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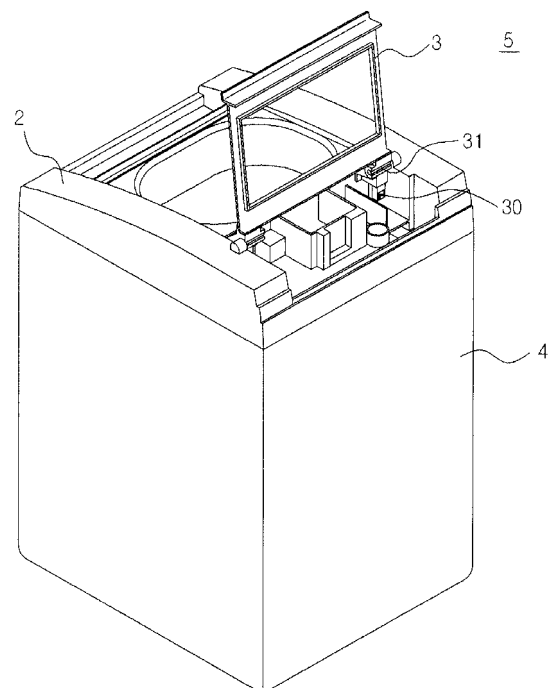
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(54) **Washing machine**

(57) A washing machine (5) that senses whether its door (3) is opened or closed, as well as the vibrations of the washing tub (1), said washing machine (5) includes an optical sensor (30) mounted at a predetermined position in the washing machine (5) and a controller to analyze an output value of the optical sensor (30) to determine whether the door (3) is opened or closed and the vibrations or weight of the washing tub (1); whether the door (3) is opened or closed as well as the vibrations or weight of the washing tub (1) may be determined using a single infrared sensor (30) in a noncontact manner.

FIG. 3



Description

BACKGROUND

1. Field

[0001] Embodiments of the present invention relate to a washing machine having an optical sensor.

2. Description of the Related Art

[0002] If a door is opened during operation of a washing machine, foreign matter may be introduced into laundry, or a user may be injured by a washing tub rotating at high speed. That is, safe and normal operation of the washing machine may be disturbed.

[0003] Also, if the washing tub abnormally vibrates due to accumulation of laundry at one side, the washing tub may collide with a machine body with the result that the washing tub may be damaged or noise may be generated. For this reason, it may be necessary to sense vibration of the washing tub and to control a washing cycle based thereupon.

[0004] In a washing machine, a device contacting a portion of a door when the door is opened or closed to sense whether the door is opened or closed or a device contacting a washing tub when the washing tub vibrates to sense the vibration of the washing tub is mounted to sense whether the door is opened or closed or whether the washing tub vibrates.

[0005] The sensing device may be damaged by shock occurring upon contact. As a result, sensing results may be incorrect. Also, if the vibration sensing device is deformed due to frequent contact, it may be necessary to replace the deformed vibration sensing device, which is troublesome.

SUMMARY

[0006] It is an aspect to provide a washing machine that senses whether a door is opened or closed in a non-contact manner using an optical sensor.

[0007] It is another aspect to provide a washing machine that senses vibration of a washing tub in a noncontact manner using an optical sensor.

[0008] It is another aspect to provide a washing machine that senses weight of a washing tub in a noncontact manner using an optical sensor.

[0009] It is a further aspect to provide a washing machine that uses a single optical sensor to senses whether a door is opened or closed, vibration of a washing tub, and weight of the washing tub in a noncontact manner.

[0010] Additional aspects will be set forth in part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

[0011] In accordance with one aspect, a washing machine includes a machine body having a washing tub, a

top cover to cover a top of the machine body, a door connected to the top cover by a hinge so that the door is opened and closed, an optical sensor comprising a light emission part mounted to the door, a direction in which the light emission part irradiates light varying depending upon movement of the door, and a light receiving part to receive the light irradiated from the light emission part and to output a signal corresponding in a magnitude to an amount of the received light, and a controller to analyze the signal output from the light receiving part to determine whether the door is opened or closed and to control an operation of the washing machine based upon the determination result.

[0012] The light emission part may be mounted to a rear part of the door adjacent to the hinge, and the light receiving part may be mounted in parallel to the light emission part to output a signal corresponding in a magnitude to an amount of light irradiated from the light emission part and reflected from a first reflection plate in the top cover or an interior of the machine body.

[0013] The light emission part may be mounted to irradiate light toward a front of the washing machine when the door is opened, and the first reflection plate may be mounted to a rear part of the top cover so that the first reflection plate faces the light emission part when the door is opened.

[0014] The light emission part may be mounted to irradiate light toward a front of the washing machine when the door is opened, and the first reflection plate may be configured by interconnecting corresponding sides of two rectangular planes in an L shape, a vertical plane of the first reflection plate reflecting the light irradiated from the light emission part when the door is opened.

[0015] A horizontal plane of the first reflection plate may be configured so as not to extend to a position where the light emission part irradiates light when the door is closed.

[0016] In accordance with another aspect, a washing machine includes a machine body having a washing tub, a top cover to cover a top of the machine body, a door connected to the top cover by a hinge so that the door is opened and closed, a structural body moving according to opening and closing of the door, an optical sensor comprising a light emission part mounted to the structural body, a direction in which the light emission part irradiates light varying depending upon movement of the structural body, and a light receiving part to receive the light irradiated from the light emission part and to output a signal corresponding in a magnitude to an amount of the received light, and a controller to analyze the signal output from the light receiving part to determine whether the door is opened or closed and to control an operation of the washing machine based upon the determination result.

[0017] The structural body may be formed in the shape of '□' and may be mounted to a rear part of the top cover in a state in which a hinge is connected to a bent part of the structural body so that an end of a rear part of the

door lifts a door contact part of the structural body when the door is moved, the light emission part may be mounted in a sensor mounting part provided at a lower end of the structural body, and the light receiving part may be mounted in parallel to the light emission part to output a signal corresponding in a magnitude to an amount of light irradiated from the light emission part and reflected from a first reflection plate in the top cover or an interior of the machine body.

[0018] The light emission part may be mounted to irradiate light toward a lower side of the washing machine when the door is closed, and the first reflection plate may be configured by interconnecting corresponding sides of two rectangular planes in an L shape, a vertical plane of the first reflection plate reflecting the light irradiated from the light emission part when the door is opened.

[0019] A horizontal plane of the first reflection plate may be configured so as not to extend to a position where the light emission part irradiates light when the door is closed.

[0020] In accordance with another aspect, a washing machine includes a machine body having a washing tub, a top cover to cover a top of the machine body, a door connected to the top cover by a hinge so that the door is opened and closed, a structural body moving according to opening and closing of the door, an optical sensor comprising a light emission part mounted to the structural body, a position at which the light emission part irradiates light varying depending upon movement of the structural body, and a light receiving part to receive the light irradiated from the light emission part and to output a signal corresponding in a magnitude to an amount of the received light, and a controller to analyze the signal output from the light receiving part to determine whether the door is opened or closed and to control an operation of the washing machine based upon the determination result.

[0021] The structural body may include a first structural body having a protrusion formed at one lateral side of an upper part thereof and a second structural body, in which the first structural body is received, a portion of an upper part of the second structural body being open so that the protrusion of the first structural body is exposed outward, a portion of a bottom of the second structural body being open, the remaining portion of the bottom of the second structural body being closed, the light emission part may be mounted to a bottom of the first structural body to irradiate light downward, and the light receiving part may be mounted in parallel to the light emission part to output a signal corresponding in a magnitude to an amount of light irradiated from the light emission part and reflected from the closed portion of the second structural body or an interior of the machine body.

[0022] When the door is closed, an end of a rear part of the door may push the protrusion of the first structural body so that the light emission part is located above the open portion of the second structural body, and, when the door is opened, the first structural body may return

to the original position thereof so that the light emission part is located above the closed portion of the second structural body.

[0023] In accordance with another aspect, a washing machine includes a machine body having a washing tub, a top cover to cover a top of the machine body, a door connected to the top cover by a hinge so that the door is opened and closed, an optical sensor comprising a light emission part mounted to a rear part of the top cover and a light receiving part mounted in parallel to the light emission part, a sensing lever provided between a rear part of the door and the optical sensor so as to move according to opening and closing of the door, the sensing lever having a screening member to screen the optical sensor according to the movement of the sensing lever, and a controller to analyze the signal output from the light receiving part to determine whether the door is opened or closed and to control an operation of the washing machine based upon the determination result.

[0024] The sensing lever may include a structural body formed in the shape of '□' and a screening member mounted to a portion vertically extending downward from a bent part of the structural body, the sensing lever being mounted to a rear part of the top cover so that the screening member screens the optical sensor when the door is opened and so that an end of a rear part of the door lifting a door contact part horizontally extending from the bent part of the sensing lever and thus the screening member does not screen the optical sensor when the door is closed.

[0025] The light emission part may be mounted to irradiate light to an inner lower part of the machine body when the door is closed, and the light receiving part may be mounted in parallel to the light emission part.

[0026] The controller may determine that the washing tub does not abnormally vibrate if the signal output from the light receiving part during rotation of the washing tub is uniform, and may determine that the washing tub abnormally vibrates if the signal output from the light receiving part during rotation of the washing tub fluctuates and control the operation of the washing machine based on the determination result.

[0027] The controller may store a pattern of a signal output from the light receiving part during normal rotation of the washing tub without abnormal vibration in a database and compare the signal output from the light receiving part during rotation of the washing tub with the stored pattern to determine whether the washing tub abnormally vibrates or whether vibration of the washing tub is high or low and to control the operation of the washing machine based on the determination result.

[0028] The controller may determine that weight of the washing tub has increased if the signal output from the light receiving part decreases in a state in which the washing tub is stopped, determine that the weight of the washing tub has decreased if the signal output from the light receiving part increases in a state in which the washing tub is stopped, determine a changed amount of the

weight of the washing tub based on a changed amount of the output signal, and control the operation of the washing machine based on the determination result.

[0029] In accordance with a further aspect, a washing machine includes a machine body having a washing tub, an optical sensor including a light emission part mounted at one side or one corner of the machine body at an inside thereof to irradiate light and a light receiving part mounted in parallel to the light emission part to receive the light irradiated from the light emission part and to output a signal corresponding in a magnitude to an amount of the received light, a second reflection plate mounted to an outside of the washing tub so that the second reflection plate faces the optical sensor, the second reflection plate having a plurality of colors exhibiting different reflectances of the light irradiated from the light emission part, the colors being vertically arranged in order of reflectance; and a controller to analyze the signal output from the light receiving part to determine whether the washing tub vibrates and whether weight of the washing tub has increased and to control an operation of the washing machine based upon the determination result.

[0030] The controller may determine that the washing tub does not abnormally vibrate if the signal output from the light receiving part during rotation of the washing tub is uniform and determine that the washing tub abnormally vibrates if the signal output from the light receiving part during rotation of the washing tub fluctuates.

[0031] The controller may determine that weight of the washing tub has varied if the signal output from the light receiving part varies in a state in which the washing tub is stopped and determine a changed amount of the weight of the washing tub using a changed amount of the signal output from the light receiving part.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032] These and/or other aspects of the invention will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

FIG. 1 is a side sectional view showing a washing machine used in an embodiment of the present invention;

FIG. 2A is a view showing the construction of an infrared sensor used in the embodiment of the present invention;

FIG. 2B is a perspective view of the infrared sensor used in the embodiment of the present invention;

FIG. 2C is a graph showing an output value of the infrared sensor used in the embodiment of the present invention;

FIG. 3 is a perspective view showing a washing ma-

chine according to an embodiment of the present invention;

FIG. 4A is a perspective view showing the upper part of the washing machine according to the embodiment of the present invention when a door of the washing machine is opened;

FIG. 4B is a side sectional view showing the upper part of the washing machine according to the embodiment of the present invention when the door of the washing machine is opened;

FIG. 4C is a perspective view showing the upper part of the washing machine according to the embodiment of the present invention when the door of the washing machine is closed;

FIG. 4D is a side sectional view showing the upper part of the washing machine according to the embodiment of the present invention when the door of the washing machine is closed;

FIG. 5A is a side sectional view showing an example of a first reflection plate of the washing machine according to the embodiment of the present invention;

FIG. 5B is a graph showing an output value of an infrared sensor of the washing machine according to the embodiment of the present invention;

FIG. 6 is a control block diagram of the washing machine according to the embodiment of the present invention;

FIG. 7A is a side sectional view showing the upper part of a washing machine according to another embodiment of the present invention when a door of the washing machine is opened;

FIG. 7B is a side sectional view showing the upper part of the washing machine according to the embodiment of the present invention when the door of the washing machine is closed;

FIG. 7C is a perspective view showing a structural body moving according to opening and closing of the door of the washing machine according to the embodiment of the present invention;

FIG. 8A is a side sectional view showing the upper part of a washing machine according to another embodiment of the present invention when the door of the washing machine is opened;

FIG. 8B is a side sectional view showing the upper part of the washing machine according to the embodiment of the present invention when the door of

the washing machine is closed;

FIGS. 8C and 8D are perspective views showing a structural body moving according to opening and closing of the door of the washing machine according to the embodiment of the present invention;

FIGS. 9A and 9B are graphs showing an output value of the infrared sensor of the washing machine according to the embodiment of the present invention;

FIG. 10A and 10B are side sectional views showing the upper part of a washing machine according to another embodiment of the present invention when a door of the washing machine is opened and closed;

FIG. 10C is a perspective view showing a structural body including a sensing lever;

FIG. 11 is a side sectional view showing the upper part of a washing machine according to another embodiment of the present invention;

FIG. 12A is a perspective view showing the interior of a washing machine according to another embodiment of the present invention when a washing tub of the washing machine vibrates;

FIG. 12B is a side sectional view showing the washing machine according to the embodiment of the present invention when the washing tub of the washing machine vibrates;

FIGS. 13A and 13B are graphs showing an output value of the infrared sensor of the washing machine according to the embodiment of the present invention;

FIG. 14A is a view showing the surface of a second reflection plate used in the embodiment of the present invention;

FIG. 14B is a plan view showing the washing machine in which the second reflection plate used in the embodiment of the present invention is mounted;

FIG. 15 is a side sectional view showing the washing machine according to the embodiment of the present invention when the washing tub of the washing machine vibrates;

FIG. 16 is a side sectional view showing the washing machine according to the embodiment of the present invention when weight of the washing tub of the washing machine is sensed;

FIG. 17 is a side sectional view showing the washing machine according to the embodiment of the present

invention when weight of the washing tub of the washing machine is sensed;

FIG. 18 is a plan view of a washing machine according to another embodiment of the present invention;

FIGS. 19A and 19B are graphs showing an output value of the infrared sensor of the washing machine according to the embodiment of the present invention;

FIG. 20A is a side view showing a washing tub, to which a second reflection plate is mounted, of a washing machine according to a further embodiment of the present invention; and

FIG. 20B is a side sectional view of the washing machine according to the embodiment of the present invention.

DETAILED DESCRIPTION

[0033] Reference will now be made in detail to the embodiments of the present invention, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout.

[0034] FIG. 1 is a side sectional view showing a washing machine 5 used in an embodiment of the present invention. The washing machine 5 includes a machine body 4 including a washing tub 1, a top cover 2 to cover the top of the machine body 4, and a door 3 connected to the cover 2 by a hinge 31 so that the door 3 is opened and closed.

[0035] A light emission part provided in a washing machine according to an embodiment of the present invention may be directly mounted to the door 3 or to a structural body moving according to opening and closing of the door 3. In this case, the structural body may be mounted at the washing machine 5.

[0036] Also, in the washing machine according to the embodiment of the present invention, a light receiving part may be mounted in parallel to the light emission part or opposite to the light emission part.

[0037] An optical sensor used may include all sensors, such as an infrared sensor, an ultraviolet sensor, a visible light sensor, and a radiation sensor, to emit light so as to obtain a sensor output value. Hereinafter, the embodiments will be described on the assumption that an infrared sensor, exhibiting high sensitivity and accuracy, is used in the embodiments.

[0038] FIG. 2A is a view simply showing the construction of an infrared sensor 30 used in the embodiments. Referring to FIG. 2A, the infrared sensor 30 includes a light emission part 10 to emit infrared light and a light receiving part 20 to sense the emitted infrared light. The light emission part 10 emits infrared light through a light emitting diode 11 to emit the infrared light, and the light receiving part 20 outputs the amount of current varying

depending upon the amount of infrared light received by the light receiving part 20 as a signal to provide information regarding presence of an object or distance from the object.

[0039] The light emission part 10 and the light receiving part 20 of the infrared sensor 30 may be opposite to each other so that infrared light emitted from the light emission part 10 is directly received by the light receiving part 20, or may be parallel to each other so that infrared light emitted from the light emission part 10 is received by the light receiving part 20 after the infrared light is reflected from an object.

[0040] FIG. 2B is a perspective view of the infrared sensor used in the embodiments. As shown in FIG. 2B, the light emission part 10 and the light receiving part 20 are mounted in a structural body so that the light emission part 10 and the light receiving part 20 are spaced a predetermined distance from each other in a state in which the light emission part 10 and the light receiving part 20 are parallel to each other. Consequently, infrared light emitted from the light emission part 10 is reflected from an object, and the reflected light is received by the light receiving part 20.

[0041] FIG. 2C is a graph showing an output value of the light receiving part 20 based on the change in distance from an object to be sensed. As previously described, the amount of current varies depending upon the amount of infrared light received by the light receiving part 20 of the infrared sensor 30. Depending upon the distance from an object reflecting infrared light, therefore, the amount of infrared light received by the light receiving part 20 varies, and the amount of current flowing in the light receiving part 20 varies. The output value of the light receiving part 20 is generally represented as voltage. The output value of the light receiving part 20 nonlinearly increases until the distance from an object to be sensed is approximately 22 mm and then nonlinearly decreases. A controller determines the distance between the infrared sensor and the object using an algorithm to analyze the output value of the light receiving part 20 and controls the washing machine based on the determination.

[0042] In a structure in which the light emission part 10 and the light receiving part 20 are opposite to each other, the output value of the light receiving part 20 does not vary depending upon the distance between the light emission part 10 and the object but the distance between the light emission part 10 and the light receiving part 20. Consequently, the light receiving part 20 may be mounted to the object to obtain information regarding presence of the object and moving pattern of the object using the output value of the light receiving part 20.

[0043] Hereinafter, an embodiment based on the position of the infrared sensor 30 will be described in detail.

[0044] FIG. 3 is a perspective view showing a washing machine according to an embodiment. Referring to FIG. 3, the infrared sensor 30, configured so that the light emission part 10 and the light receiving part 20 are parallel to each other, is directly mounted to the door 3 con-

nected to the top cover 2 of the washing machine. The infrared sensor 30 is mounted to the rear part of the door adjacent to the hinge 31 so that an infrared irradiation direction varies according to opening and closing of the door 3 and the amount of reflected and returning infrared light varies depending upon variation of the irradiation direction due to a structural body disposed around the hinge 31.

[0045] The infrared sensor 30 may be mounted at any position of the door 3 of the washing machine so long as the infrared irradiation direction varies depending upon movement of the door 3, and therefore, the output value of the light receiving part 20 varies. Consequently, placement of the infrared sensor 30 is not limited to embodiments which will be described below.

[0046] An embodiment will be described in detail with reference to FIGS. 4A, 4B, 4C and 4D. FIG. 4A is a perspective view showing one side of the top cover 2 of the washing machine 5 including the infrared sensor 30 mounted to the end of the rear part of the door 3. Before FIGS. 4A, 4B, 4C and 4D are described, it is assumed that the front of the washing machine or the door of the washing machine corresponds to a direction in which the door 3 is opened, and the rear of the washing machine or the door of the washing machine corresponds to a direction in which the door 3 is closed. Also, it is assumed that the rear part of the door or the top cover corresponds to a predetermined area provided at the rear of the door or the top cover.

[0047] FIG. 4A is a perspective view showing one side of the upper part of the washing machine 5 when the door 3 is opened, and FIG. 4B is a side sectional view showing one side of the upper part of the washing machine 5 when the door 3 is opened. Referring to FIGS. 4A and 4B, the infrared sensor 30 is mounted to the end of the rear part of the door 3 to irradiate light toward the front of the washing machine 5 when the door 3 is fully opened.

[0048] A first reflection plate 32 is provided at the rear part of the top cover 2 at the inside thereof. The first reflection plate 32 is a structural body to reflect infrared light irradiated from the infrared sensor 30 mounted to the door 3 and to vary an output value of the light receiving part 20 when the door 3 is opened and closed.

[0049] To this end, the first reflection plate 32 is configured by interconnecting corresponding sides of two rectangular planes in an L shape. The vertical plane of the first reflection plate 32 reflects light irradiated from the light emission part 10 when the door 3 is opened.

[0050] The horizontal plane of the first reflection plate 32 reflects light irradiated from the light emission part 10 when the door 3 is closed. To sense vibration and weight of the washing tub 1, however, the horizontal plane of the first reflection plate 32 is configured so as not to extend to a position where the light emission part 10 irradiates infrared light.

[0051] In this embodiment, the first reflection plate 32 is formed in an L shape. However, the shape of the first reflection plate 32 is not restricted so long as the first

reflection plate 32 varies the output value of the light receiving part 20 when the door 3 is opened and closed.

