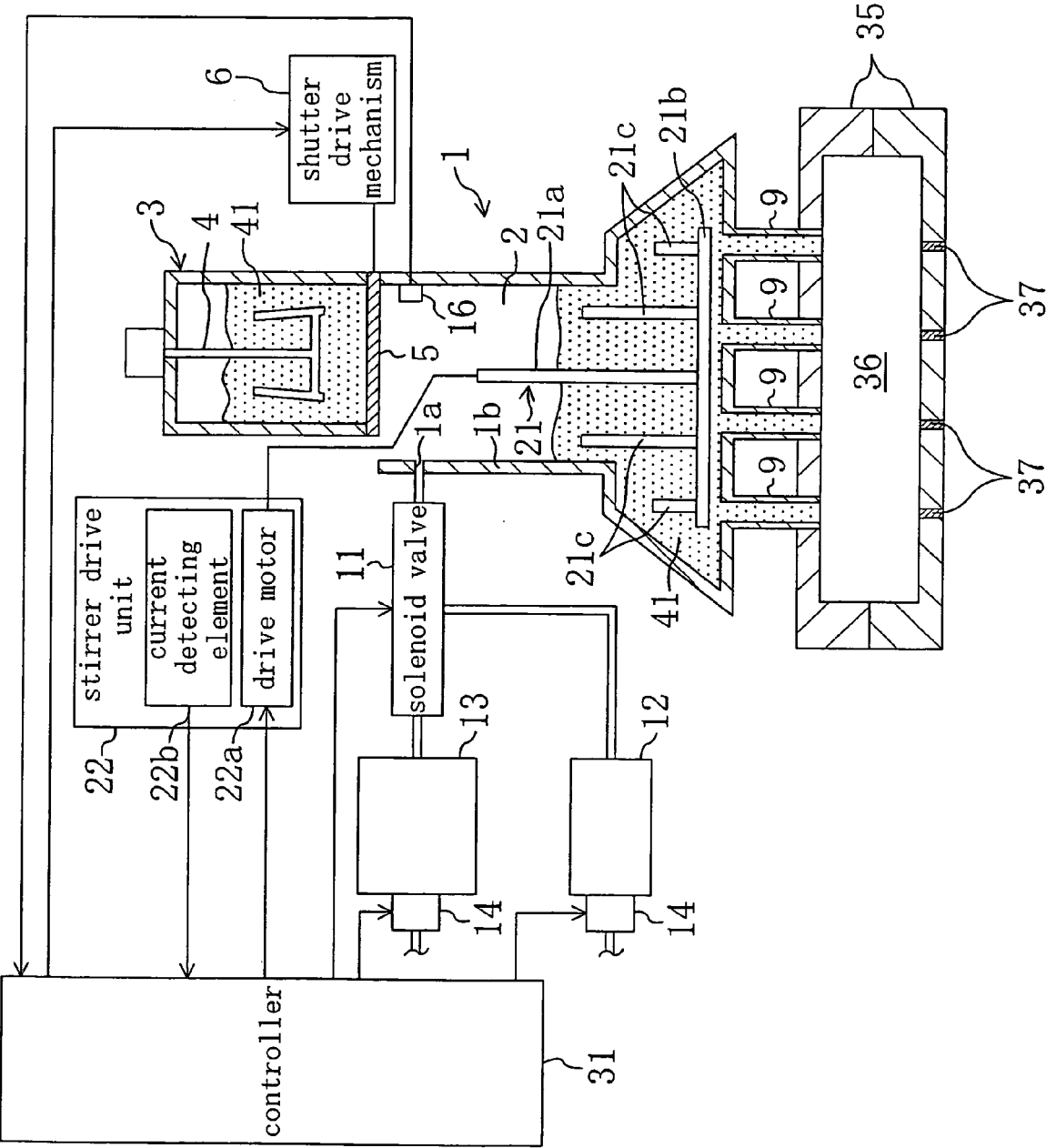


FIG. 1

FIG. 2

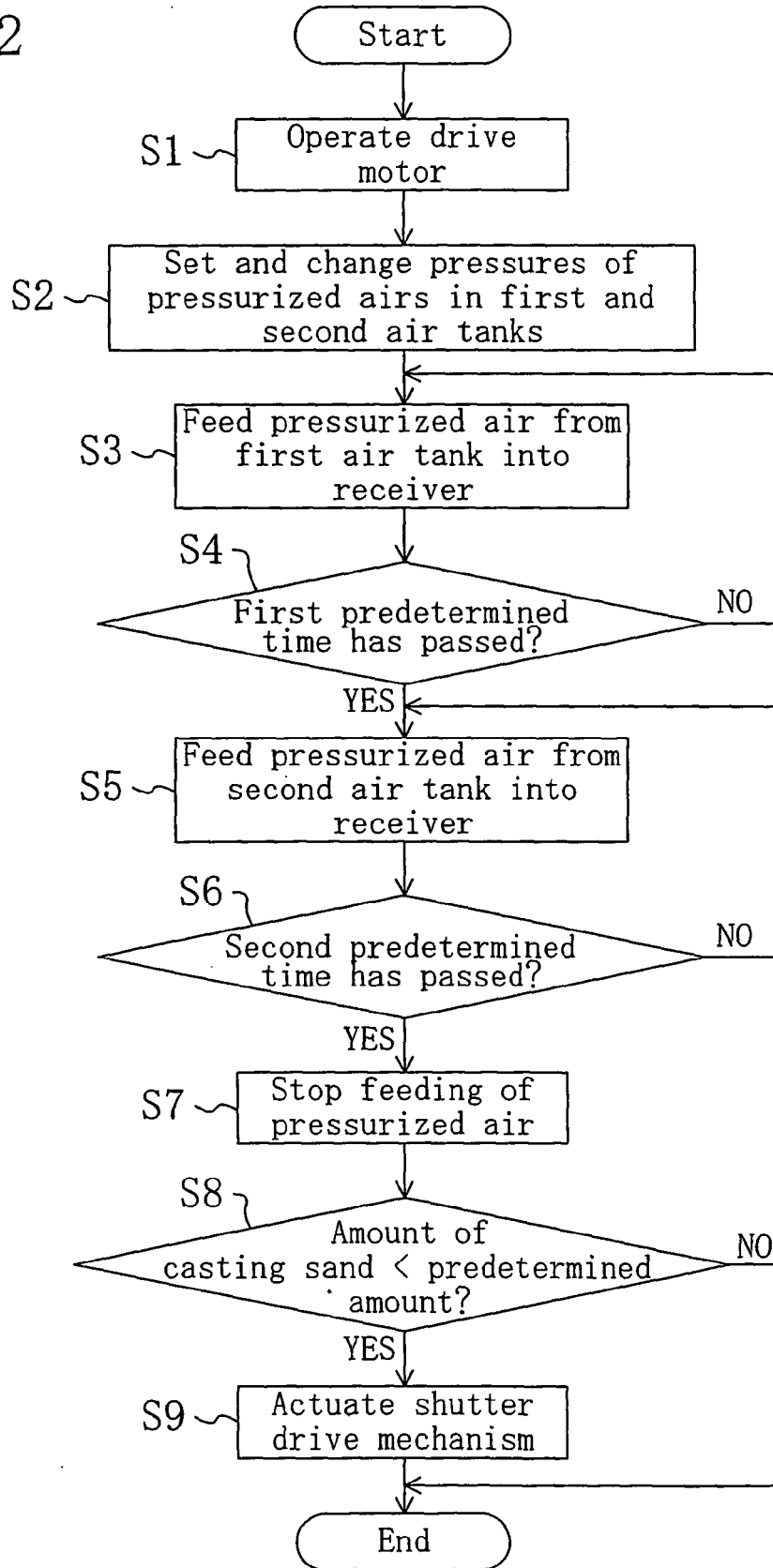