[0052] Referring to FIGS. 4A and 4B, the distance between the infrared sensor 30 and the first reflection plate 32 decreases when the door 3 is opened with the result that the output value (voltage) of the light receiving part 20 of the infrared sensor 30 becomes high.

[0053] FIG. 4C is a perspective view showing one side of the upper part of the washing machine 5 when the door 3 is closed, and FIG. 4D is a side sectional view showing one side of the upper part of the washing machine 5 when the door 3 is closed. Referring to FIGS. 4C and 4D, the infrared sensor 30 irradiates light to the lower part of the machine body 4 when the door 3 is closed. No obstacle is located in the infrared irradiation direction excluding the washing tub 1 so as to sense vibration and weight of the washing tub 1, which will be described below, while the amount of infrared light received when the door 3 is closed differs from the amount of infrared light received when the door 3 is opened.

[0054] When the door 3 is fully closed, the infrared sensor 30 irradiates light toward the lower part of the machine body 4 with the result that the output value of the light receiving part 20 becomes lower than that when the door 3 is opened.

[0055] FIG. 5A is a side sectional view showing the shape of the first reflection plate 32 when the door 3 is opened, and FIG. 5B is a graph showing an output value of the light receiving part 20 when the door 3 is opened. As previously described, the infrared sensor 30 may irradiate infrared light toward the front of the washing machine when the door 3 is opened.

[0056] When the first reflection plate 32 is curved as shown in FIG. 5A, the distance between the infrared sensor 30 and the first reflection plate 32 is uniform until the door 3 is fully opened after the door 3 is partially opened to a predetermined position.

[0057] When the first reflection plate 32 has a structure as shown in FIG. 5A, therefore, the output value of the light receiving part 20 is uniform until the door 3 is fully opened after the door 3 is partially opened to the predetermined position as shown in FIG. 5B. The predetermined position is a position where the infrared sensor 30, irradiating infrared light toward the washing tub 1, starts to irradiate infrared light to the curved portion of the first reflection plate 32.

[0058] FIG. 6 is a control block diagram of the washing machine according to the embodiment of the present invention. As previously described, the optical sensor 30, mounted to the door 3 of the washing machine 5 or a structural body, which will be described below, moving according to opening and closing of the door 3, includes the light emission part 10 and the light receiving part 20. When the light emission part 10 irradiates infrared light, the amount of the infrared light received by the light receiving part 20 varies depending upon the distance from an object reflecting the infrared light or the distance from the light receiving part 20, and the light receiving part 20

outputs a signal corresponding to the amount of the infrared light.

[0059] A signal output from the light receiving part 20 is transmitted to a controller 100 of the washing machine. The controller 100 includes a door open and close determination unit 110, a vibration generation determination unit 120, a weight determination unit 130, and a washing cycle control unit 140.

[0060] The door open and close determination unit 110 analyzes the signal output from the light receiving part 20 to determine whether the door 3 is open or closed. Upon determining that the door 3 is closed, the weight determination unit 130 and the vibration generation determination unit 120 are controlled depending upon whether the washing tub 1 is rotated.

[0061] The vibration generation determination unit 120 determines whether the washing machine 1 vibrates during rotation of the washing tub 1 and whether the vibration is strong or weak. The weight determination unit 130 determines the weight of the washing tub 1 in a state in which the washing tub 1 is stopped.

[0062] Determination results of the respective determination units are transmitted to the washing cycle control unit 140, which performs control suitable for the current state of the washing machine.

[0063] In this embodiment, when the output value of the light receiving part 20 remains high, it is determined that the door 3 is open. When the output value of the light receiving part 20 abruptly decreases, it is determined that the door 3 is being closed. When the output value of the light receiving part 20 remains low, it is determined that the door 3 is fully closed.

[0064] On the other hand, when the output value of the light receiving part 20 remains low or fluctuates, it is determined that the door 3 is closed. When the output value of the light receiving part 20 abruptly increases and then remains high, it is determined that the door 3 is fully open.

[0065] Control performed by the washing cycle control unit 140 based on the determination result of the door open and close determination unit 110 will be described in detail after other embodiments are described.

[0066] The vibration generation determination unit 120 will be described together with an embodiment to sense vibration of the washing tub 1, and the weight determination unit 130 will be described together with an embodiment to determine weight of the washing tub 1.

[0067] In the washing machine according to this embodiment, as described above, the infrared sensor may be directly mounted to the door or the structural body moving according to opening and closing of the door. Hereinafter, an embodiment in which the structural body moving according to opening and closing of the door is mounted to the rear part of the top cover will be described.

[0068] FIGS. 7A and 7B are side sectional views showing the upper part of a washing machine according to another embodiment, and FIG. 7C shows a structural body mounted at the rear part of the top cover to move according to opening and closing of the door. Referring

to FIG. 7A, the infrared sensor 30 is not directly mounted to the door 3 but to a structural body 40 moving according to opening and closing of the door. Also, in this embodiment, the infrared sensor 30 is configured to have a structure in which the light emission part 10 and the light

receiving part 20 are mounted in parallel to each other. **[0069]** Referring to FIGS. 7A and 7B, the structural body 40 is formed in the shape of '□' and is mounted to the rear part of the top cover 2. A bent part 42 of the structural body 40 is fixed by a hinge 44 so that the structural body 40 performs a pendulum motion about the bent part 42.

[0070] A protrusion is formed at the end of the rear part of the door 3. When the door 3 is closed, the protrusion lifts the structural body 40. In a state in which the door 3 is open, the structural body 40 does not move. When the door 3 is closed, the protrusion formed at the rear part of the door 3 lifts a corresponding portion of the structural body 40.

[0071] A first reflection plate 32 is provided at the rear part of the top cover 2 to vary an output value of the light receiving part 20 according to movement of the structural body 40. The first reflection plate 32 is formed in the same shape as the first reflection plate of the previous embodiment. In this embodiment, however, the horizontal plane of the first reflection plate 32 extends toward the front of the washing machine from the bent part thereof. The vertical plane or the horizontal plane of the first reflection plate 32 reflects light irradiated from the light emission part 10 when the door 3 is opened. The horizontal plane of the first reflection plate 32 is configured so as not to extend to a position where the light emission part 10 irradiates infrared light when the door 3 is closed.

[0072] The structural body 40 is shown in FIG. 7C. The structural body 40 is formed in the shape of '□' and includes a door contact part 41 formed at the end horizontally extending from the bent part 42 to contact the door 3 and a sensor mounting part 43 formed at the end vertically extending downward from the bent part 42 to receive the infrared sensor 30.

[0073] FIG. 7C is a perspective view showing the structural body 40 moving according to opening and closing of the door when the rear part of the door 3 lifts the door contact part 41. The upper part of the hinge 44 is configured to be raised when upward force is applied the hinge 44 from below. When upward force is applied to the door contact part 41 from below, therefore, cut cylindrical members mounted to opposite sides of the bent part 42 lift the hinge 44 with the result that the whole structural body 40 moves.

[0074] When the door 3 is opened, the force applied to the door contact part 41 is released with the result that the upper part of the hinge 44 pushes the cylindrical members mounted to the opposite sides of the bent part 32, and therefore, the structural body 40 returns to the state shown in FIG. 7A.

[0075] The direction in which the infrared sensor 30 is mounted in the sensor mounting part 43 is not restricted

so long as the output value of the light receiving part 20 varies depending upon whether the door is opened or closed. In this embodiment, the infrared sensor 30 is mounted so that the infrared sensor 30 irradiates infrared light to the lower side of the washing machine so as to sense vibration and weight of the washing tub, which will be described below. As shown in FIGS. 7A and 7B, therefore, the infrared sensor 30 irradiates infrared light toward the first reflection plate 32 when the door 3 is opened and irradiates infrared light toward the washing tub 1 or the inner lower part of the machine body when the door 3 is closed.

[0076] In this embodiment, the door open and close determination unit 110 determines that the door 3 is open when the output value of the light receiving part 20 remains uniform. The door open and close determination unit 110 determines that the door 3 is closed when the output value of the light receiving part 20 remains low or varies nonuniformly.

[0077] FIGS. 8A and 8B are side sectional views showing the upper part of a washing machine according to another embodiment, and FIG. 8C shows a structural body mounted at the rear part of the top cover to move according to opening and closing of the door. Referring to FIGS. 8A and 8B, in the structural body 50 moving according to opening and closing of the door used in this embodiment, a protrusion 54 is mounted at the rear part of the top cover 2 so that the protrusion 54 is directed to the front of the washing machine 5. Below the rear part of the top cover 2, the lower side of the structural body 50 is opened.

[0078] When the door 3 is opened, the protrusion 54 of the structural body remains protruding toward the front of the washing machine in a state in which the structural body 50 and the door 3 do not contact each other.

[0079] When the door 3 is closed, the rear part of the door 3 at the rear of the hinge 31 rises in the form of a parabola to contact the protrusion 54 of the structural body 50. When the door 3 is fully closed, the end of the rear part of the door 3 pushes the protrusion 54 into the structural body 50.

[0080] FIG. 8C is a perspective view showing the interior of the structural body 50. Referring to FIG. 8C, the structural body 50 includes a first structural body 51 and a second structural body 52. The first structural body 51 is formed in a hexahedral shape. The protrusion 54 is formed at one of the four lateral sides of the first structural body 51. The second structural body 52 is formed in a hexahedral shape. The second structural body 52 is hollow so that the first structural body 51 is received in the second structural body 52 and moves in the second structural body 52.

[0081] Also, one of the four lateral sides of the second structural body 52 corresponding to the protrusion 54 is open so that the protrusion 54 of the first structural body 51 protrudes outward. A portion of the bottom of the second structural body 52 is open, and the remaining portion of the bottom of the second structural body 52 is closed.

[0082] The infrared sensor 30 is mounted to the bottom of the first structural body 51. In a state in which the protrusion 54 is not pushed, the infrared sensor 30 is located above the closed portion of the second structural body 52. In this embodiment, the infrared sensor 30 is configured to have a structure in which the light emission part and the light receiving part are parallel to each other.

[0083] As previously described, the rear part of the door 3 contacts the protrusion 54 when the door 3 is closed. The portion of the protrusion 54 contacting the rear part of the door 3 is curved as shown in FIG. 8C to prevent a phenomenon in which the rear part of the door 3 is caught by the protrusion 54 with the result that the rear part of the door 3 does not rise any longer. Consequently, the protrusion 54 is slowly pushed in until the door 3 is fully closed.

[0084] As the protrusion 54 is pushed, the first structural body 51 moves in the opposite direction, and the infrared sensor 30 mounted to the bottom of the first structural body 51 is located above the open portion of the second structural body 52.

[0085] The portion of the bottom of the top cover 2 immediately under the structural body 50 is open. When the infrared sensor 30 is located above the open portion of the second structural body 52, therefore, the infrared sensor 30 irradiates infrared light toward the washing tub 1 or the inner lower part of the machine body 4. The open portion and the closed portion of the second structural body 52 may be changed. However, the infrared sensor 30 is configured to be located above the open portion of the second structural body 52 when the door is closed so as to sense vibration or weight of the washing tub, which will be described below.

[0086] An elastic member, such as a spring, is mounted between the opposite side of the protrusion 54 of the first structural body 51 and the inside of the second structural body 52 facing the opposite side of the protrusion 54 so that the first structural body 51 returns to the original position thereof when the door 3 is opened and external force applied to the protrusion 54 is released.

[0087] FIGS. 9A and 9B are graphs showing an output value of the light receiving part 20 in this embodiment. Referring to FIG. 9A, when the door 3 is closed, the infrared sensor 30 is located above the open portion of the second structural body 52 to irradiate infrared light toward the washing tub 1. Consequently, the output value of the light receiving part 20 varies depending upon movement of the washing tub 1. When the washing tub 1 is not moved, the output value of the light receiving part 20 is uniform. When the washing tub 1 abnormally vibrates during rotation of the washing tub 1, the output value of the light receiving part 20 is nonuniform as shown in FIG. 9A. The nonuniform output value of the light receiving part 20 may have a regular pattern. Also, the nonuniform output value of the light receiving part 20 may have an irregular pattern due to abnormal vibration of the washing tub.

[0088] Referring to FIG. 9B, when the door 3 is opened,

the infrared sensor 30 is located above the closed portion 53 of the second structural body 42 with the result that the output value of the light receiving part 20 remains high. Since the output value of the light receiving part 20 remains high when the door 3 is opened although the output value of the light receiving part 20 does not have a regular pattern when the door 3 is closed, the door open and close determination unit 110 of the controller 100 determines whether the door 3 is open or closed and sends the determination result to the washing cycle control unit 140 to perform appropriate control.

[0089] In this embodiment, the protrusion 54 is pushed when the door 3 is closed. Based on the location of the structural body 50 in the top cover 2, however, the protrusion 54 may be pushed when the door 3 is opened. For example, the structural body 50 may not be mounted at the rear of the hinge 31 but at the front of the hinge 31 so that the bottom of the rear part of the door 3 pushes the protrusion 54 of the first structural body 51 when the door 3 is opened.

[0090] FIG. 10A and 10B are side sectional views showing the upper part of a washing machine according to another embodiment. In the previous embodiments, the infrared sensor 30 is configured to move as the door 3 is moved with the result that the infrared irradiation direction or position varies. In this embodiment, the infrared sensor 30 is fixed so that the infrared sensor does not move according to opening and closing of the door 3. Instead, a sensing lever 61 having a screening member 63 moves according to opening and closing of the door 3.

[0091] Referring to FIG. 10A, a structural body 60 having a sensing lever 61 is mounted at the rear part of the top cover 2. When the door 3 is opened, the door 3 does not contact the sensing lever 61, and therefore, the sensing lever 61 does not move. Referring to FIG. 10B, when the door 3 is closed, the protrusion formed at the end of the rear part of the door 3 lifts a door contact part 62 of the sensing lever 61, and therefore, the sensing lever 61 moves.

[0092] FIG. 10C is a perspective view showing the structural body 60 including the sensing lever. The operation of this embodiment will be described in detail with reference to FIG. 10C. The sensing lever 61 is a structural body, formed in the shape of '□' to which the screening member 63 is mounted. The portion horizontally extending from a bent part 65 of the sensing lever 61 constitutes the door contact part 62 contacting the end of the door 3. The screening member 63 having a size sufficient to screen the infrared sensor 30 is mounted at the portion vertically extending downward from the bent part 65 of the sensing lever 61.

[0093] A horizontal hole is formed through the bent part 65 of the sensing lever 61, a fastening rod is inserted through the horizontal hole, and opposite ends of the fastening rod are fixed to the structural body 60. Consequently, the sensing lever 61 may be rotated about the bent part 65.

[0094] A sensor mounting part 64, in which the infrared

sensor 30 is mounted, is provided at the lower part of the structural body 60. The sensor mounting part 64 is open at the bottom thereof. No obstacle, excluding the screening member 63, is located between the infrared sensor 30 and the washing tub. The infrared sensor 30 is mounted so as to irradiate infrared light in the open direction of the sensor mounting part 64.

[0095] When springs are fitted on the fastening rod between the opposite sides of the vent part 65 of the sensing lever 62 and the structural body 60 in a state in which the bottom of the sensor mounting part 64 is screened by the screening member 63, the screening member 63 screens the bottom of the sensor mounting part 64 when external force is not applied to the sensing lever 62 as shown in first and second drawings of FIG. 10C. When the door 3 is closed, the protrusion formed at the end of the rear part of the door 3 lifts the door contact part 62, and therefore, the screening member 63 moves with the result that the screening member 63 does not screen the infrared sensor 30.

[0096] Referring back to FIGS. 10A and 10B, when the door 3 is opened, the screening member 63 of the sensing lever 61 screens the infrared sensor 30 mounted in the sensor mounting part 64. When the door 3 is closed, the protrusion formed at the end of the rear part of the door 3 lifts the door contact part 62 with the result that the screening member 63 does not screen the infrared sensor 30.

[0097] Consequently, when the door 3 is opened, infrared light irradiated from the light emission part 10 of the infrared sensor 30 is reflected by the screening member 63, which is very near the light emission part 10, and is received by the light receiving part 20 with the result that the output value of the light receiving part 20 becomes high. When the door 3 is closed, infrared light irradiated from the light emission part 10 is reflected from the washing tub 1 or the inner lower part of the machine body 4 and is received by the light receiving part 20 with the result that the output value of the light receiving part 20 becomes lower than that when the door 3 is opened.

[0098] In this embodiment, the infrared sensor 30 is mounted to the structural body 60 including the sensing lever. Alternatively, the sensing lever 61 may be separately mounted to the rear part of the top cover 2 adjacent to the rear part of the door 3, and the infrared sensor 30 may be mounted to the rear part of the top cover 2 adjacent to the sensing lever 61. In this case, the screening member 63 of the sensing lever 61 screens the infrared sensor 30 when the door 3 is opened as shown in FIG. 10A, and the protrusion formed at the end of the rear part of the door 3 lifts the door contact part 62 of the sensing lever 61 when the door 3 is closed as shown in FIG. 10B with the result that the screening member 63 moves to a position where the screening member 63 does not screen the infrared sensor 30.

[0099] This embodiment is not limited by the above description. The structure of the structural body 60 is not restricted so long as the sensing lever 61 moves accord-

ing to opening and closing of the door 3, and the infrared sensor 30 is screened by the screening member 63 according to movement of the sensing lever 61.

[0100] The door open and close determination unit 110 determines that the door 3 is open when the output value of the light receiving part 20 remains high. The door open and close determination unit 110 determines that the door 3 is closed when the output value of the light receiving part 20 becomes low or fluctuates.

[0101] FIG. 11 is a side sectional view showing the upper part of a washing machine according to another embodiment. In the previous embodiments, the infrared sensor 30 is configured so that the light emission part 10 and the light receiving part 20 are parallel to each other. In this embodiment, the infrared sensor 30 is configured so that the light emission part 10 and the light receiving part 20 are opposite to each other.

[0102] The light emission part 10 is mounted to the end of the rear part of the door 3, and the light receiving part 20 is mounted to a portion of the circumference 8 of the washing tub where the light receiving part 20 faces the light emission part 10 when the door 3 is closed. Since the light receiving part 20 receives infrared light only when the door 3 is closed, the output value of the light receiving part 20 varies depending upon whether the door 3 is opened or closed.

[0103] In this embodiment, the light emission part 10 is mounted to the door 3. Alternatively, the light emission part 10 may be mounted to the structural body 40 or 50 as in the embodiment shown in FIGS. 7A to 7C or the embodiment shown in FIGS. 8A to 8D. Also, the light emission part 10 may be mounted to the top cover 2 or the structural body 60 as in the embodiment shown in FIGS. 10A to 10C. Furthermore, the positions of the light emission part 10 and the light receiving part 20 may be varied. In this case, the light receiving part 20 faces the light emission part 10 only when the door 3 is opened or closed. To sense vibration and weight of the washing tub 1, which will be described below, the light emission part 10 is mounted to irradiate infrared light toward the circumference of the washing tub 1 when the door 3 is closed, and the light receiving part 20 is mounted to the circumference of the washing tub 1.

[0104] The door open and close determination unit 110 determines that the door 3 is closed when the output value of the light receiving part 20 remains uniform. The door open and close determination unit 110 determines that the door 3 is open when the output value of the light receiving part 20 decreases to approximately 0. During a washing cycle, however, the output value of the light receiving part 20 may not be uniform due to motion of the washing tub 1. When the output value of the light receiving part 20 fluctuates, therefore, the door open and close determination unit 110 determines that the door 3 is closed.

[0105] Hereinafter, a control operation of the washing cycle control unit 140 based on the determination of the door open and close determination unit 110 will be de-

scribed. When the door open and close determination unit 110 determines that the door 3 is open during the washing cycle, the door open and close determination unit 110 transmits a signal to the washing cycle control unit 140, and the washing cycle control unit 140 stops the washing cycle for safety's sake. Also, the washing cycle control unit 140 informs a user that the door 3 is open in a visual or acoustic manner to prompt the user to close the door 3. On the other hand, when the door open and close determination unit 110 determines that the door 3 is closed, the door open and close determination unit 110 transmits a signal to the washing cycle control unit 140, and the washing cycle control unit 140 resumes the stopped cycle.

[0106] If the washing cycle is not carried out when the door 3 is opened, the washing cycle control unit 140 waits until the door 3 is closed to perform the user-requested washing cycle.

[0107] Depending upon the place where the infrared sensor 30 is mounted, the infrared sensor 30 may sense whether the washing tub 1 vibrates during the washing cycle as well as whether the door 3 is opened or closed. Also, the infrared sensor 30 may sense the change in weight of the washing tub 1 due to laundry or wash water. Hereinafter, a structure to sense weight or vibration of the washing tub 1 using the infrared sensor 30 to sense whether the door 3 is opened or closed and an operation thereof will be described.

[0108] If the laundry accumulates at one side of the washing tub 1 during rinsing or spin-drying of the washing cycle, the washing tub 1 abnormally vibrates during rotation of the washing tub 1. In this case, the washing tub 1 may collide with the machine body 4 during rotation of the washing tub 1 with the result that noise may occur, and the washing tub 1 or the machine body 4 may be damaged. Also, if the laundry accumulates at one side of the washing tub 1, the laundry may not be properly washed. For this reason, the washing cycle is controlled based on sensing of abnormal vibration of the washing tub 1.

[0109] FIGS. 12A and 12B show a washing machine that senses whether the door is opened or closed and whether the washing tub vibrates according to another embodiment of the present invention. The infrared sensor of the embodiment shown in FIGS. 3 to 6 may be used as the infrared sensor 30 of this embodiment. Alternatively, any one selected from among the infrared sensors shown in FIGS. 7A to 7C, 8A to 8D, and 10A to 10C may be used as the infrared sensor 30 of this embodiment. However, the light emission part 10 is mounted to irradiate infrared light toward the washing tub 1 when the door 3 is closed.

[0110] As shown in FIG. 12A, when the door 3 is closed, and the light emission part 10 is mounted to irradiate infrared light toward the bottom of the washing machine 5, the amount of the infrared light received by the light receiving part 20 varies depending upon whether or not the washing tub 1 is located in an infrared irradiation

region of the infrared sensor 30.

[0111] When the washing tub 1 abnormally vibrates, as shown in FIG. 12B, the washing tub 1 repeatedly moves into or out of the infrared irradiation region of the infrared sensor 30. As a result, the output value of the light receiving part 20 fluctuates, and the vibration determination unit 120 analyzes the output value to determine that the washing tub 1 abnormally vibrates.

[0112] Depending upon the size and position of the door 3, the infrared sensor 30 may be located at the circumference 8 of the washing tub or outside the circumference 8. The position of the infrared sensor 30 is adjusted so that the position of the infrared sensor 30 is in a range within which motion of the washing tub 1 is sensed, and therefore, the infrared sensor 30 irradiates infrared light to sense abnormal vibration of the washing tub 1 during rotation of the washing tub 1.

[0113] The washing machine according to the embodiment shown in FIG. 11 may sense abnormal vibration of the washing tub 1 if the light emission part 10 is mounted at the position of the infrared sensor 30, and the light receiving part 20 is mounted to the circumference of the washing tub 1.

[0114] FIGS. 13A and 13B are graphs showing the output value of the light receiving part 20 when the washing tub 1 normally rotates and when the washing tub 1 abnormally vibrates. The output value of the light receiving part 20 shown in FIGS. 13A and 13B is obtained in a case in which the infrared sensor 30 is mounted above and outside the circumference 8 of the washing tub 1.

[0115] FIG. 13A is a graph showing the output value of the light receiving part 20 when the washing tub 1 normally rotates. Since the washing tub 1 does not move into the infrared irradiation region of the infrared sensor 30 when the washing tub 1 normally rotates, the output value of the light receiving part 20 is uniform. Also, since the bottom of the machine body 4, from which the irradiated infrared light is reflected, is farther from the infrared sensor 30 than the washing tub 1, the output value is low.

[0116] FIG. 13B is a graph showing the output value of the light receiving part 20 when the washing tub 1 abnormally vibrates during rotation of the washing tub 1. Since the washing tub 1 repeatedly moves into and out of the infrared irradiation region of the infrared sensor 30 when the washing tub 1 abnormally vibrates during rotation of the washing tub 1, the output value of the light receiving part 20 periodically varies. When the washing tub 1 is driven to the infrared irradiation region during abnormal vibration of the washing tub 1, the output value of the light receiving part 20 increases. When the washing tub 1 is further driven and the infrared irradiation region is located within the washing tub 1 or when the washing tub 1 returns to the original position thereof, the output value of the light receiving part 20 decreases.

[0117] Since laundry is contained in the washing tub 1, and the bottom of the washing tub 1 is higher than the bottom of the machine body 4, the output value of the light receiving part 20 is higher when the infrared light

from the infrared sensor 30 is irradiated into the washing tub 1 than when the infrared light is irradiated to the bottom of the machine body outside the circumference of the washing tub 1.

[0118] The vibration generation determination unit 120 determines whether the washing tub 1 vibrates using the above information. For example, a sensor output pattern when the washing tub 1 normally rotates is stored, and an output value of the light receiving part 20 during rotation of the washing tub is transmitted and compared with the stored pattern. Since errors may occur depending upon the amount of laundry or rotational speed of the washing tub, a critical value is set, and it is determined that the washing tub 1 abnormally vibrates if the difference between the output value of the light receiving part 20 and the stored pattern is greater than the critical value. Also, it may be determined whether vibration of the washing tub 1 is high or low based on how much the difference between the output value of the light receiving part 20 and the stored pattern deviates from the critical value.

[0119] In another example, it may be determined that the washing tub 1 does not vibrate if the output value of the light receiving part 20 is uniform. Also, it may be determined that the washing tub 1 vibrates if the output value of the light receiving part 20 exceeds the critical value, and it may be determined whether vibration of the washing tub 1 is high or low based on the magnitude of the fluctuation of the output value.

[0120] The above determination method is merely one embodiment of the function performed by the vibration generation determination unit 120. Various other algorithms may be used.

[0121] FIG. 14A shows a second reflection plate 33, and FIG. 14B shows a washing machine having the second reflection plate 33. Vibration of the washing tub 1 may be sensed without the second reflection plate 33. When the second reflection plate 33 having color gradation is mounted at the washing machine as shown in FIGS. 14A and 14B, however, vibration of the washing tub may be more accurately sensed.

[0122] Reflectance of infrared light varies depending upon colors of an object. White has very high reflectance of infrared light, and black has very low reflectance of infrared light. Consequently, the output value of the light receiving part 20 varies depending upon the color of an object, to which infrared light is irradiated. FIG. 14A shows the surface of the second reflection plate 33 having color gradation from white to black. One end of the second reflection plate 33 is painted white, and the color transitions from white to black so that the other end of the second reflection plate 33 is painted black. Other different colors may be arranged so long as the colors have different reflectances of infrared light.

[0123] FIG. 14B is a plan view of the washing tub 1 to which the second reflection plate 33 is mounted. Although the infrared sensor 30 is omitted, one of the infrared sensors of the embodiments shown in FIGS. 3 to 6, 7A to 7C, 8A to 8D, and 10A to 10C may be used.

When the second reflection plate 33 having color gradation as shown in FIG. 14A is mounted to the washing tub 1, the gradation of the color reflecting infrared light varies depending upon how much the washing tub 1 slants. Consequently, the output value of the light receiving part 20 is easily analyzed, thereby easily determining whether abnormal vibration of the washing tub 1 caused during rotation of the washing tub 1 is high or low.

[0124] In a case in which the second reflection plate 33 is mounted to the circumference 8 of the washing tub so that the white portion of the second reflection plate 33 is directed to the interior of the washing tub 1, the washing tub 1 passes an irradiation region of the infrared sensor 30 during rotation of the washing tub 1 in a state in which the washing tub 1 slants toward the side to which the second reflection plate 33 is mounted. At this time, the infrared sensor 30 irradiates infrared light to the vicinity of the white region of the second reflection plate 33 with the result that the output value of the light receiving part 20 instantaneously increases. At this time, gradation of the color of the second reflection plate 33, reflecting the infrared light, varies depending upon how much the washing tub 1 slants, and therefore, the output value of the light receiving part 20 varies.

[0125] If the washing tub 1 relatively greatly slants and thus highly vibrates, the infrared light is irradiated to the vicinity of the white region of the second reflection plate 33 with the result that the output value of the light receiving part 20 rapidly increases.

[0126] If the washing tub 1 relatively slightly slants and thus slightly vibrates, the infrared light is irradiated to the vicinity of the black region of the second reflection plate 33 with the result that the output value of the light receiving part 20 relatively slightly increases.

[0127] The vibration generation determination unit 12 may store an output value pattern of the light receiving part 20 in a database and compare an output signal transmitted from the infrared sensor 30 during rotation of the washing tub 1 with the stored output value pattern to determine whether the washing tub 1 abnormally vibrates and whether vibration of the washing tub 1 is high or low. Alternatively, an additional determination algorithm may be used.

[0128] The direction in which achromatic or chromatic colors are arranged on the second reflection plate 33 is not restricted.

[0129] In this embodiment, the infrared sensor 30 is configured so that the light emission part and the light receiving part are parallel to each other. Alternatively, in the washing machine according to the embodiment shown in FIGS. 10A to 10C, in which the light emission part and the light receiving part are opposite to each other, it may be sensed whether the washing tub vibrates, which will be described hereinafter in detail.

[0130] FIG. 15 is a side sectional view showing the washing machine according to the embodiment shown in FIG. 11 when the washing tub of the washing machine abnormally vibrates. When the washing tub 1 slants to

one side during rotation of the washing tub 1 and thus abnormally vibrates, infrared light irradiated from the light emission part 10 repeatedly moves into or out of the light receiving region of the light receiving part 20. As a result, the output value of the light receiving part 20 fluctuates. At this time, the output value is similar to that shown in FIG. 13B except that the minimum is approximately 0.

[0131] When the washing tub 1 normally rotates, the light receiving part 20 receives infrared light at predetermined time intervals according to rotation speed of the washing tub 1. During normal rotation of the washing tub 1, therefore, the output value of the light receiving part 20 periodically rapidly increases.

[0132] The vibration generation determination unit 12 may store an output value pattern of the light receiving part 20 based on rotational speed or weight of the washing tub when the washing tub 1 normally rotates in a database, receive the output value of the infrared sensor 30 during rotation of the washing tub 1, and determine that the washing tub 1 abnormally vibrates if the difference between the output value and the stored output value pattern is greater than a predetermined critical value. Also, the vibration generation determination unit 12 may determine whether vibration of the washing tub 1 is high or low based on how much the difference between the output value and the stored pattern deviates from the critical value. The above determination method is merely one embodiment of the function performed by the vibration generation determination unit 120. Various other algorithms may be used.

[0133] Although the positions of the light emission part 10 and the light receiving part 20 are changed, it may be determined whether the washing tub 1 abnormally vibrates using the above method.

[0134] When the vibration generation determination unit 120 determines that the washing tub 1 abnormally vibrates, the vibration generation determination unit 120 transmits a signal to the washing cycle control unit 140, and the washing cycle control unit 140 performs an operation to eliminate the abnormal vibration. For example, the washing cycle control unit 140 may supply water to the washing tub 1 so that an untangling cycle is carried out to untangle laundry. At this time, the washing cycle control unit 140 may adjust the amount of water to be supplied depending upon whether the abnormal vibration is high or low when the washing cycle control unit 140 has received information regarding whether the abnormal vibration is high or low from the vibration generation determination unit 120.

[0135] In one aspect of the present invention, the washing machine may sense weight of the washing tub as well as whether the door is opened or closed and whether or not the washing tub vibrates using a single optical sensor. Hereinafter, an embodiment of the washing machine that senses weight of the washing tub will be described.

[0136] FIG. 16 is a side sectional view showing a washing machine according to an embodiment of the present

invention when weight of a washing tub of the washing machine is sensed. The infrared sensor 30 of the embodiment shown in FIGS. 3 to 6 may be used as the infrared sensor 30 of this embodiment. Of course, any infrared sensors 30 may be used so long as the infrared sensors sense whether the door is opened or closed. In order to sense weight of the washing tub, however, the infrared sensor 30 may be mounted to irradiate infrared light to the inner lower part of the machine body 4 when the door 3 is closed.

[0137] The second reflection plate 33 is mounted to the circumference 8 of the washing tub of the washing machine shown in FIG. 16. The second reflection plate 33 is located at a position where the second reflection plate 33 faces the infrared sensor 30, i.e. a position at which the second reflection plate 33 moves into the infrared irradiation region of the infrared sensor 30. The second reflection plate 33 may have no color gradation unlike that shown in FIG. 13.

[0138] When the second reflection plate 33 is mounted within the infrared irradiation region of the infrared sensor 30 as shown in FIG. 16, vertical movement of the washing tub 1 may be sensed. For example, when laundry is contained in the washing tub 1, the washing tub 1 sags downward due to the weight of the laundry with the result that the distance between the second reflection plate 33 and the infrared sensor 30 increases. When laundry is contained in the washing tub 1, therefore, the output value of the light receiving part 20 decreases, and the weight determination unit 130 may analyze the output value to determine the amount of the laundry.

[0139] If the output value of the light receiving part 20 decreases, the weight determination unit 130 determines that the weight of the washing tub 1 has increased and determines the increased weight of the washing tub 1 using the decreased amount of the output value of the light receiving part 20. On the other hand, if the output value of the light receiving part 20 increases, the weight determination unit 130 determines that the weight of the washing tub 1 has decreased and determines the decreased amount of the weight of the washing tub 1 using the increased amount of the output value of the light receiving part 20. For example, the increased weight of the washing tub 1 based on the decreased amount of the output value of the light receiving part 20 or the decreased amount of the weight of the washing tub 1 based on the increased amount of the output value of the light receiving part 20 may be stored in a database, and the changed amount of the weight of the washing tub 1 corresponding to the decreased amount of the output value of the light receiving part 20 or the increased amount of the output value of the light receiving part 20 may be extracted. Alternatively, an additional algorithm to calculate the change in weight of the washing tub 1 based on the output value of the light receiving part 20 may be used.

[0140] In a case in which the infrared sensor 30 is located immediately above the circumference 8 of the washing tub, the weight of the washing tub 1 may be

sensed without the second reflection plate 33. On the other hand, when the second reflection plate 33, having a predetermined area, is mounted to the circumference of the washing tub 1, the distance between the infrared sensor 30 and the washing tub 1 may be more accurately sensed.

[0141] However, if the size of the second reflection plate 33 is too large, the second reflection plate 33 may collide with the machine body 4 during rotation of the washing tub 1 with the result that noise may be generated, or the second reflection plate 33 or the machine body 4 may be damaged. For this reason, the size of the second reflection plate 33 is adjusted to prevent a washing cycle from being affected.

[0142] FIG. 17 shows an operation to sense weight of the washing tub 1 in the washing machine corresponding to the embodiment shown in FIG. 11. As previously described, when the weight of the washing tub 1 increases, the washing tub 1 sags downward with the result that the distance between the light emission part 10 and the light receiving part 20 increases. Consequently, the output value of the light receiving part 20 decreases. As previously described, the increased weight of the washing tub 1 based on the decreased amount of the output value of the light receiving part 20 may be stored in a database, and the weight determination unit 130 may extract the increased weight of the washing tub 1 corresponding to the increased weight of the washing tub 1. Alternatively, the increased weight of the washing tub 1 may be calculated using an additional algorithm to calculate the change in weight of the washing tub based on the output value of the light receiving part 20

[0143] In this embodiment, the weight and vibration of the washing tub 1 may be sensed in a noncontact manner as well as based upon whether the door 3 is opened or closed using a single infrared sensor 30 so as to control the washing machine.

[0144] If priority is given to sensing of vibration or weight of the washing tub 1 rather than to determination as to whether the door 3 is opened or closed, however, the infrared sensor 30 may be mounted at one side or one corner of the machine body 4 at the inside thereof to sense the weight or vibration of the washing tub 1.

[0145] Hereinafter, an infrared sensor 30 mounted at one corner of the machine body 4 at the inside thereof to sense the weight or vibration of the washing tub 1 and a washing machine having the infrared sensor 30 will be described in detail.

[0146] FIG. 18 is a plan view of a washing machine according to another embodiment of the present invention. An infrared sensor 30 used in this embodiment is configured so that the light emission part 10 and the light receiving part 20 are parallel to each other as shown in FIG. 2B. The infrared sensor 30 may be mounted at any position of one side or one corner of the machine body 4 at the inside thereof so long as the infrared sensor 30 directly faces the outer surface of the washing tub 1. In this embodiment, the infrared sensor 30 is mounted at

one of the four corners of the machine body 4 as shown in FIG. 18.

[0147] When the washing tub rotates so that the washing machine having the infrared sensor 30 performs an operation, such as spin-drying, the distance between the washing tub 1 and the infrared sensor 30 continuously varies if the washing tub 1 vibrates in a state in which the washing tub 1 slants to one side. As a result, the output value of the light receiving part 20 is not uniform. Consequently, the vibration generation determination unit 120 of the controller 100 analyzes the output value of the light receiving part 20 to determine whether the washing tub 1 vibrates.

[0148] FIGS. 19A and 19B are graphs showing an output value of the light receiving part 20 based on whether vibration of the washing tub 1 is high or low. If the vibration of the washing tub 1 is high, the output value of the light receiving part 20 greatly varies as shown in FIG. 19A. If the vibration of the washing tub 1 is low, the output value of the light receiving part 20 slightly varies as shown in FIG. 19B.

[0149] Specifically, if the distance between the washing tub 1 and the infrared sensor 30 decreases, the amount of infrared light received by the light receiving part 20 of the infrared sensor 30 increases with the result that the output value of the light receiving part 20 increases. On the other hand, if the distance between the washing tub 1 and the infrared sensor 30 increases, the amount of infrared light received by the light receiving part 20 of the infrared sensor 30 decreases with the result that the output value of the light receiving part 20 decreases. If the washing tub 1 rotates without vibration, the distance between the infrared sensor 30 and the washing tub 1 is uniform with the result that the output value of the light receiving part 20 is uniform. If the washing tub 1 vibrates, however, the distance between the washing tub 1 and the infrared sensor 30 repeatedly increases and decreases with the result that the output value of the light receiving part 20 repeatedly increases and decreases.

[0150] The magnitude in vibration of the washing tub 1 may vary depending upon how much the washing tub 1 slants. If the change in output value of the light receiving part 20 is large, it may be determined that the magnitude of the vibration is high, i.e. the washing tub 1 excessively slants. On the other hand, if the change in output value of the light receiving part 20 is small, it may be determined that the magnitude of the vibration is low, i.e. that the washing tub 1 slightly slants.

[0151] The vibration generation determination unit 120 may analyze the output value of the light receiving part 20 to determine the magnitude of vibration generated in the washing tub 1, i.e. how much the washing tub 1 slants, and the washing cycle control unit 140 may adjust the amount of wash water to be supplied during an untangling cycle to untangle laundry based on the determination result.

[0152] Since the washing tub 1 reflects infrared light,

the vibration of the washing tub 1 may be sensed without an additional reflection plate mounted to the washing tub 1. However, if the second reflection plate 33 is mounted to the outside of the washing tub 1, the weight of the washing tub 1 may be easily sensed using the second reflection plate 33.

[0153] FIGS. 20A and 20B show a washing machine according to a further embodiment of the present invention in which a second reflection plate 33 is mounted to the outside of a washing tub 1. As previously described, reflectance of infrared light varies depend upon color, and, if the reflectance of infrared light varies, the output value of the light receiving part 20 varies. When the second reflection plate 33 having color gradation exhibiting different reflectances is mounted to the outside of the washing tub 1 so that the second reflection plate 33 faces the infrared sensor 30 mounted at one side or one corner of the machine body 4 at the inside thereof as shown in FIG. 20A, the output value of the light receiving part 20 varies depending upon vertical movement of the washing tub 1.

[0154] Colors having different reflectances are vertically arranged at the outside of the second reflection plate 33. For example, colors may be arranged from top to bottom so that the surface of the second reflection plate 33 has color gradation from black to white.

[0155] FIG. 20B is a side sectional view of the washing machine at which the second reflection plate 33 is mounted. Referring to FIG. 20B, if laundry is contained in the washing tub 1 or water is supplied to the washing machine, the weight of the washing tub 1 increases with the result that the washing tub 1 sags downward. At this time, the position of the second reflection plate 33 reflecting infrared light from the infrared sensor 30 relatively rises with the result that reflectance of infrared light varies, and therefore, the output of the light receiving part 20 varies. For example, in a case in which the second reflection plate 33 has color gradation from light to dark colors, the colors reflecting infrared light are darkened if the weight of the washing tub 1 increases. As a result, the output value of the light receiving part 20 decreases, and therefore, the output value of the light receiving part 20 further decreases as the weight of the washing tub 1 increases.

[0156] If the output value of the light receiving part 20 varies in a state in which the washing tub 1 is stopped, the weight determination unit 130 determines that the weight of the washing tub 1 has varied and senses how much the washing tub 1 sags downward based on the varied output value of the light receiving part 20. The weight determination unit 130 may store output values of the light receiving part 20 based on the respective colors provided at the surface of the second reflection plate 33 in a database, and, in addition, the weight of the washing tub when the infrared irradiation region reaches the corresponding color may also be stored. However, the control operation of the weight determination unit 130 is not limited to the above method.

[0157] If the weight determination unit determines the

weight of the washing tub 1 using the infrared sensor 30 mounted at the washing machine as described above, the washing cycle control unit 140 may adjust the amount of water to be supplied to the washing machine and control rotational speed of the washing tub 1 or drive force to rotate the washing tub 1 depending upon the weight of the washing tub 1, to which, however, the embodiments of the present invention are not limited. Alternatively, various washing cycles may be controlled based upon the weight of the washing tub.

[0158] As is apparent from the above description, according to the embodiments, whether the door is opened or closed, the vibration of the washing tub, and the weight of the washing tub are sensed using the optical sensor which does not directly contact the door or the washing tub. Also, costs are reduced since whether the door is opened or closed, the vibration of the washing tub, and the weight of the washing tub are sensed using a single sensor.

[0159] Although a few embodiments have been shown and described, it would be appreciated by those skilled in the art that changes may be made in these embodiments without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.