FIG. 3

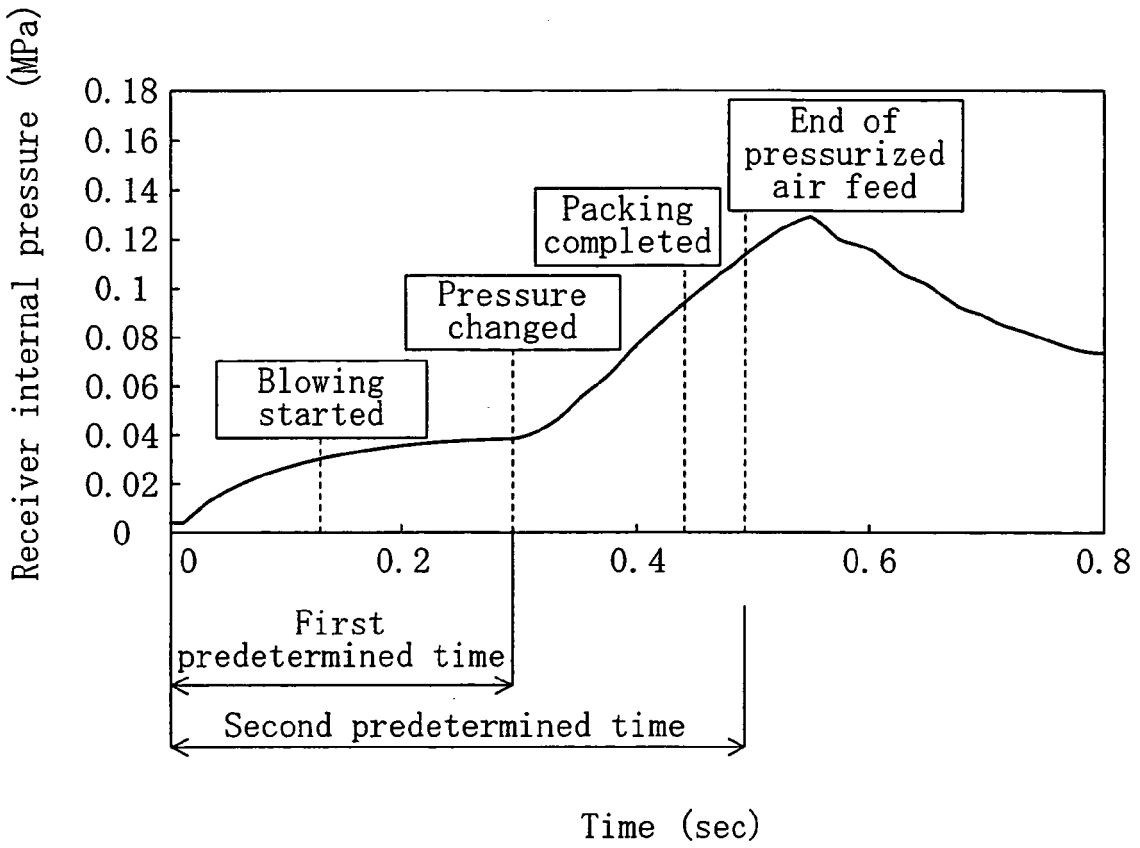


FIG. 4

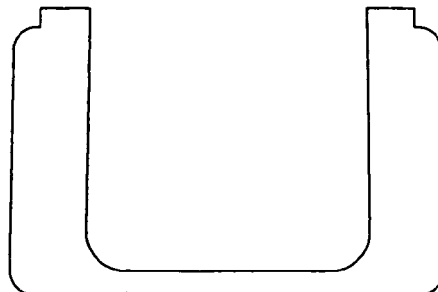


FIG. 5

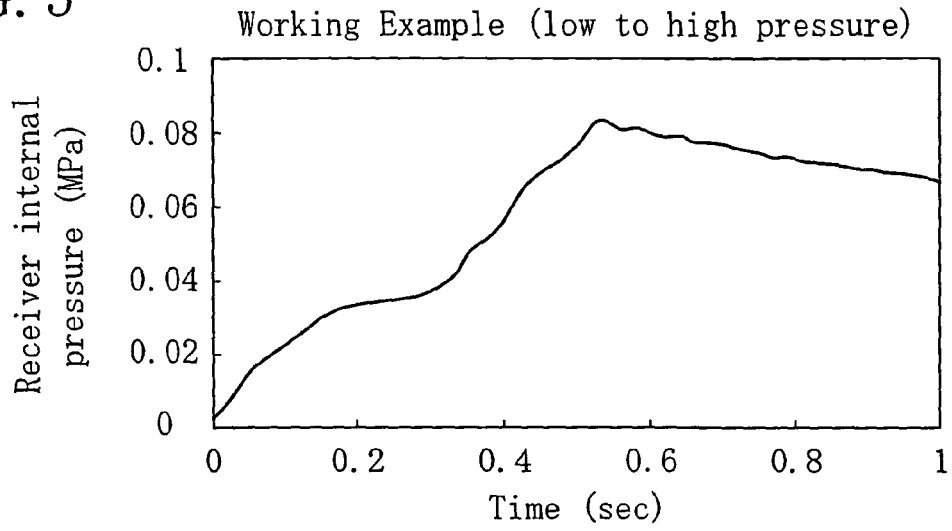


FIG. 6