Claims

1. A washing machine comprising:

a machine body having a washing tub;
a top cover to cover a top of the machine body;
a door connected to the top cover by a hinge so that the door is opened and closed;
an optical sensor comprising a light emission part mounted to the door, a direction in which the light emission part irradiates light varying depending upon movement of the door, and a light receiving part to receive the light irradiated from the light emission part and to output a signal corresponding in a magnitude to an amount of the received light; and
a controller to analyze the signal output from the light receiving part to determine whether the door is opened or closed and to control an operation of the washing machine based upon the determination result.

2. The washing machine according to claim 1, wherein the light emission part is mounted to a rear part of the door adjacent to the hinge, and the light receiving part is mounted in parallel to the light emission part to output a signal corresponding in a magnitude to an amount of light irradiated from the light emission part and reflected from a first reflection plate in the top cover or an interior of the machine body.

3. The washing machine according to claim 2, wherein the light emission part is mounted to irradiate light toward a front of the washing machine when the door is opened, and
the first reflection plate is mounted to a rear part of the top cover so that the first reflection plate faces the light emission part when the door is opened. 5
4. The washing machine according to claim 2, wherein the light emission part is mounted to irradiate light toward a front of the washing machine when the door is opened, and
the first reflection plate is configured by interconnecting corresponding sides of two rectangular planes in an L shape, a vertical plane of the first reflection plate reflecting the light irradiated from the light emission part when the door is opened. 10
5. The washing machine according to claim 4, wherein a horizontal plane of the first reflection plate is configured so as not to extend to a position where the light emission part irradiates light when the door is closed. 15
6. A washing machine comprising: 20
 - a machine body having a washing tub;
 - a top cover to cover a top of the machine body;
 - a door connected to the top cover by a hinge so that the door is opened and closed;
 - a structural body moving according to opening and closing of the door; 30
 - an optical sensor comprising a light emission part mounted to the structural body, a direction in which the light emission part irradiates light varying depending upon movement of the structural body, and a light receiving part to receive the light irradiated from the light emission part and to output a signal corresponding in a magnitude to an amount of the received light; and 35
 - a controller to analyze the signal output from the light receiving part to determine whether the door is opened or closed and to control an operation of the washing machine based upon the determination result. 40
7. The washing machine according to claim 6, wherein the structural body is formed in a shape of '□' and is mounted to a rear part of the top cover in a state in which a hinge is connected to a bent part of the structural body so that an end of a rear part of the door lifts a door contact part of the structural body when the door is moved, 50
the light emission part is mounted in a sensor mounting part provided at a lower end of the structural body, and
the light receiving part is mounted in parallel to the light emission part to output a signal corresponding in a magnitude to an amount of light irradiated from the light emission part and reflected from a first reflection plate in the top cover or an interior of the machine body.
8. The washing machine according to claim 7, wherein the light emission part is mounted to irradiate light toward a lower side of the washing machine when the door is closed, and
the first reflection plate is configured by interconnecting corresponding sides of two rectangular planes in an L shape, a vertical plane of the first reflection plate reflecting the light irradiated from the light emission part when the door is opened.
9. The washing machine according to claim 8, wherein a horizontal plane of the first reflection plate is configured so as not to extend to a position where the light emission part irradiates light when the door is closed.
10. A washing machine comprising:
 - a machine body having a washing tub;
 - a top cover to cover a top of the machine body;
 - a door connected to the top cover by a hinge so that the door is opened and closed;
 - a structural body moving according to opening and closing of the door;
 - an optical sensor comprising a light emission part mounted to the structural body, a position at which the light emission part irradiates light varying depending upon movement of the structural body, and a light receiving part to receive the light irradiated from the light emission part and to output a signal corresponding in a magnitude to an amount of the received light; and
 - a controller to analyze the signal output from the light receiving part to determine whether the door is opened or closed and to control an operation of the washing machine based upon the determination result.
11. The washing machine according to claim 10, wherein the structural body comprises a first structural body having a protrusion formed at one lateral side of an upper part thereof and a second structural body, in which the first structural body is received, a portion of an upper part of the second structural body being open so that the protrusion of the first structural body is exposed outward, a portion of a bottom of the second structural body being open, the remaining portion of the bottom of the second structural body being closed, 55
the light emission part is mounted to a bottom of the first structural body to irradiate light downward, and the light receiving part is mounted in parallel to the light emission part to output a signal corresponding

in a magnitude to an amount of light irradiated from the light emission part and reflected from the closed portion of the second structural body or an interior of the machine body.

12. The washing machine according to claim 11, wherein when the door is closed, an end of a rear part of the door pushes the protrusion of the first structural body so that the light emission part is located above the open portion of the second structural body, and when the door is opened, the first structural body returns to an original position thereof so that the light emission part is located above the closed portion of the second structural body.

13. A washing machine comprising:

a machine body having a washing tub;
a top cover to cover a top of the machine body;
a door connected to the top cover by a hinge so that the door is opened and closed;
an optical sensor comprising a light emission part mounted to a rear part of the top cover and a light receiving part mounted in parallel to the light emission part;
a sensing lever provided between a rear part of the door and the optical sensor so as to move according to opening and closing of the door, the sensing lever having a screening member to screen the optical sensor according to movement of the sensing lever; and
a controller to analyze the signal output from the light receiving part to determine whether the door is opened or closed and to control an operation of the washing machine based upon the determination result.

14. The washing machine according to claim 13, wherein the optical sensor is mounted to irradiate light to an inner lower part of the machine body, and the sensing lever comprises a structural body formed in a shape of '□' and a screening member mounted to a portion vertically extending downward from a bent part of the structural body, the sensing lever being mounted to a rear part of the top cover so that the screening member screens the optical sensor when the door is opened and so that an end of a rear part of the door lifting a door contact part horizontally extending from the bent part of the sensing lever and thus the screening member does not screen the optical sensor when the door is closed.

15. The washing machine according to any one of claims 1, 6, 10 or 13, wherein the light emission part is mounted to irradiate light to an inner lower part of the machine body when the door is closed, and the light receiving part is mounted in parallel to the

light emission part.

16. The washing machine according to claim 15, further comprising a second reflection plate mounted to a circumference of the washing tub within a light irradiation region of the optical sensor.

17. The washing machine according to claim 15, wherein the controller determines that the washing tub does not abnormally vibrate if the signal output from the light receiving part during rotation of the washing tub is uniform, and determines that the washing tub abnormally vibrates if the signal output from the light receiving part during rotation of the washing tub fluctuates and controls the operation of the washing machine based on a determination result.

18. The washing machine according to claim 15, wherein the controller stores a pattern of a signal output from the light receiving part during normal rotation of the washing tub without abnormal vibration in a database and compares the signal output from the light receiving part during rotation of the washing tub with the stored pattern to determine whether the washing tub abnormally vibrates or whether vibration of the washing tub is high or low and to control the operation of the washing machine based on a determination result.

19. The washing machine according to claim 16, wherein the controller determines that weight of the washing tub has increased if the signal output from the light receiving part decreases in a state in which the washing tub is stopped, determines that the weight of the washing tub has decreased if the signal output from the light receiving part increases in a state in which the washing tub is stopped, determines a changed amount of the weight of the washing tub based on an changed amount of the output signal, and controls the operation of the washing machine based on a determination result.

20. A washing machine comprising:

a machine body having a washing tub;
an optical sensor comprising a light emission part mounted at one side or one corner of the machine body at an inside thereof to irradiate light and a light receiving part mounted in parallel to the light emission part to receive the light irradiated from the light emission part and to output a signal corresponding in a magnitude to an amount of the received light;
a second reflection plate mounted to an outside of the washing tub so that the second reflection plate faces the optical sensor, the second reflection plate having a plurality of colors exhibiting different reflectances of the light irradiated

from the light emission part, the colors being vertically arranged in order of reflectance; and a controller to analyze the signal output from the light receiving part to determine whether the washing tub vibrates and whether weight of the washing tub has increased and to control an operation of the washing machine based upon the determination result.

21. The washing machine according to claim 20, wherein the controller determines that the washing tub does not abnormally vibrate if the signal output from the light receiving part during rotation of the washing tub is uniform and determines that the washing tub abnormally vibrates if the signal output from the light receiving part during rotation of the washing tub fluctuates.
22. The washing machine according to claim 21, wherein the controller determines that weight of the washing tub has varied if the signal output from the light receiving part varies in a state in which the washing tub is stopped and determines a changed amount of the weight of the washing tub using a changed amount of the signal output from the light receiving part.

23. A washing machine comprising:

a machine body having a washing tub;
 a top cover to cover a top of the machine body;
 a door connected to the top cover by a hinge so that the door is opened and closed;
 a single optical sensor comprising a light emission part and a light receiving part to receive the light irradiated from the light emission part and to output a signal corresponding in a magnitude to an amount of the received light; and
 a controller to analyze the signal output from the light receiving part to determine whether the door is opened or closed, determine whether the washing tub vibrates and determine whether weight of the washing tub has increased and to control an operation of the washing machine based upon the determination result.