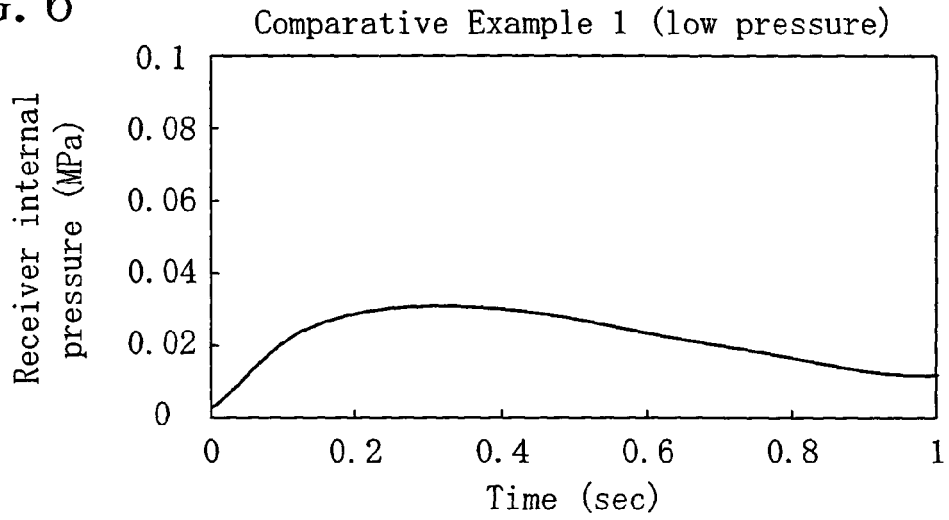


FIG. 7

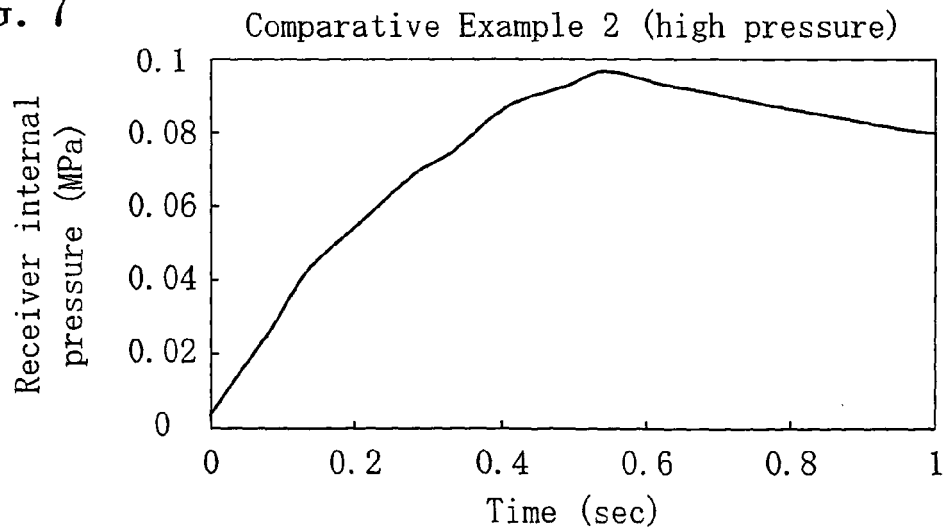


FIG. 8

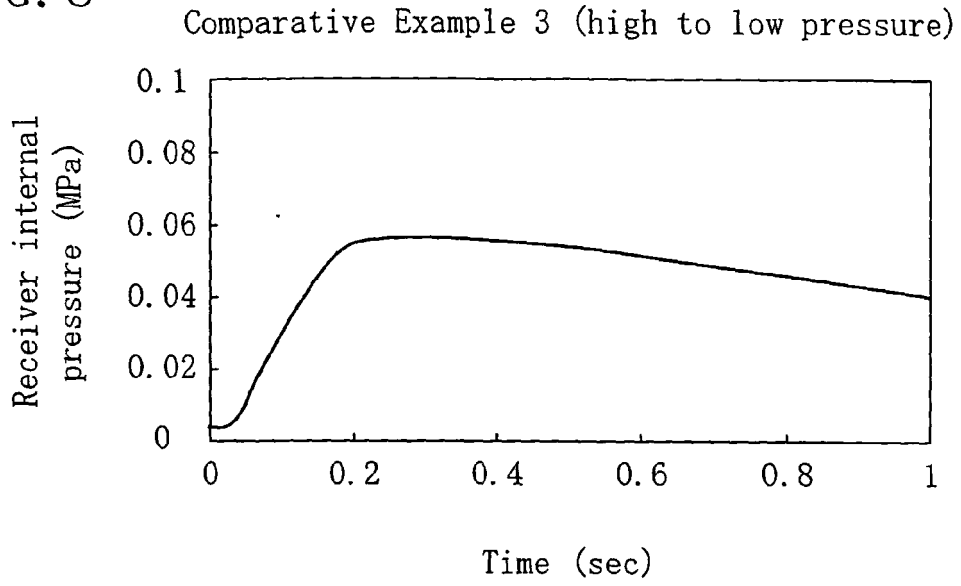
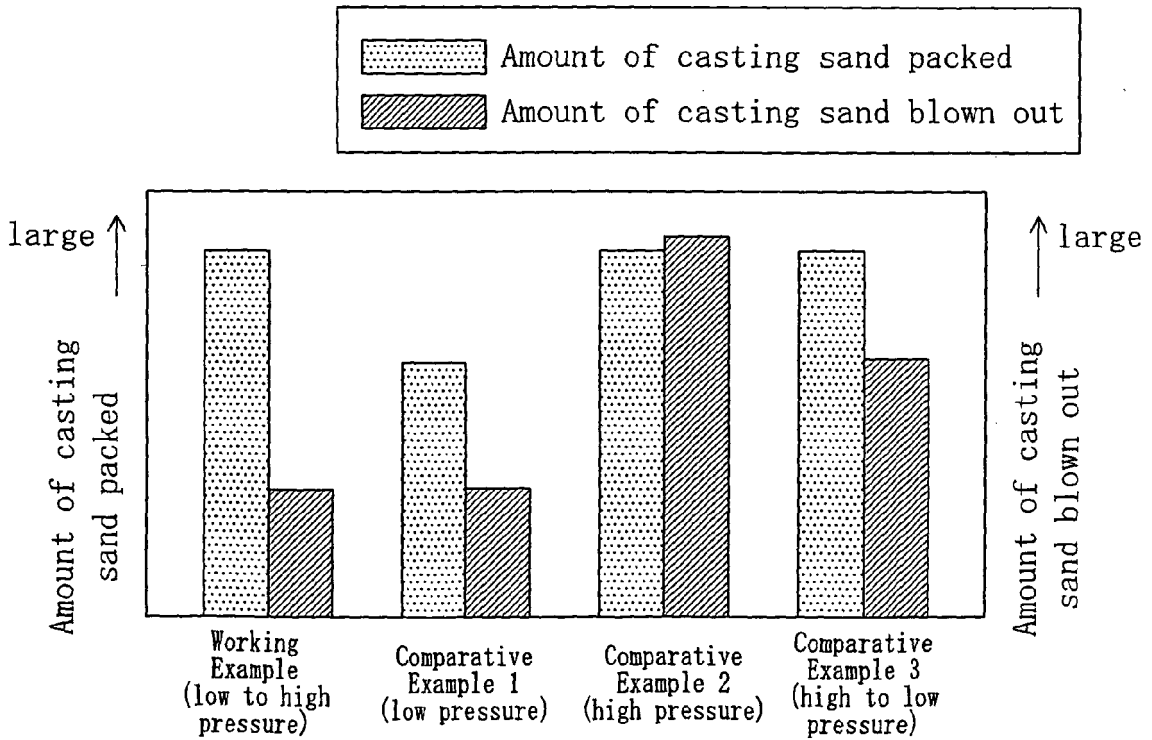