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FIG. 1

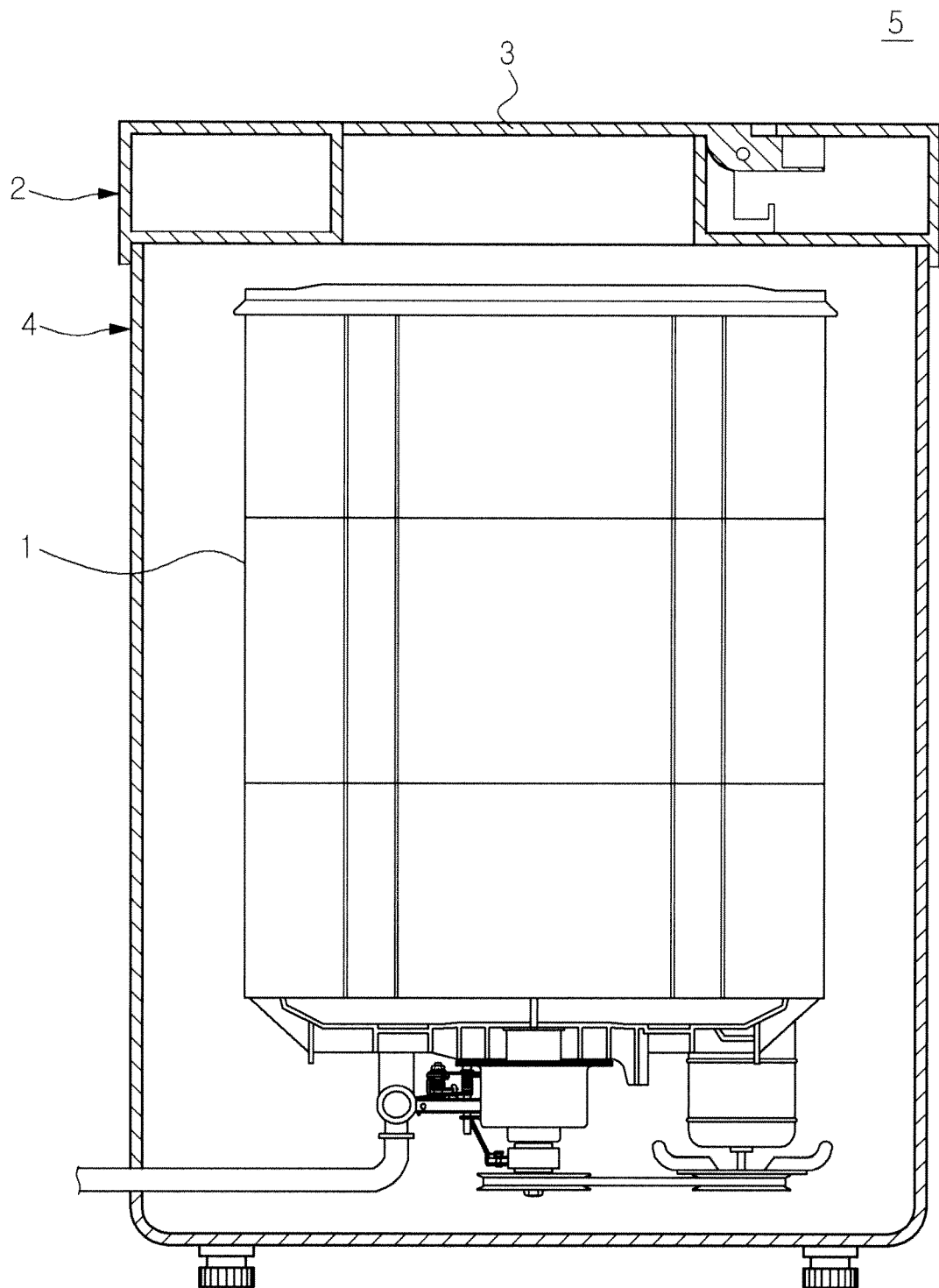


FIG. 2A

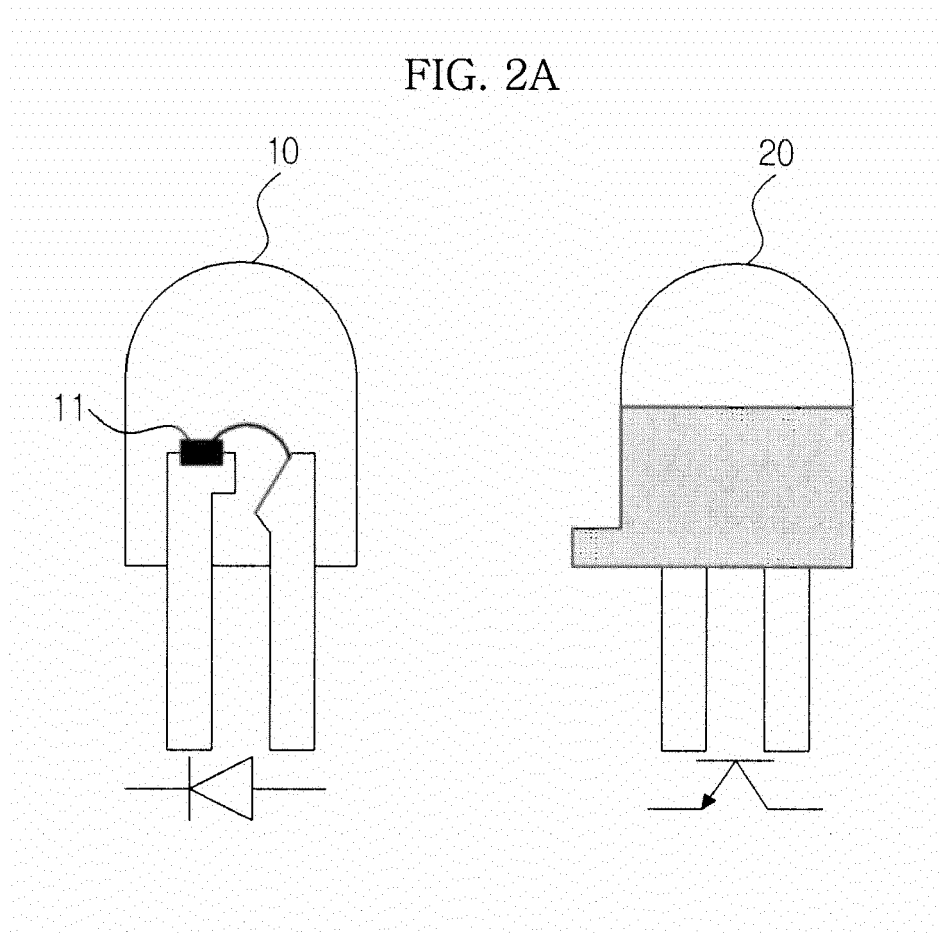


FIG. 2B

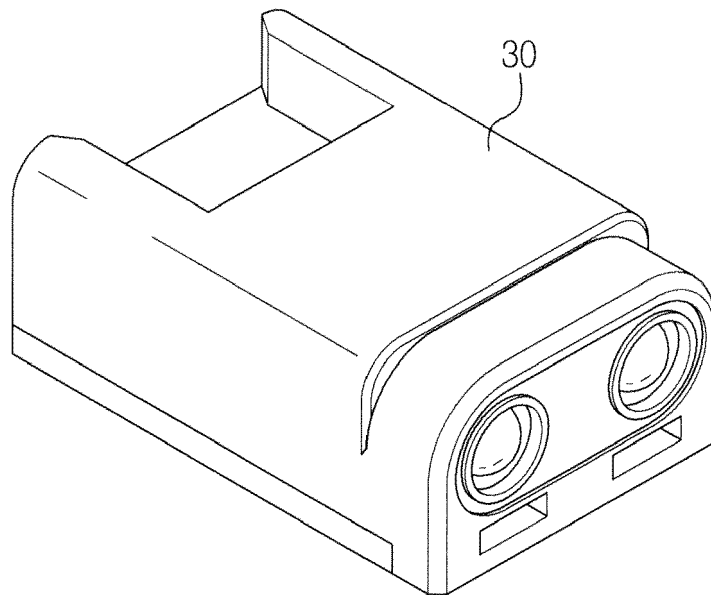


FIG. 2C

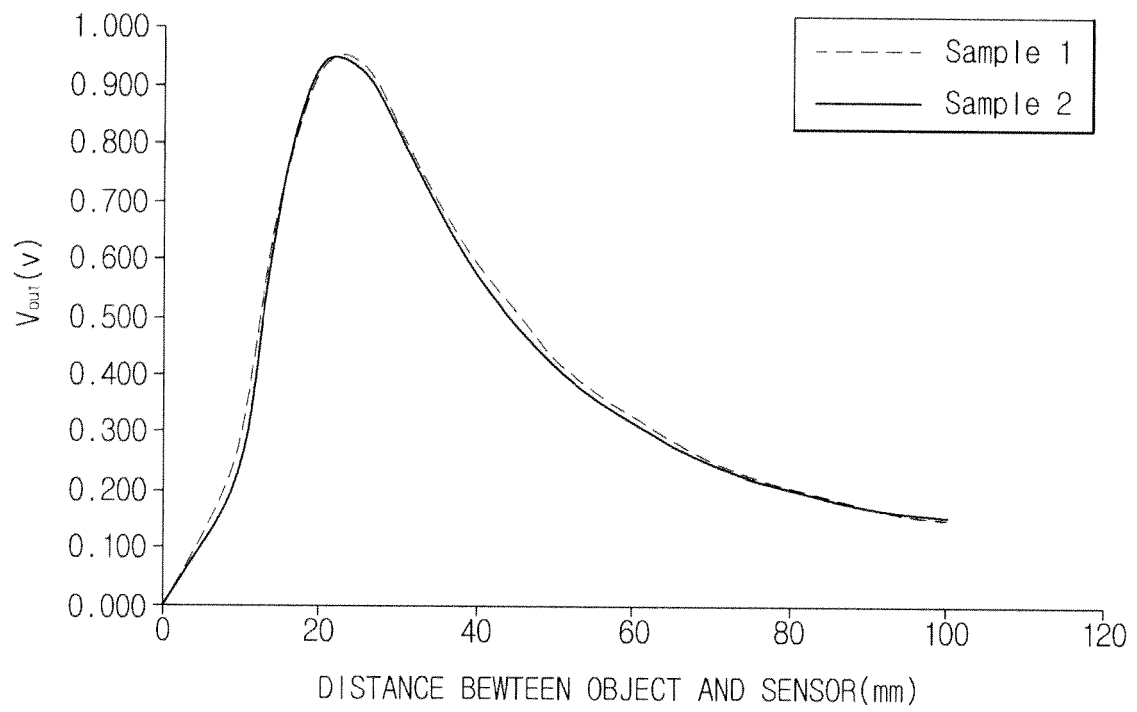


FIG. 3

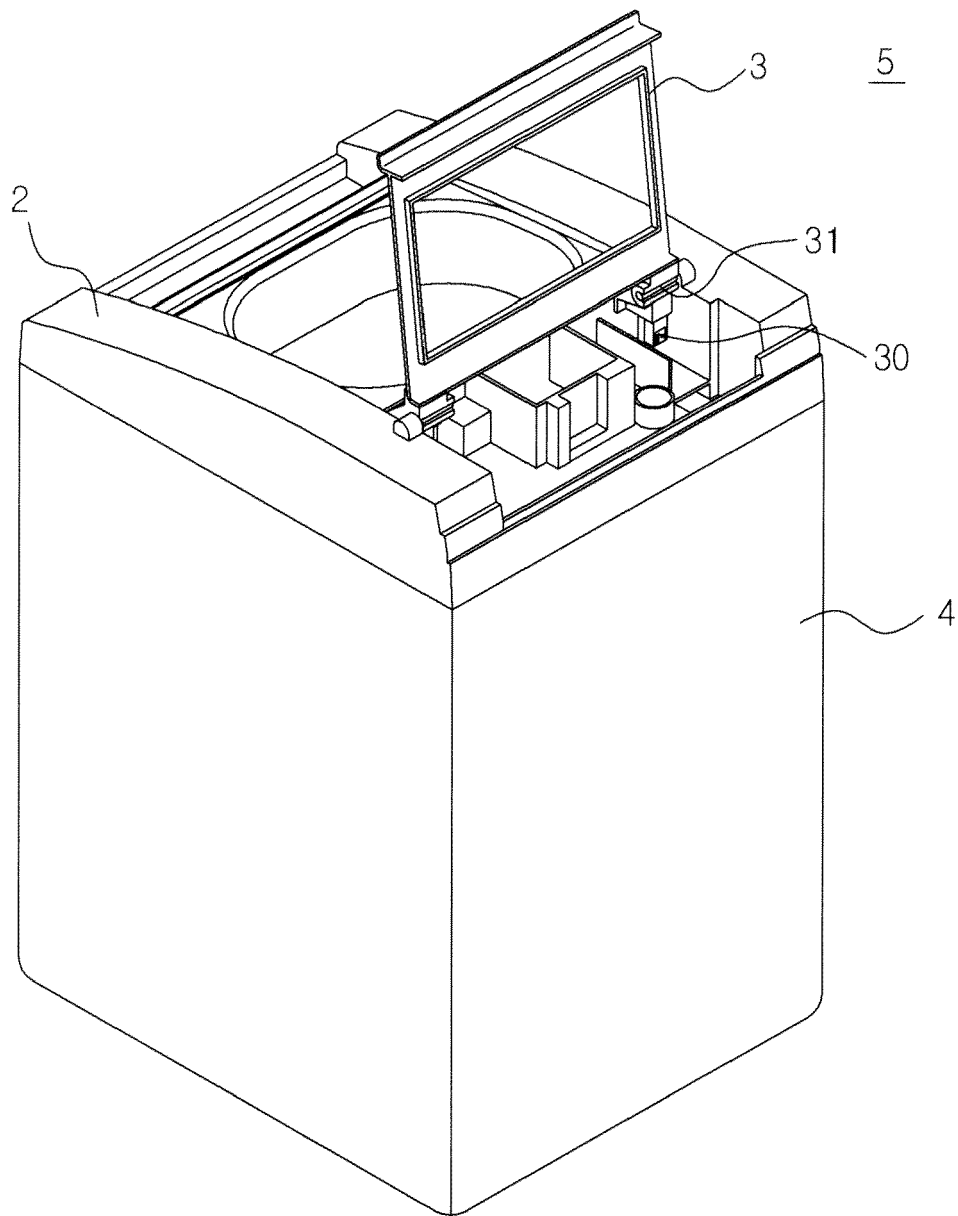


FIG. 4A

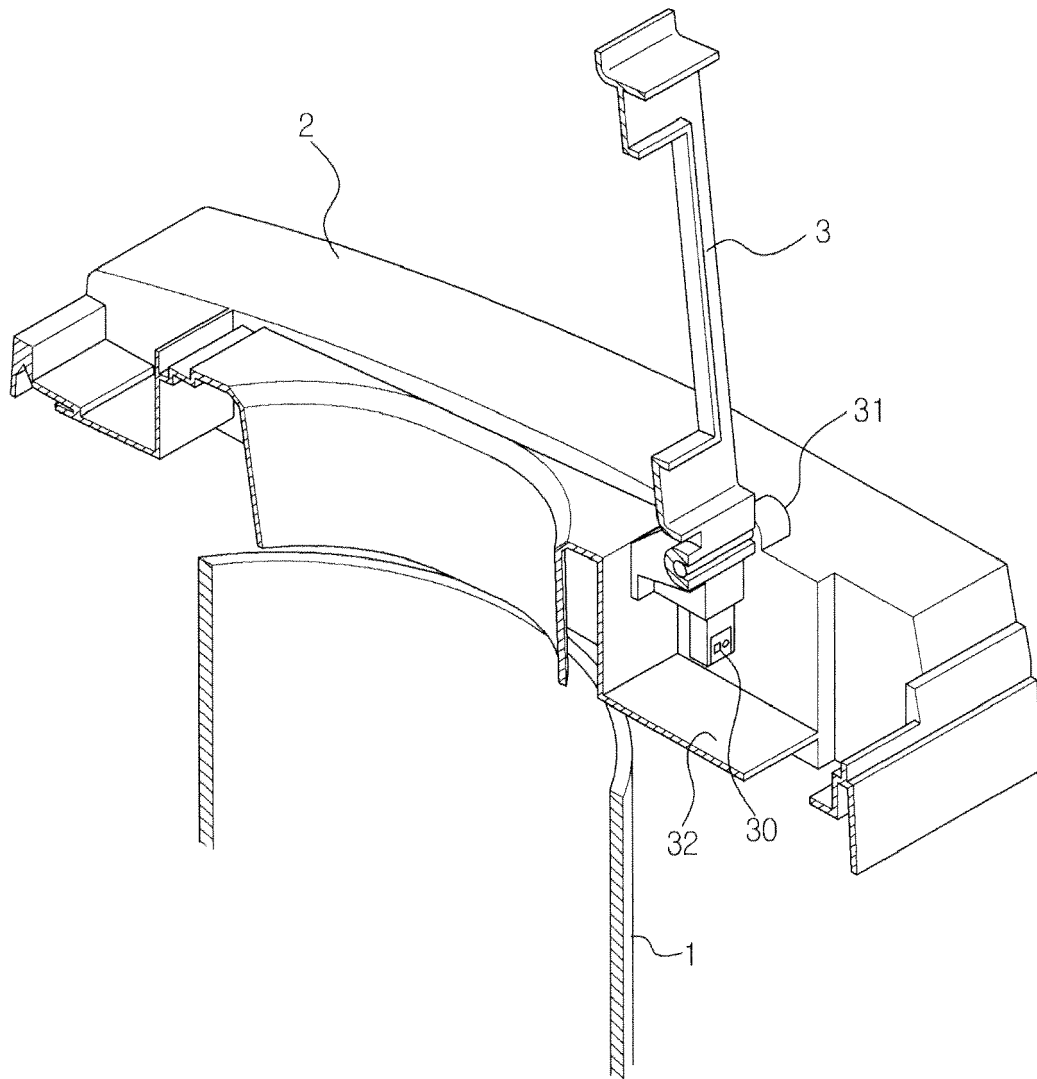


FIG. 4B

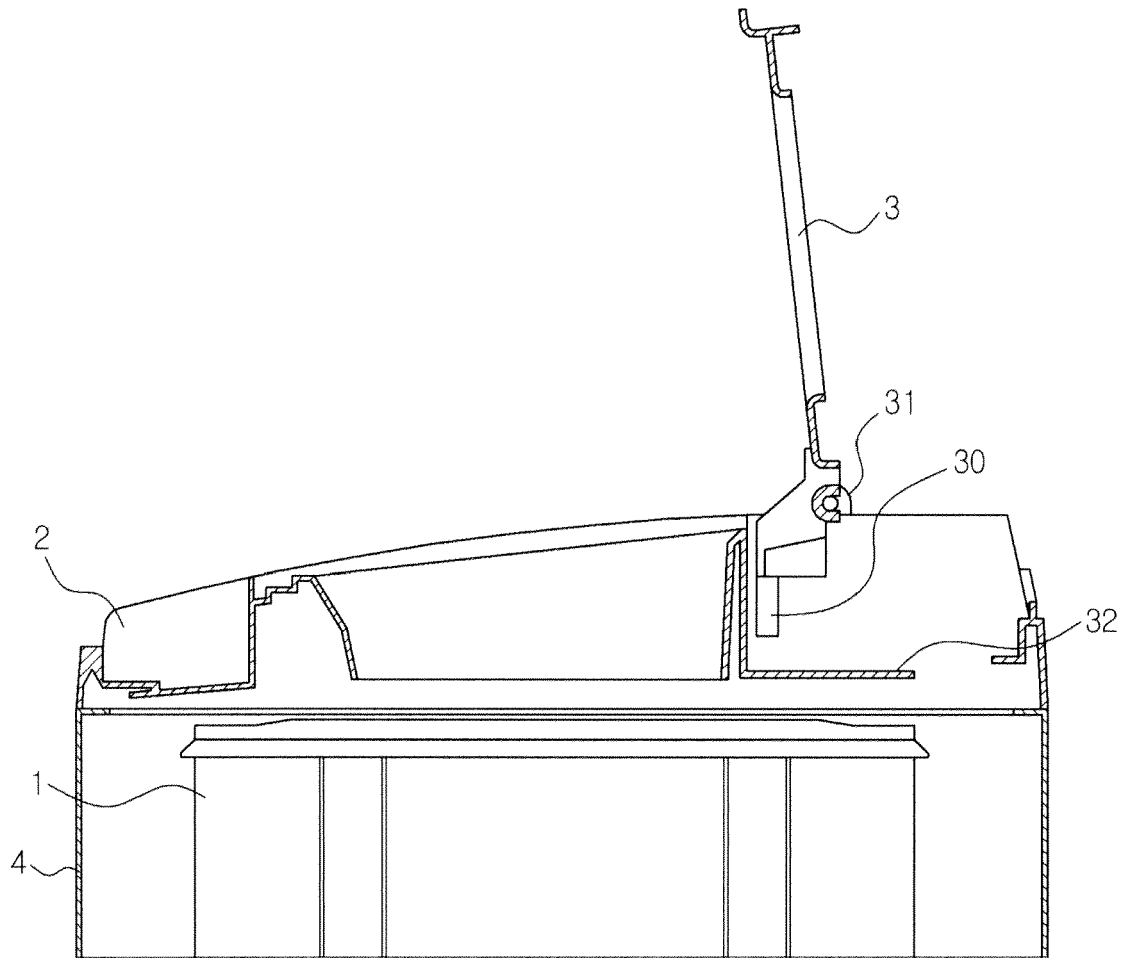


FIG. 4C

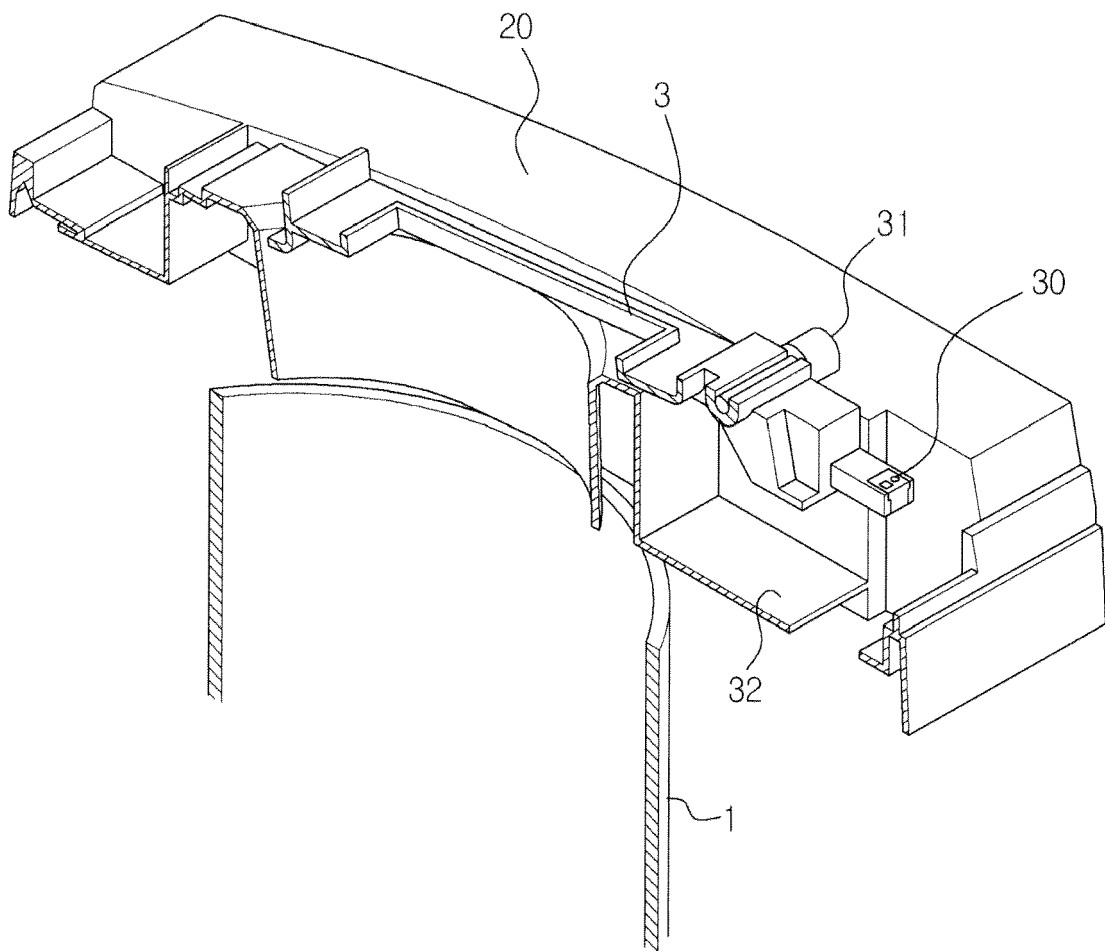


FIG. 4D

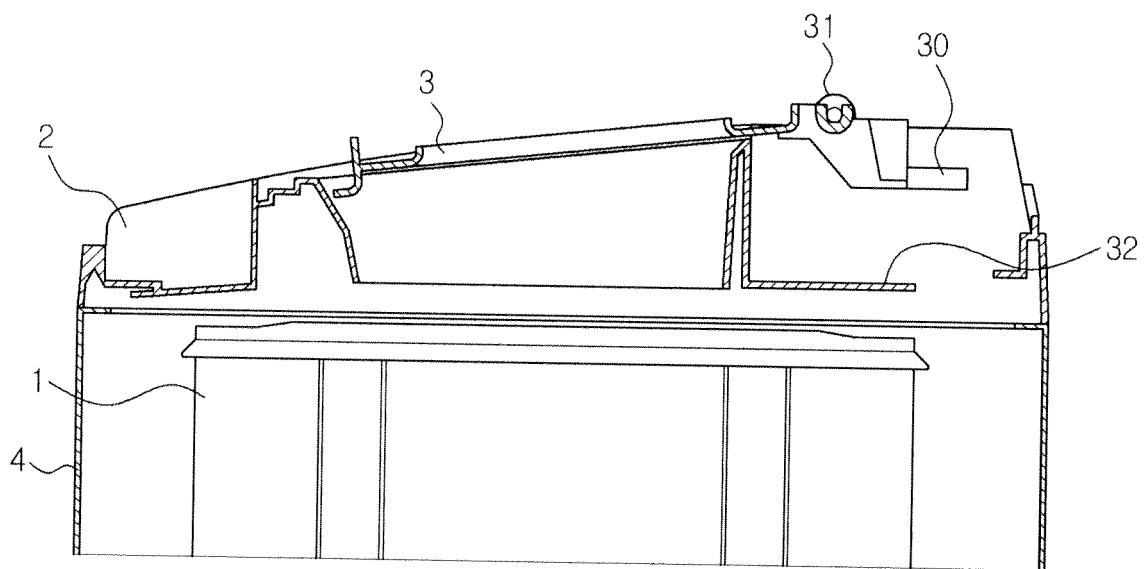