FIG. 9





DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP 58 196145 A (SINTOKOGIO LTD) 15 November 1983 (1983-11-15) * abstract; figures 1,2 *	1-7	INV. B22C15/24
X	JP 55 001961 A (SINTOKOGIO LTD) 9 January 1980 (1980-01-09) * abstract; figures 1,2 *	1,6,7	
X	US 3 934 858 A (PARSONAGE RAYMOND ARTHUR ET AL) 27 January 1976 (1976-01-27) * column 3, line 17 - column 5, line 30; claims 1-6 *	1,6,7	
X	US 4 570 694 A (LUND ROBERT S [US]) 18 February 1986 (1986-02-18) * column 6, line 27 - column 11, line 44 * * claims 1-5,9,12,13; figures 1,5,7,9 *	1,6,7	
X	US 4 196 768 A (NAKATA KUNII [JP]) 8 April 1980 (1980-04-08) * column 9, line 24 - column 11, line 56 * * claims 1,2; figures 4,6 *	1-7	TECHNICAL FIELDS SEARCHED (IPC)
X	US 2004/031580 A1 (SMITH DOUGLAS W [US]) 19 February 2004 (2004-02-19) * paragraphs [0004], [0012], [0013], [0043] - [0053] * * figures 5,7 *	1-7	B22C B29B
X	US 3 994 332 A (KOPP JOSEPH N) 30 November 1976 (1976-11-30) * column 7, line 23 - column 14, line 35 * * claims 1,6,9; figures 6-12 *	1-7	
		-/--	
The present search report has been drawn up for all claims			
Place of search <b>Munich</b>		Date of completion of the search <b>12 July 2007</b>	Examiner <b>Gavriliu, Alexandru</b>
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... & : member of the same patent family, corresponding document	

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	"MIXING WITH THE EXPERTS" FOUNDRY TRADE JOURNAL, INSTITUTE OF CAST METALS ENGINEERS, WEST BROMWICH, GB, vol. 175, no. 3578, May 2001 (2001-05), pages 28-29, XP001102817 ISSN: 0015-9042 * the whole document * -----	6,7	
			TECHNICAL FIELDS SEARCHED (IPC)
The present search report has been drawn up for all claims			
Place of search <b>Munich</b>		Date of completion of the search <b>12 July 2007</b>	Examiner <b>Gavriliu, Alexandru</b>
<b>CATEGORY OF CITED DOCUMENTS</b> X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... & : member of the same patent family, corresponding document	

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 07 00 4052

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

12-07-2007

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
JP 58196145	A	15-11-1983	NONE	
JP 55001961	A	09-01-1980	JP 1278885 C JP 60001099 B	29-08-1985 11-01-1985
US 3934858	A	27-01-1976	AU 469115 B2 AU 6820174 A BE 814098 A1 DE 2358051 A1 ES 425619 A1 FR 2227069 A1 GB 1431193 A IT 1020586 B JP 50029422 A NL 7405511 A	05-02-1976 23-10-1975 16-08-1974 07-11-1974 01-07-1976 22-11-1974 07-04-1976 30-12-1977 25-03-1975 28-10-1974
US 4570694	A	18-02-1986	NONE	
US 4196768	A	08-04-1980	NONE	
US 2004031580	A1	19-02-2004	NONE	
US 3994332	A	30-11-1976	CA 1042623 A1	21-11-1978

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- JP H09141389 B [0002] [0003]