FIG. 5A

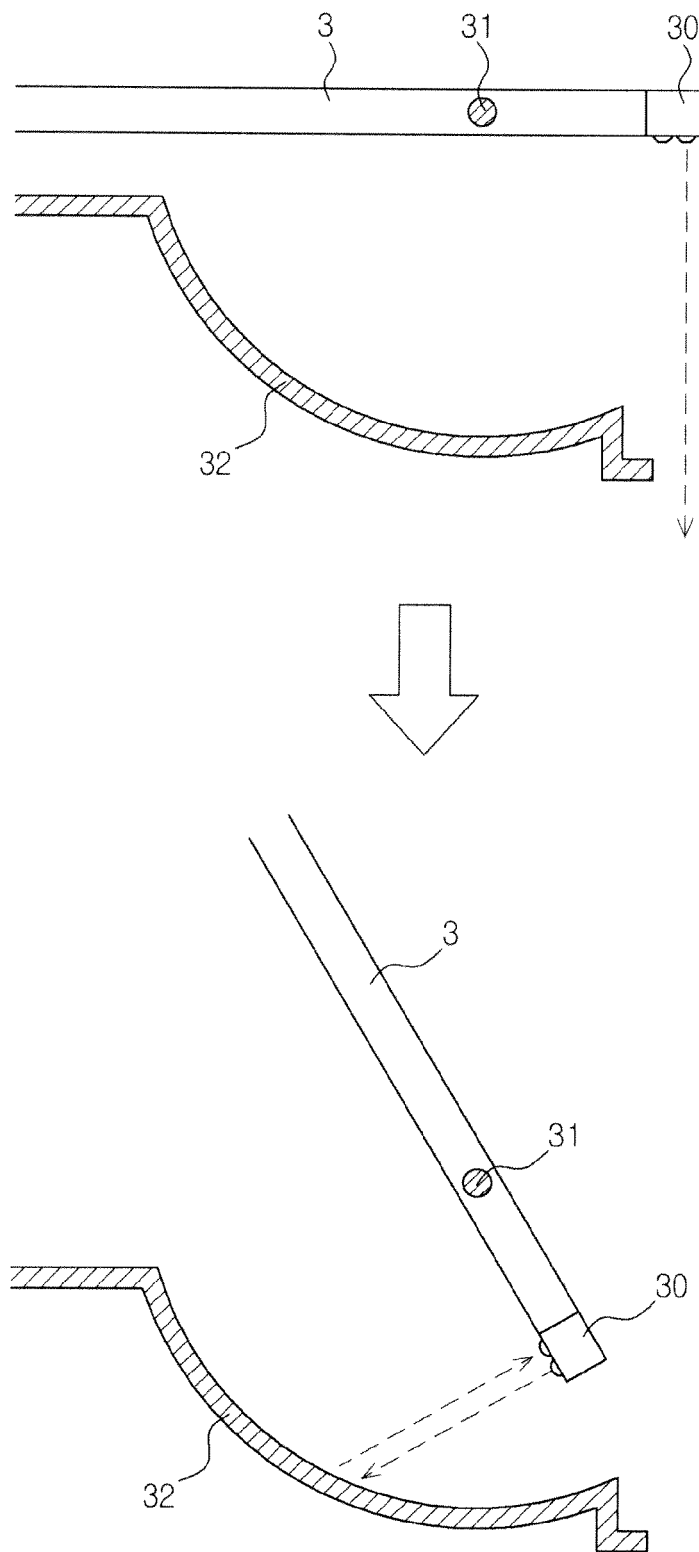


FIG. 5B

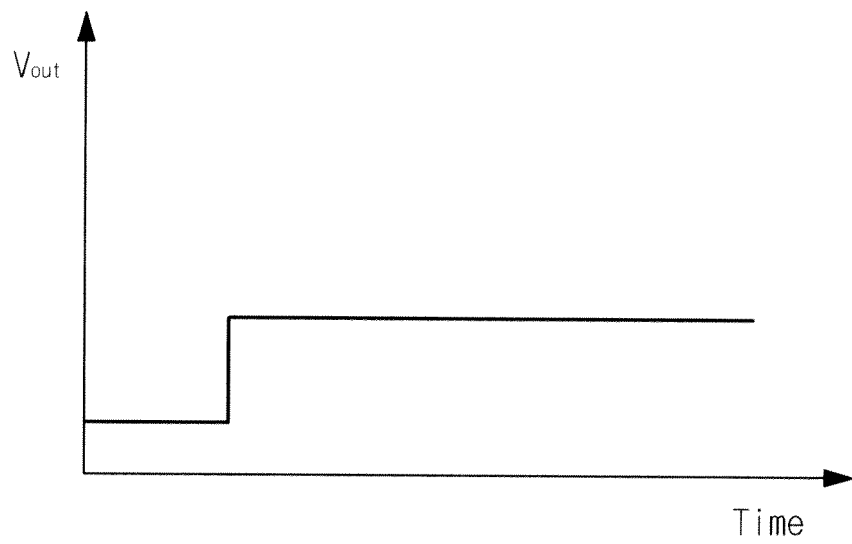


FIG. 6

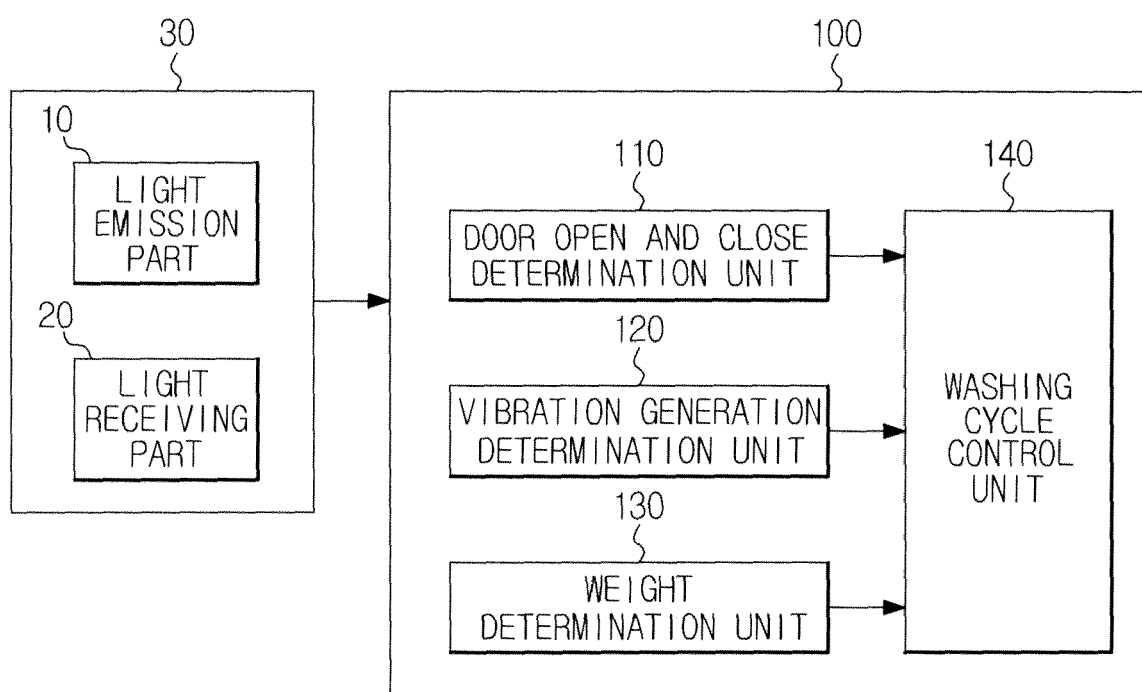


FIG. 7A

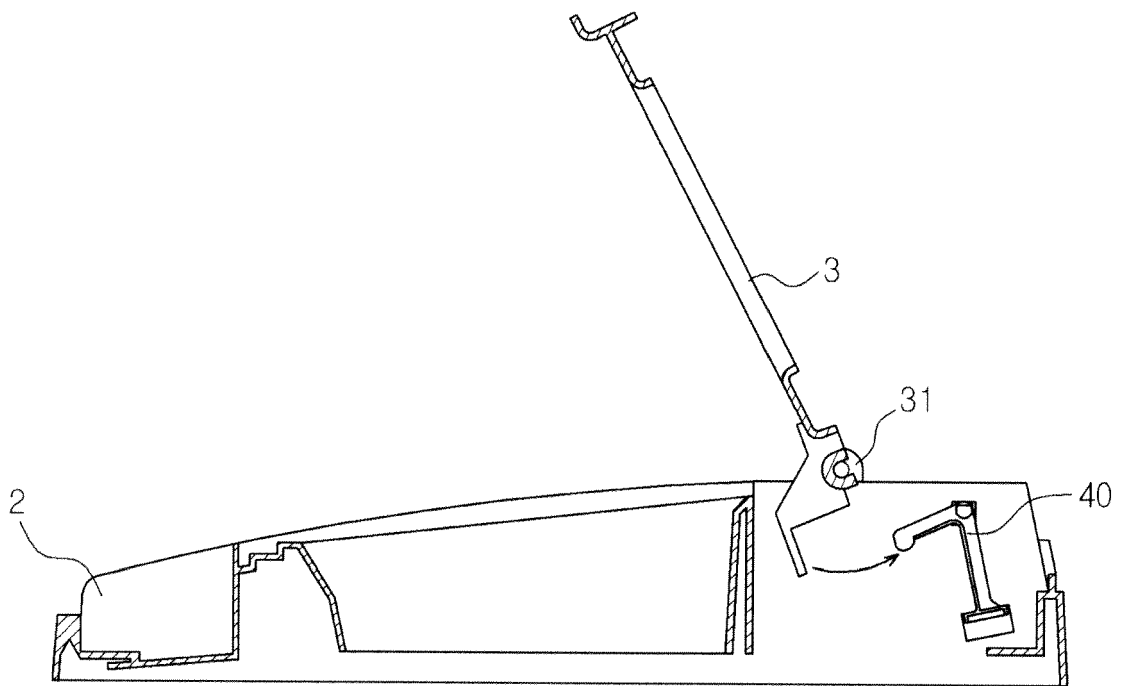


FIG. 7B

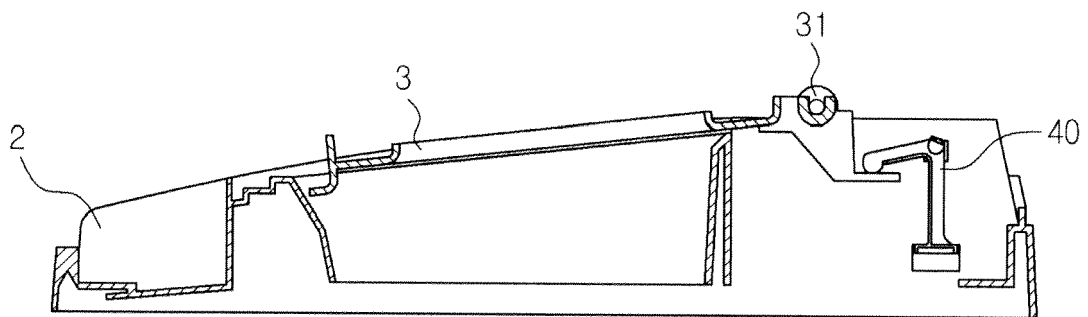


FIG. 7C

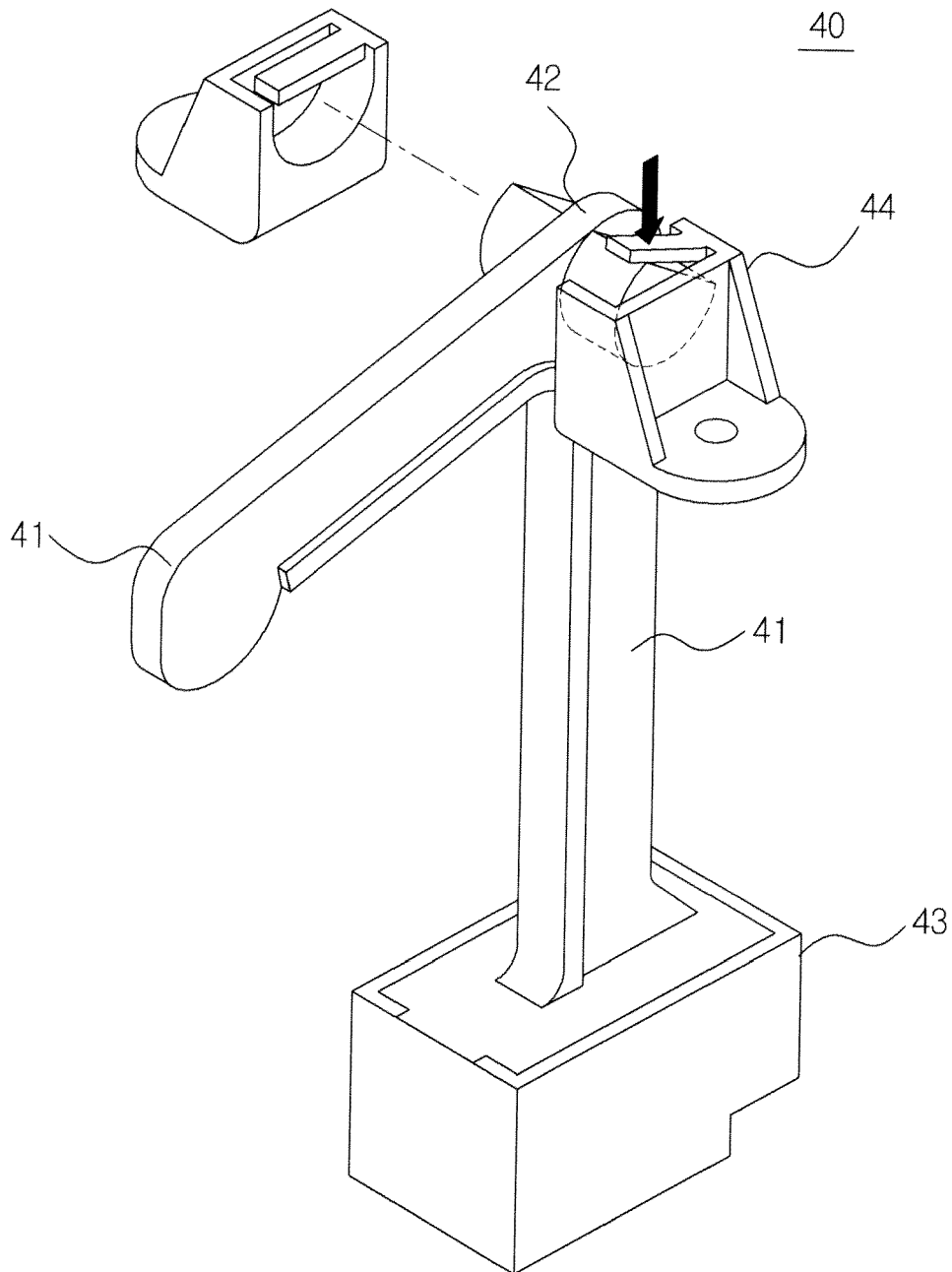


FIG. 8A

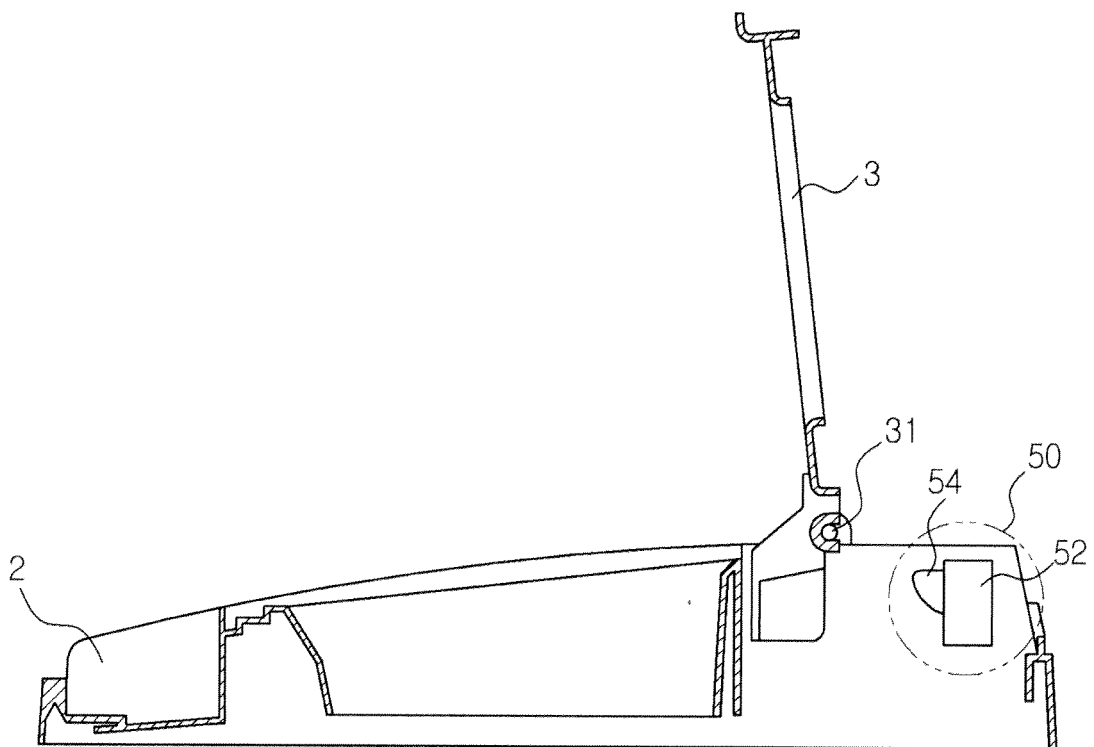


FIG. 8B

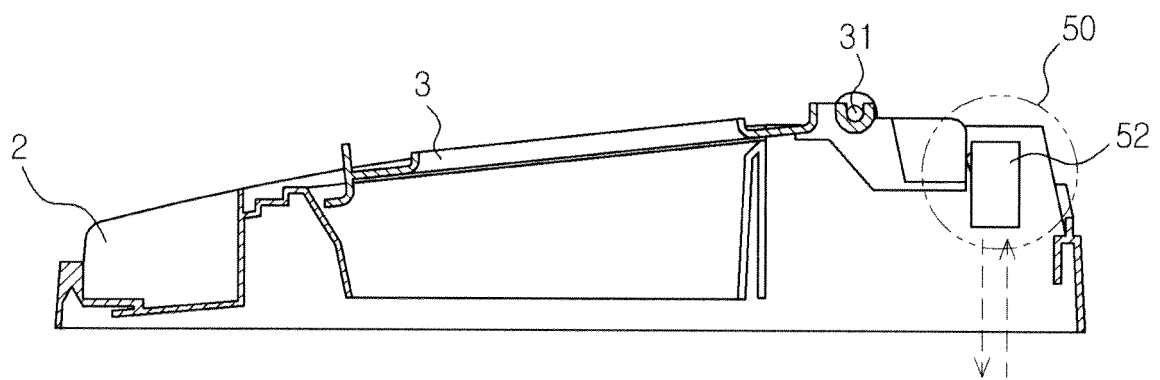


FIG. 8C

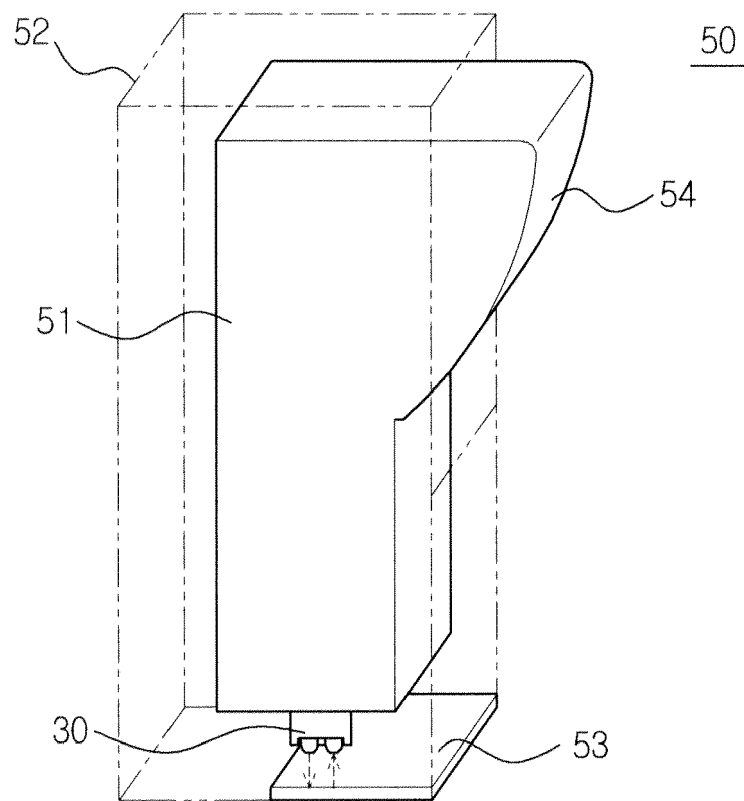


FIG. 8D

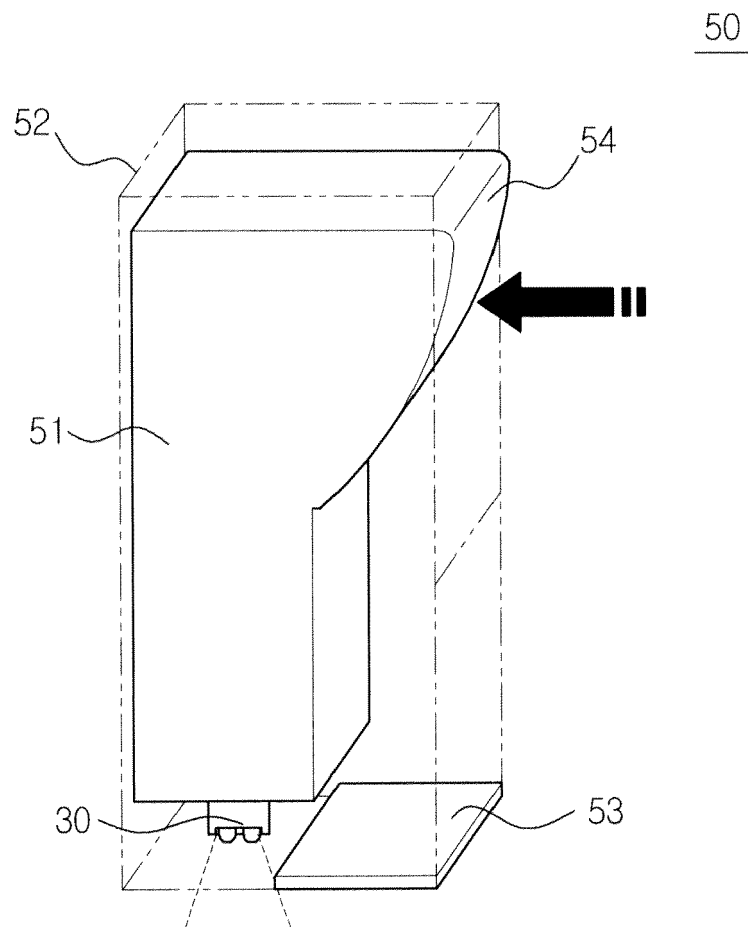


FIG. 9A

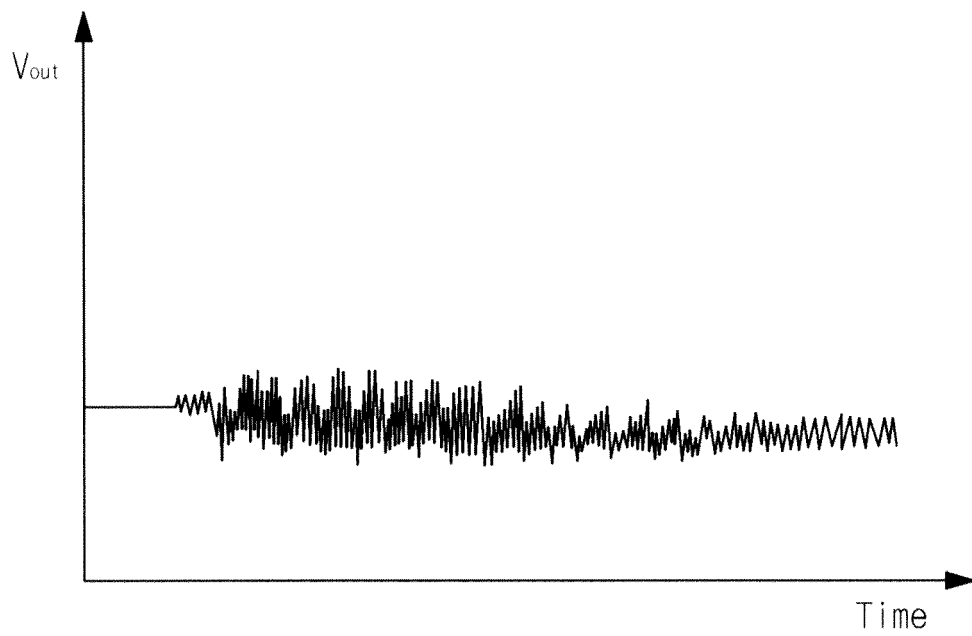


FIG. 9B

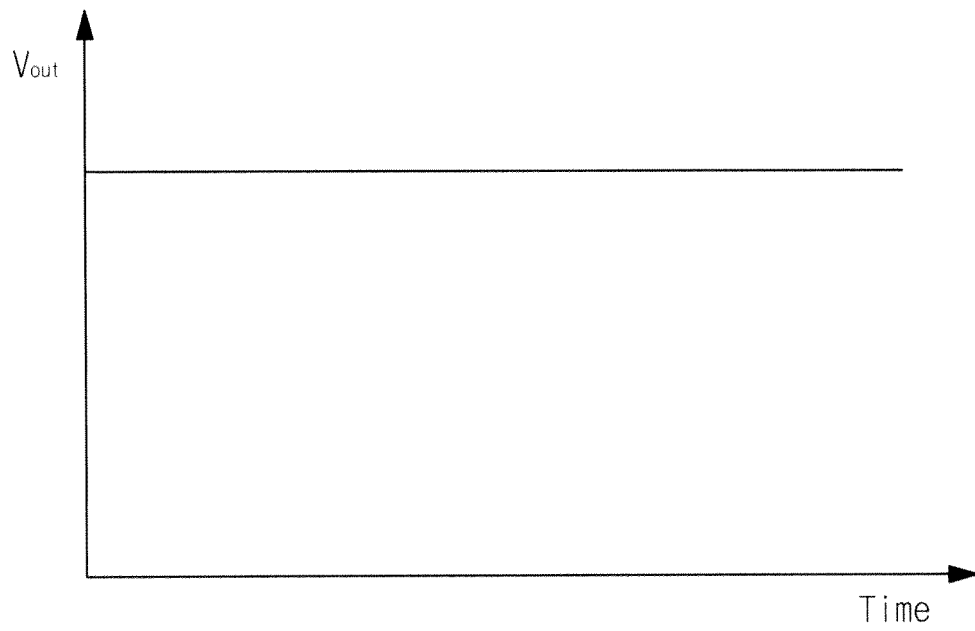


FIG. 10A

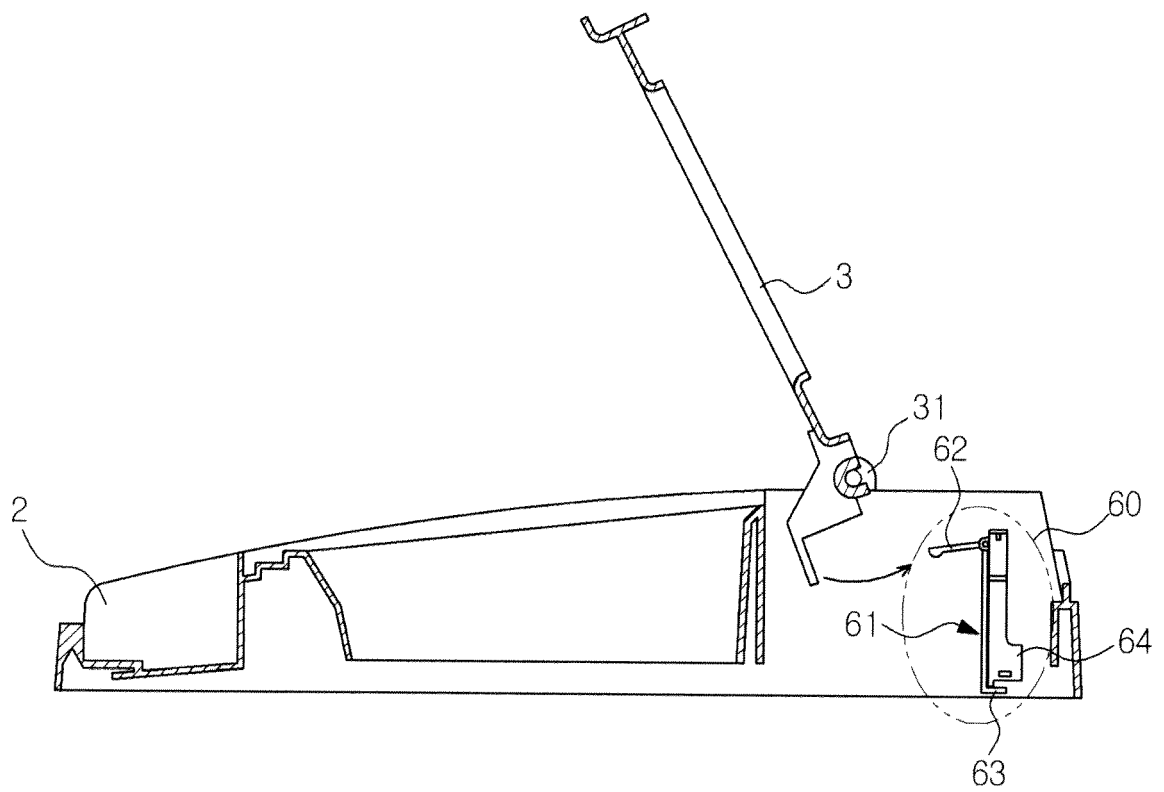


FIG. 10B

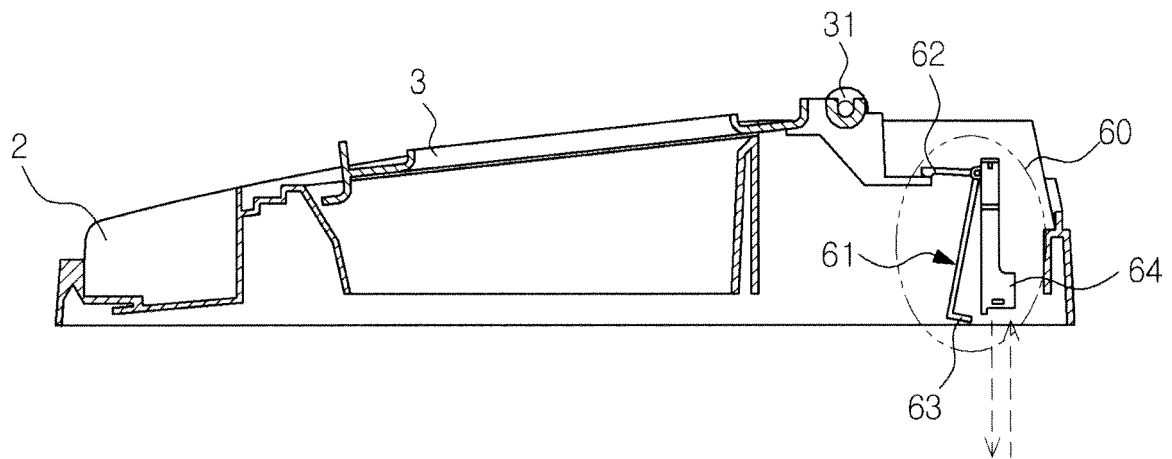


FIG. 10C

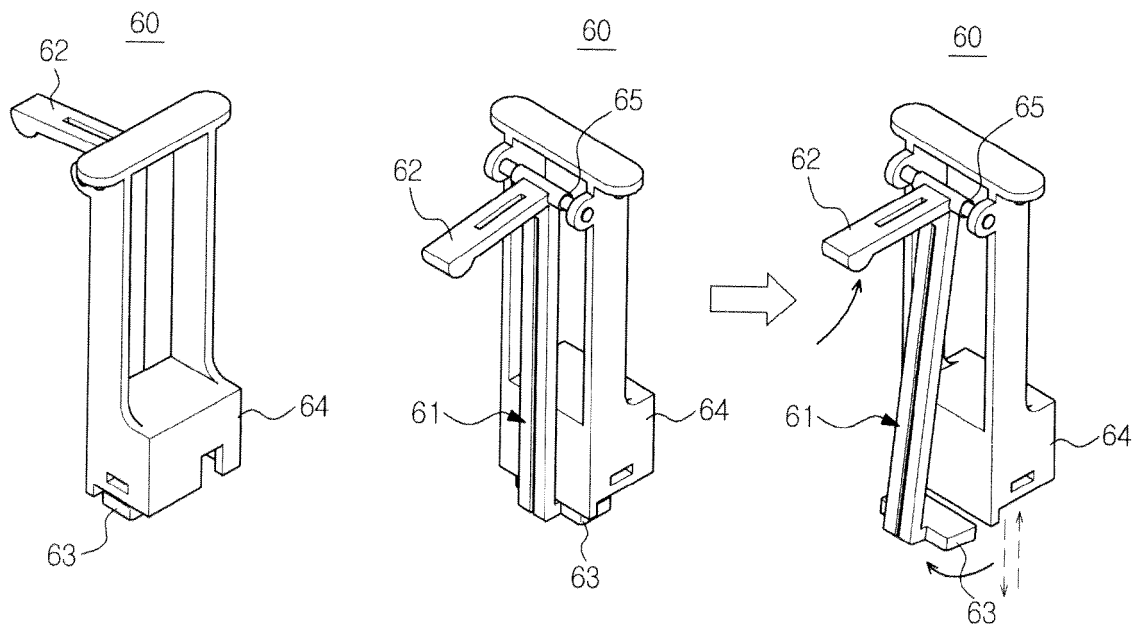


FIG. 11

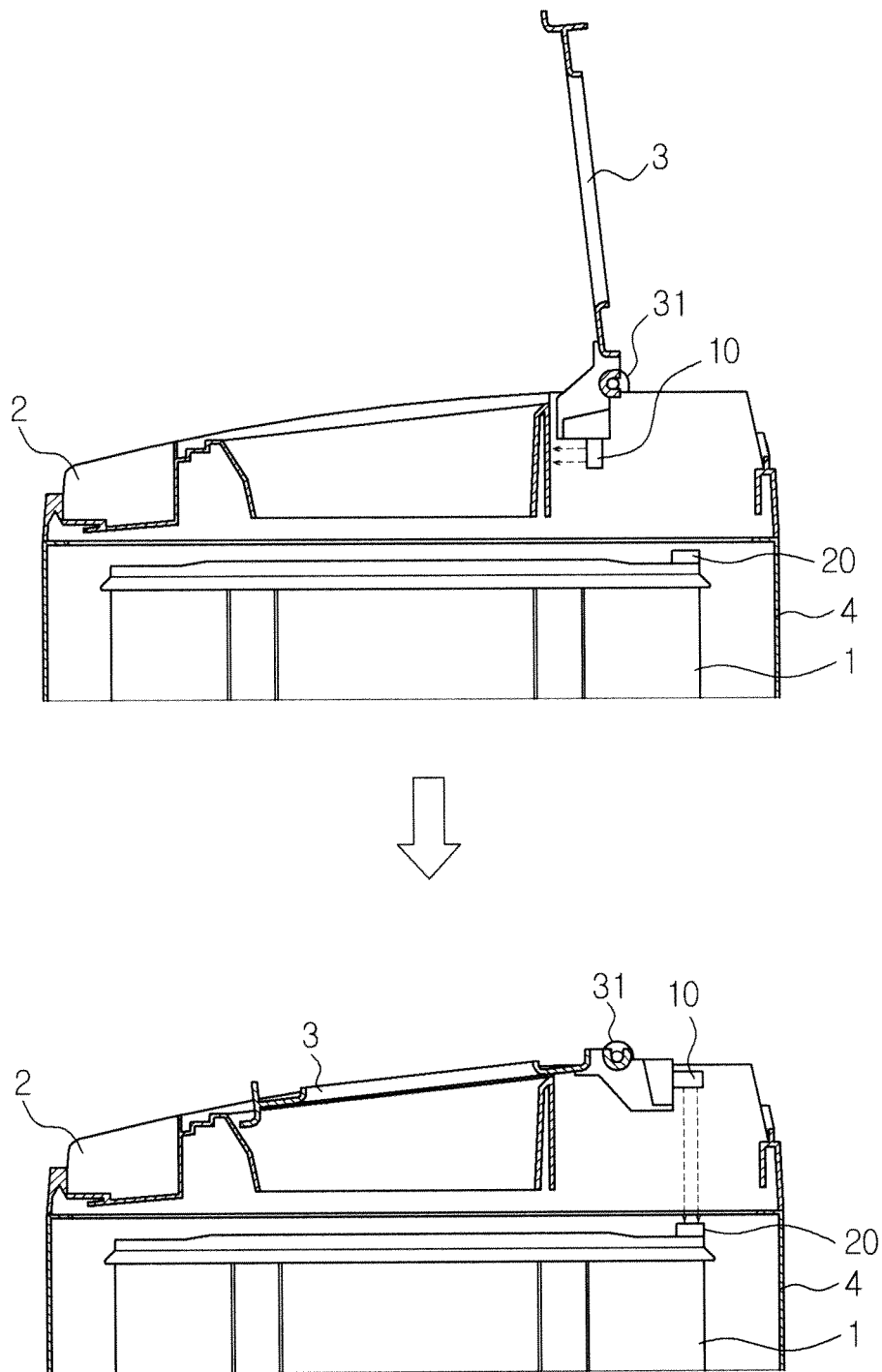


FIG. 12A

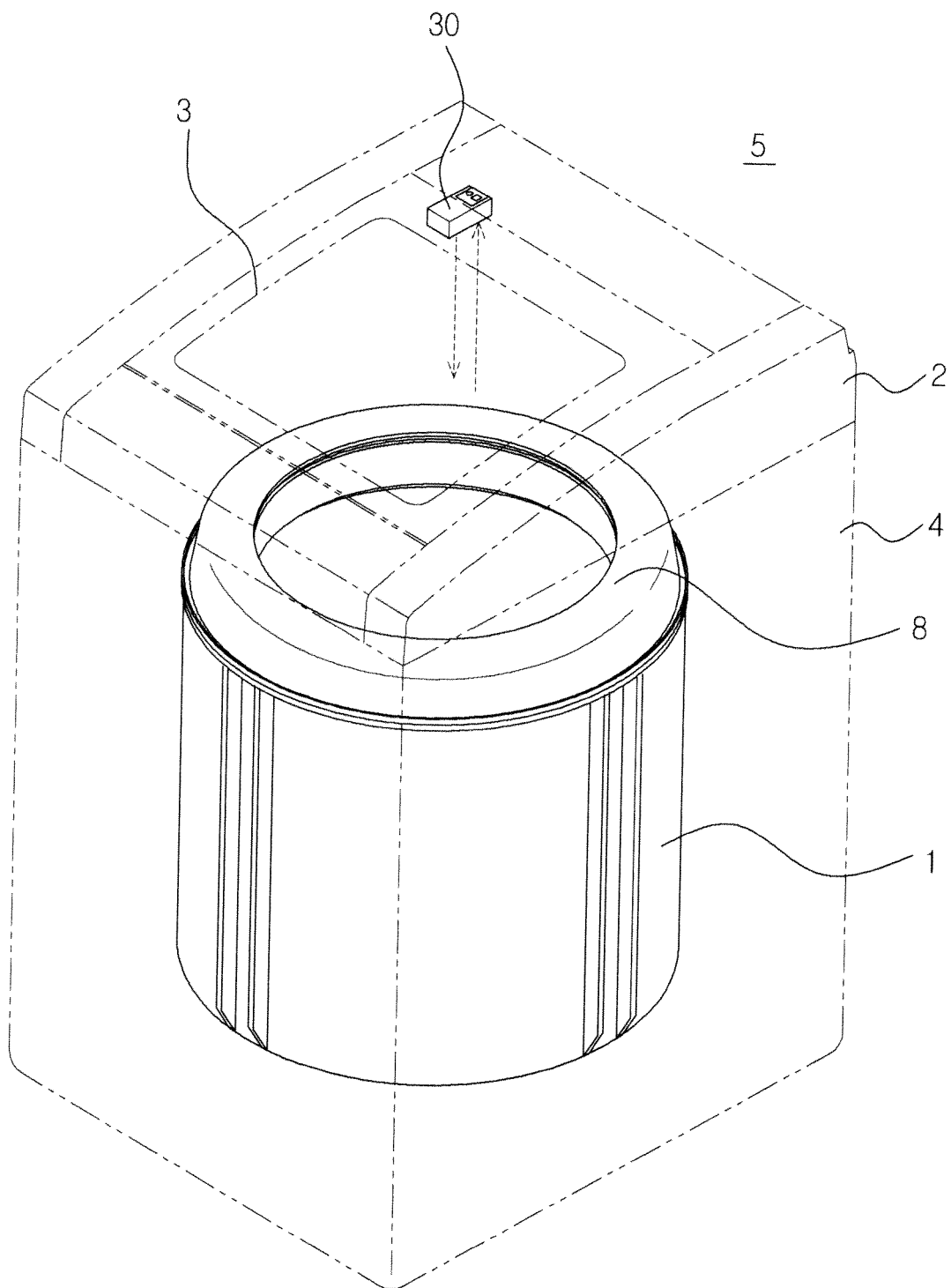


FIG. 12B

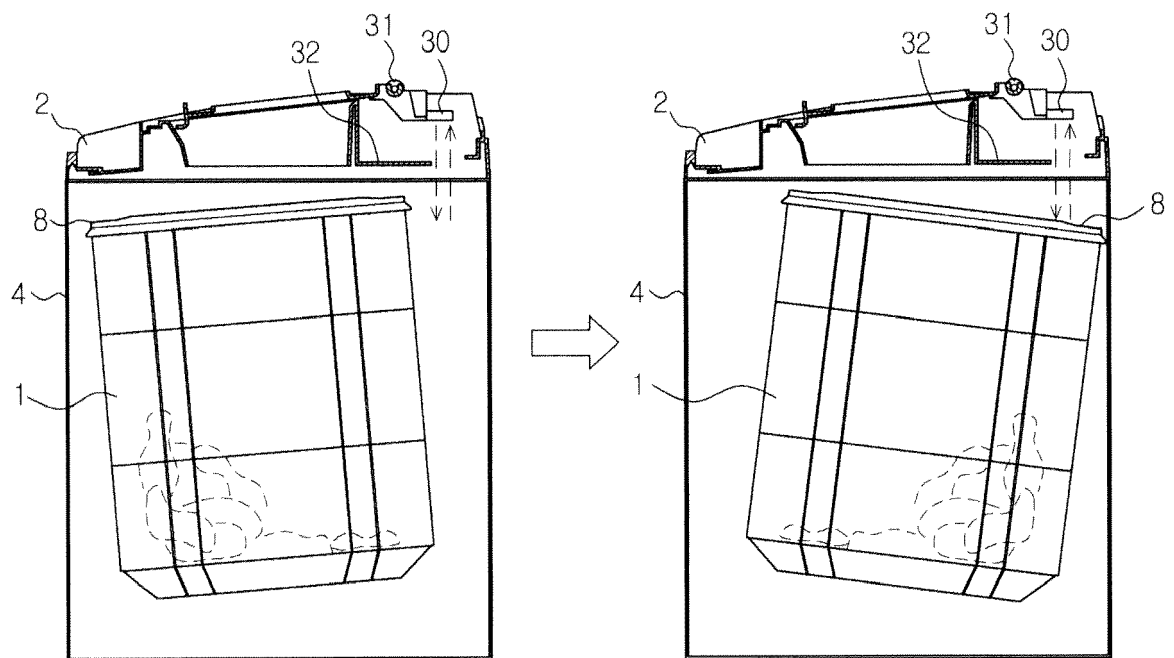


FIG. 13A

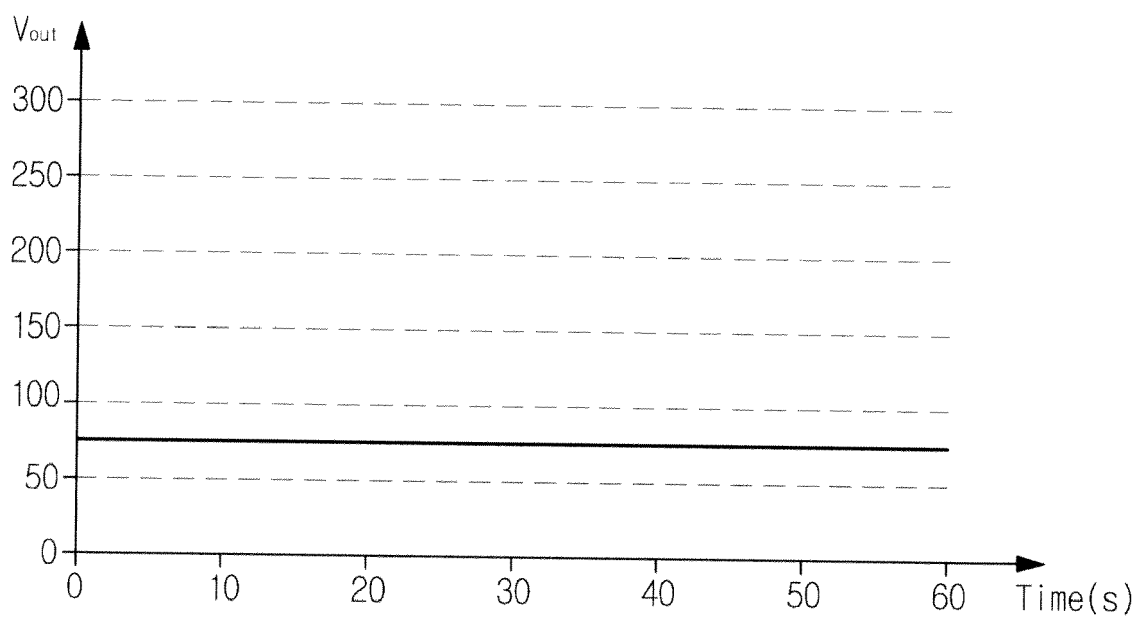


FIG. 13B

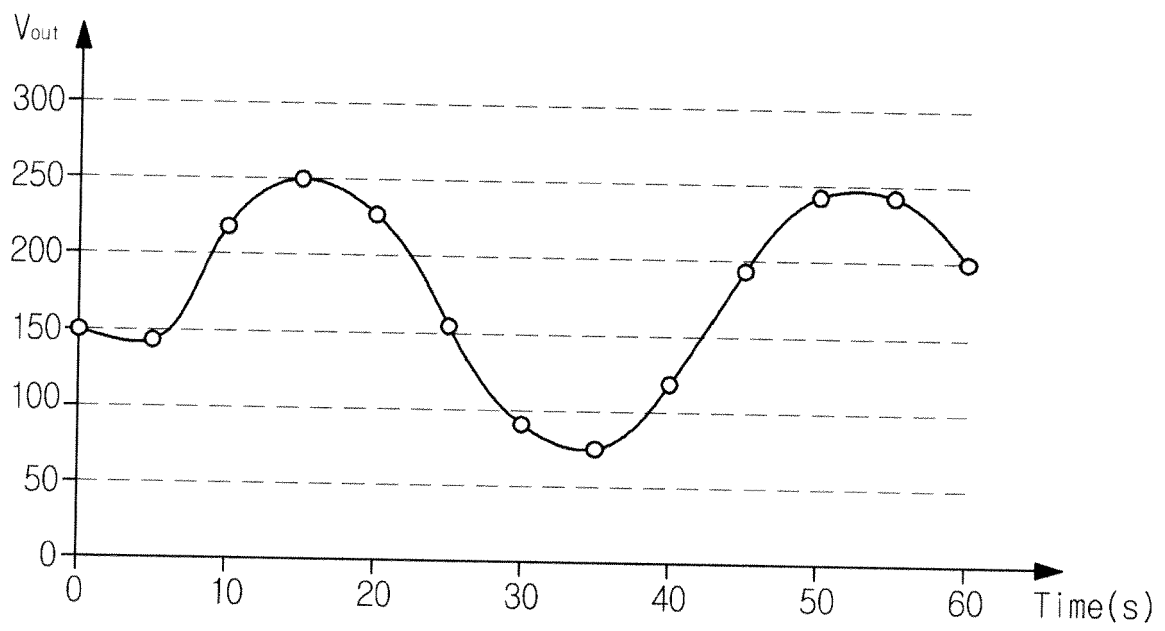


FIG. 14A

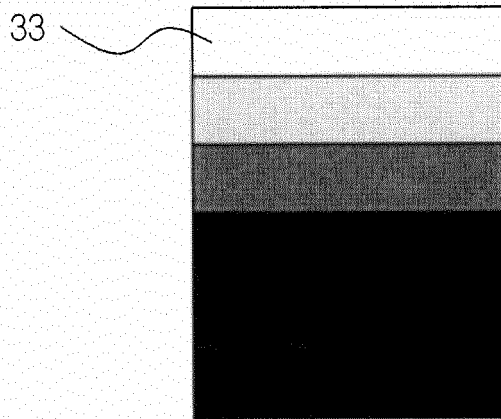


FIG. 14B

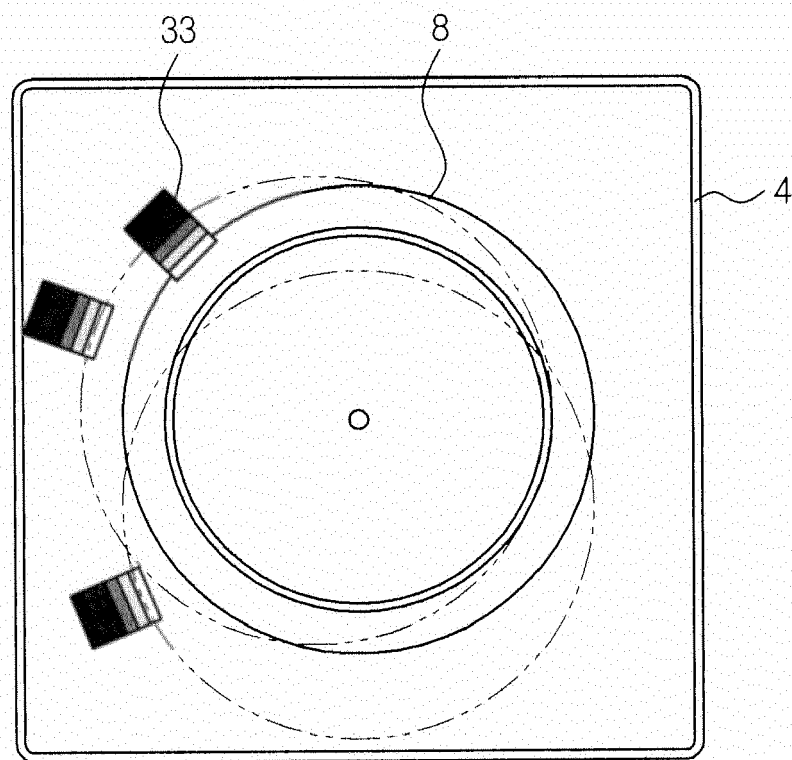


FIG. 15

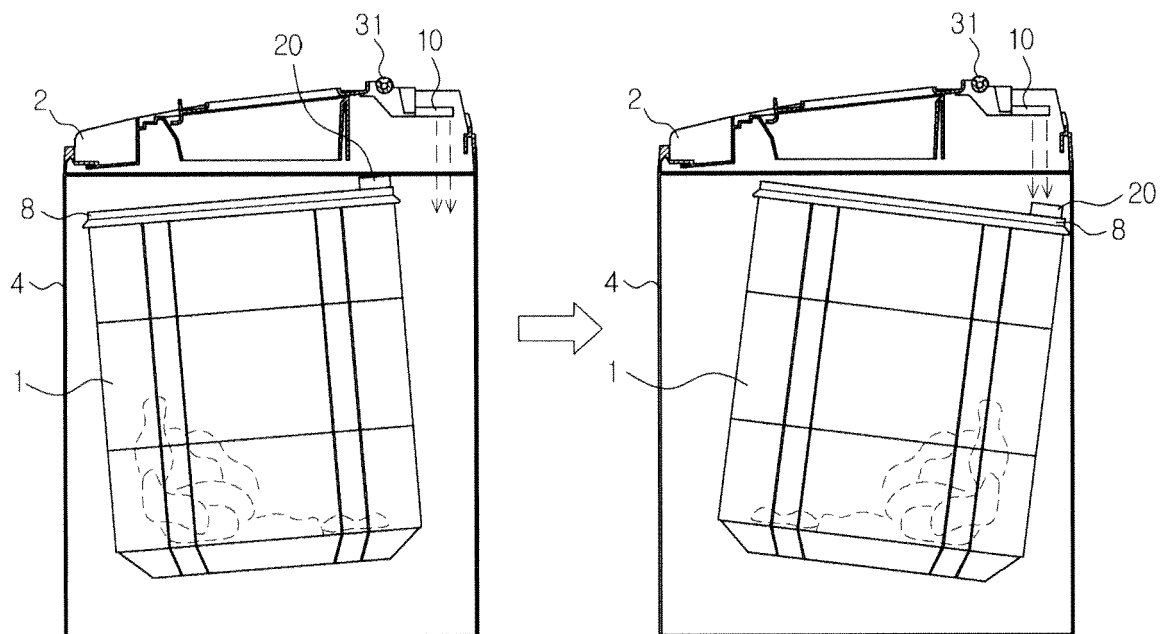


FIG. 16

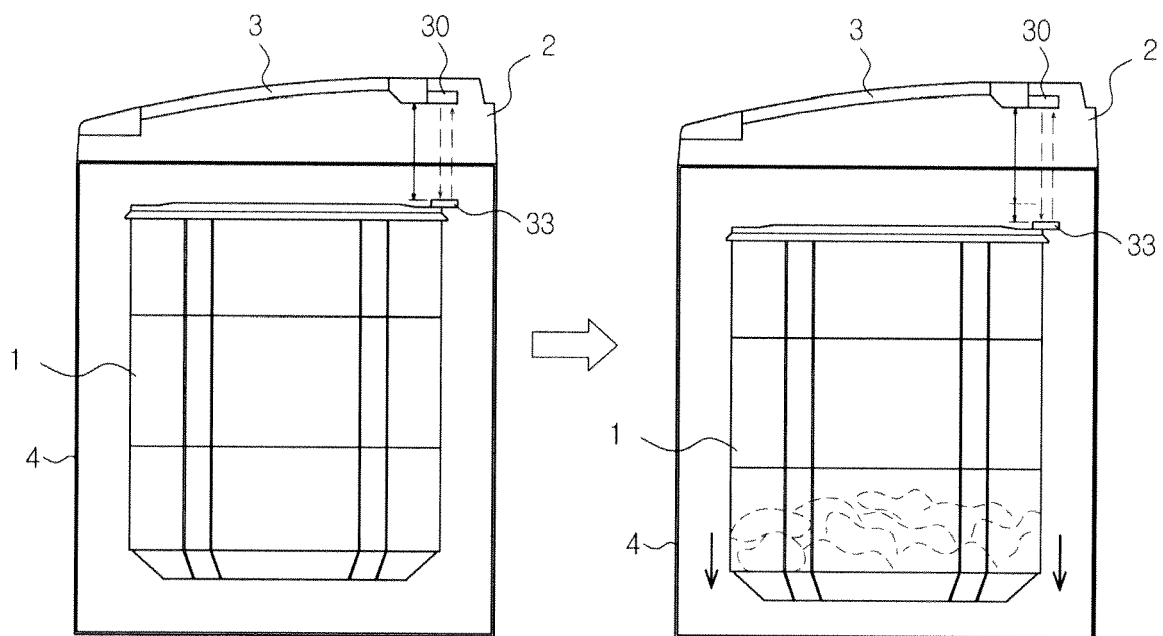


FIG. 17

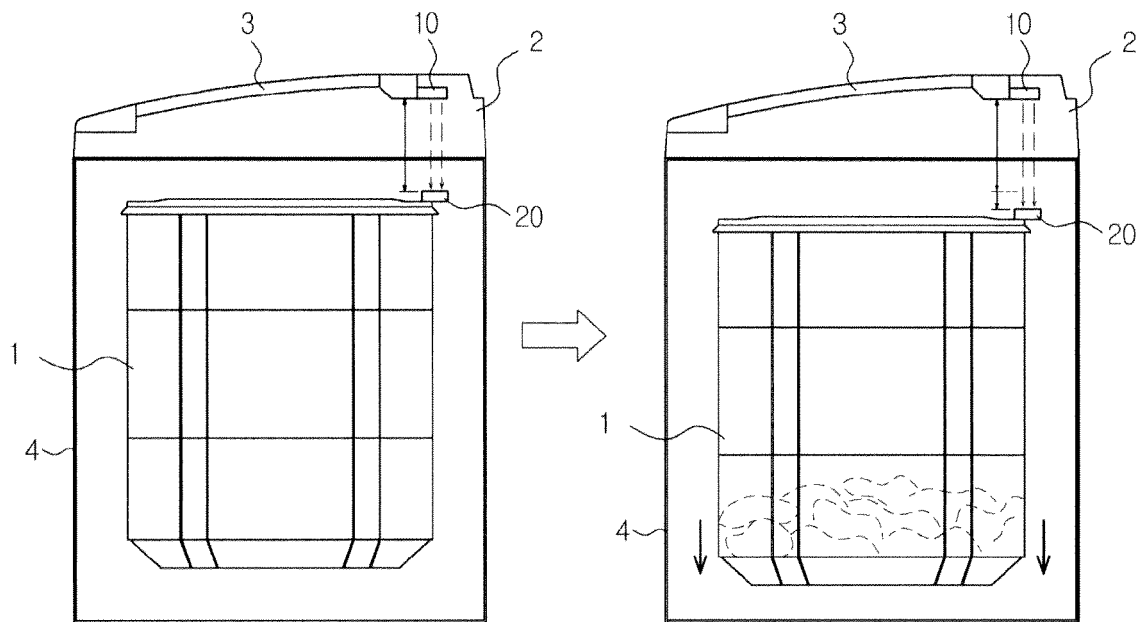


FIG. 18

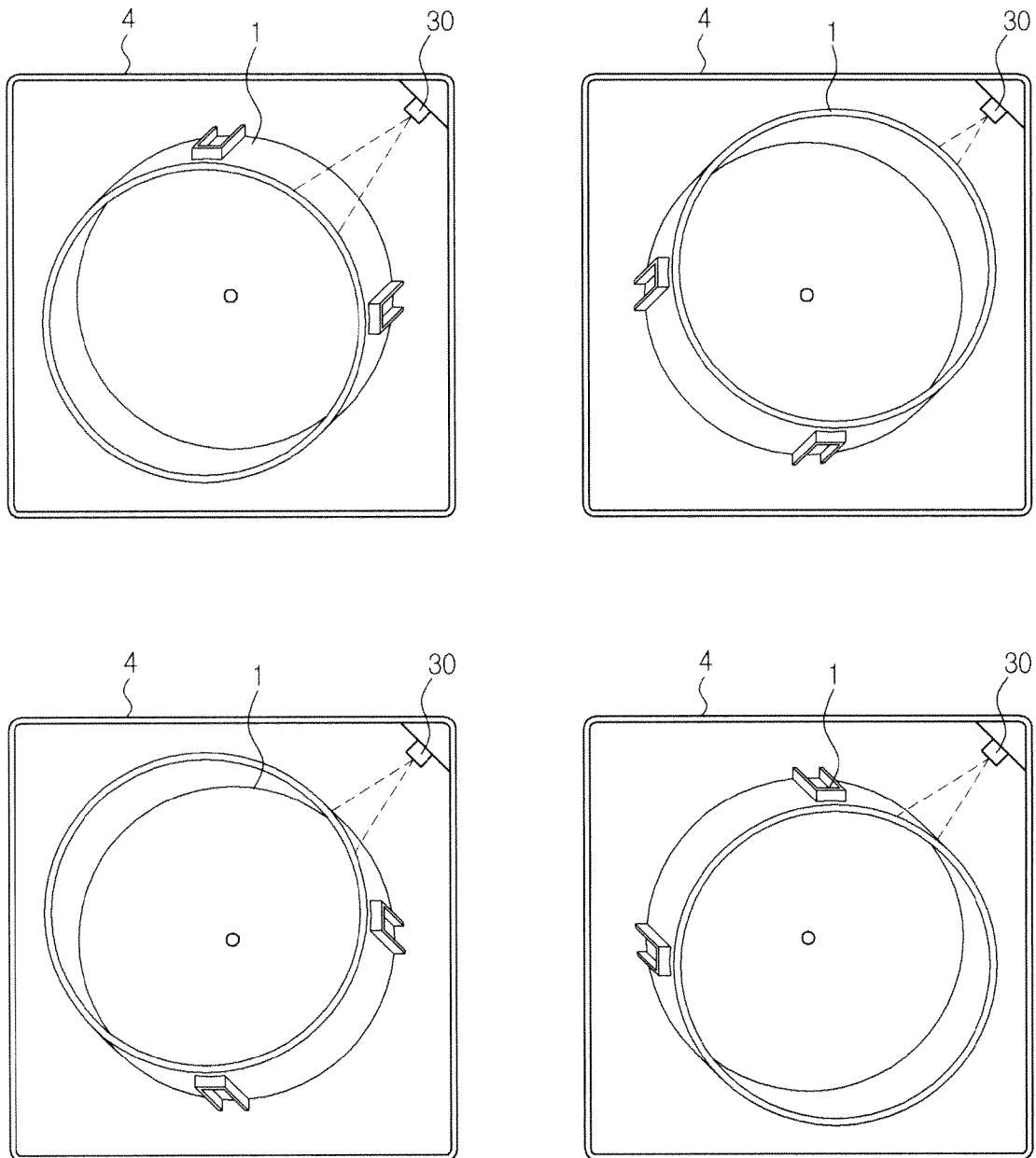


FIG. 19A

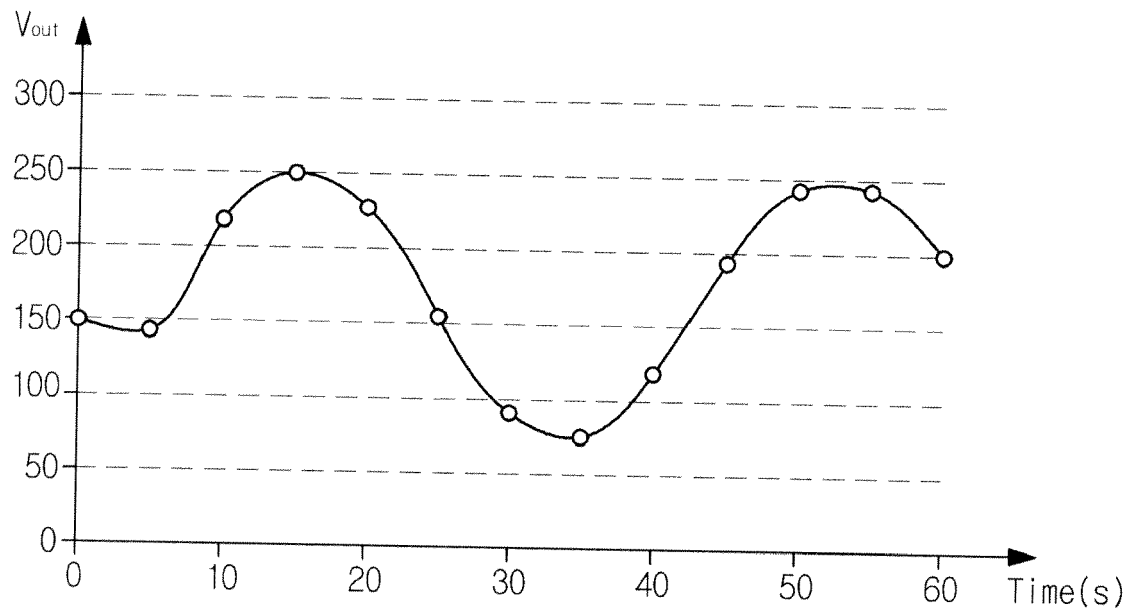


FIG. 19B

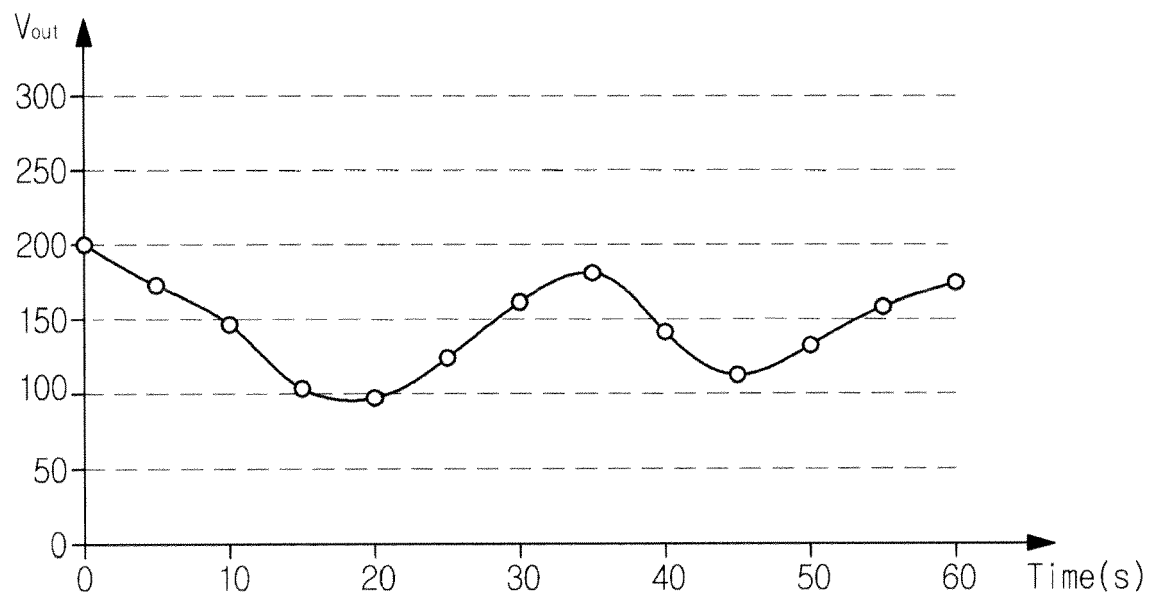


FIG. 20A

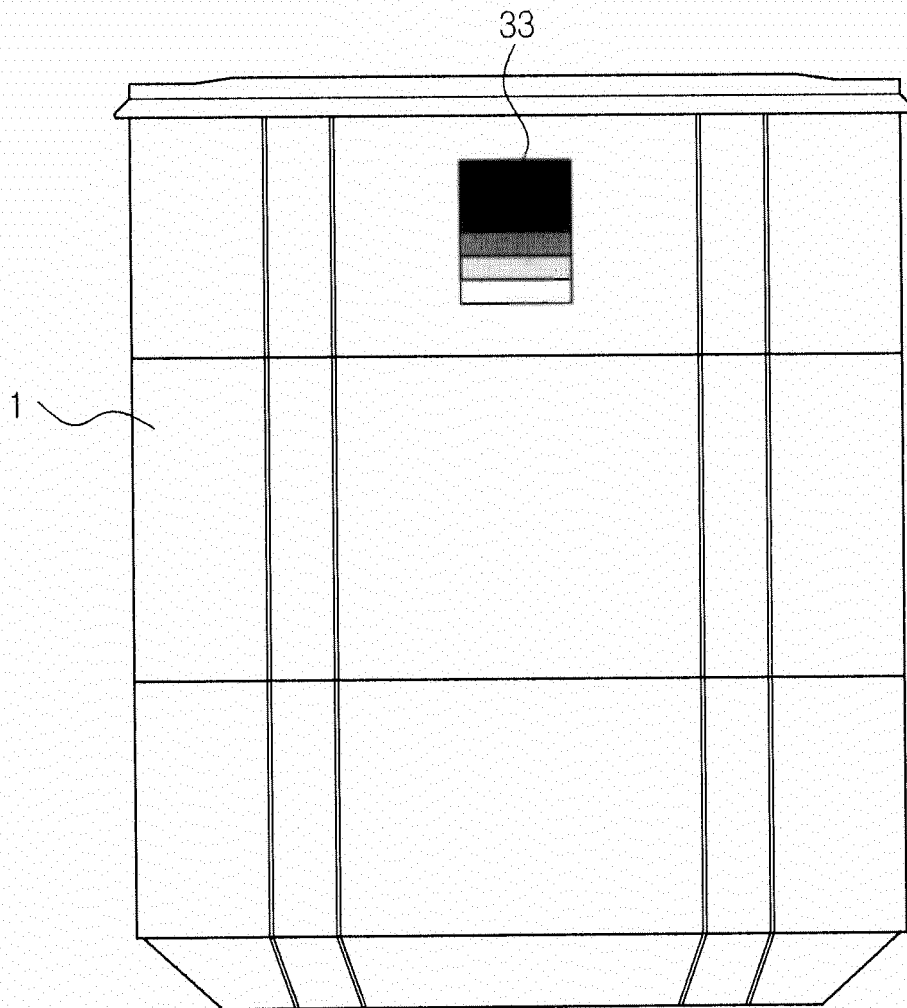


FIG. 20B

