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(54) **Liquid ejecting system**

(57) A liquid ejecting system includes a liquid cartridge, a mounting portion to which the liquid cartridge is mounted, a mount detector configured to detect the liquid cartridge mounted to the mounting portion, an optical detector comprising a light emitter and a light receiver, a magnetic field generator, a magnetic field controller, and a state determiner configured to determine a state of the liquid cartridge. The liquid cartridge includes a liquid chamber for storing liquid, and a pivotable member con-

figured to move relative to a position of a surface of the liquid in the liquid chamber, and a contact portion. The pivotable member comprises a ferromagnetic portion. The magnetic field generator is configured to generate a magnetic field from which the ferromagnetic portion receives a force. The magnetic field controller is configured to control the magnetic field generator such that strength of the magnetic field around the ferromagnetic portion changes.

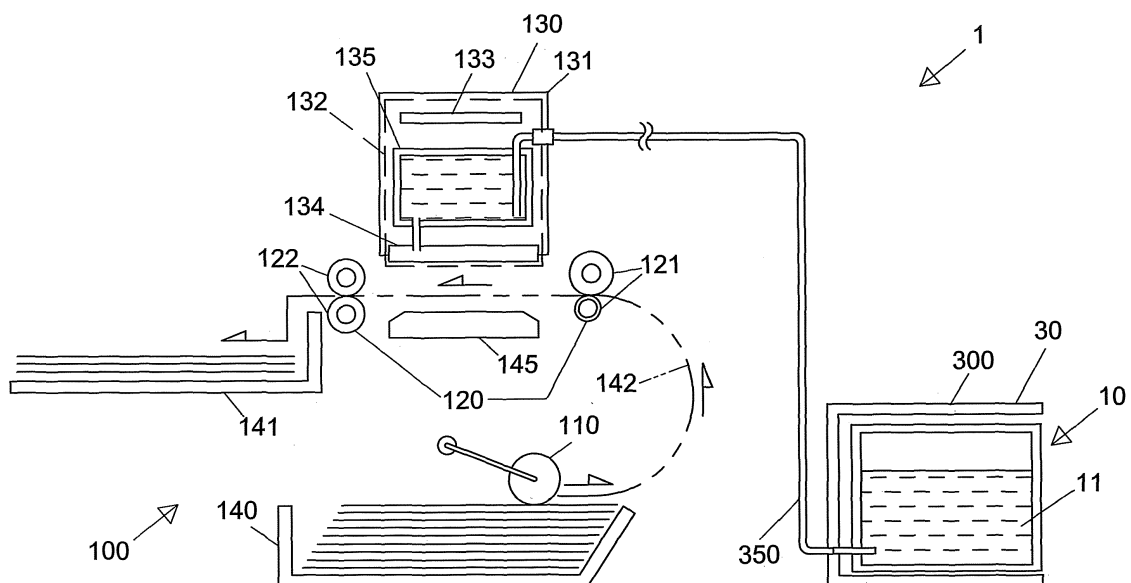


Fig. 1

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates generally to a liquid ejecting system comprising a mounting portion to which a liquid cartridge, which comprises a pivotable member configured to pivot according to a position of a surface of liquid in a liquid chamber, is removably mounted. In particular, the present invention relates to a liquid ejecting system comprising a determiner configured to determine whether or not the liquid cartridge is normal when the liquid cartridge is mounted to the mounting portion.

2. Description of Related Art

[0002] A known inkjet printer as an example of a liquid ejecting apparatus is used with an ink cartridge. The inkjet printer comprises a cartridge mounting portion, to which the ink cartridge is removably mounted. The inkjet printer comprises a recording head. When the ink cartridge is mounted to the mounting portion, the ink cartridge is connected to the recording head such that ink stored in the ink cartridge is supplied to the recording head. When ink is ejected from the recording head, ink is accordingly supplied from the ink cartridge to the recording head.

[0003] When there is no ink in the ink cartridge, ink can not be ejected from the recording head in the inkjet printer. Once the recording head becomes unable to eject ink with the empty ink cartridge, in order to eject ink from the recording head, a new ink cartridge is mounted to the cartridge mounting portion, and then an operation to suck out large quantity of ink from nozzles of the recording head, that is, a purge operation, is required. The purge operation requires time and wastes a large quantity of ink. Thus, the inkjet printer needs to be configured to recognize the amount of ink in the cartridge mounted to the cartridge mounting portion. To recognize the amount of ink in the cartridge mounted to the cartridge mounting portion, an inkjet printer and an ink cartridge which are configured as follows are known. The ink cartridge comprises a movable member configured to move in response to a change in the amount of ink in the ink cartridge, and the inkjet printer comprises a detector configured to detect whether the movable member is in a specified position. The inkjet printer determines whether ink is sufficient in the ink cartridge based on whether the detector detects the movable member. When the inkjet printer determines that ink in the ink cartridge is not sufficient, it stops image recording onto a recording medium, e.g. a recording sheet, or notifies the user to replace the ink cartridge with a new one.

[0004] Japanese Laid-Open Patent Publication No. 2005-125738 describes an example of the above ink cartridge and inkjet printer. The ink cartridge comprises a

case and an ink chamber formed inside the case. A pivotable member is positioned in the ink chamber. The pivotable member includes a light blocking portion at one end, and a float at the other end. The float has a specific gravity which is less than that of ink. A support base is positioned at the bottom of the ink chamber. The support base supports the pivotable member at a position between the light blocking portion and the float. The pivotable member is pivotable about a portion supported by the support base. A restricting member is positioned in the ink chamber. The restricting member restricts the pivotal movement of the pivotable member. That is, when the pivotable member rotates in a direction and contacts the restricting member, it cannot further rotate in the direction. Because the specific gravity of the float is less than that of ink, the float attempts to float on the ink surface. However, the movement of the float toward the ink surface is restricted when the pivotal movement of the pivotable member is restricted by the restricting member. Thus, when the amount of ink stored in the ink chamber is greater than a predetermined amount, the pivotable member is positioned in a predetermined position in contact with the restricting member. At this time, the float is submerged in ink. When ink in the ink chamber is consumed, the ink surface is lowered. When the amount of ink reaches the predetermined amount, a portion of the float is exposed from the ink surface. When ink is further consumed and the ink surface is further lowered, the float moves downward according to the lowering ink surface. The pivotable member rotates in response to the downward movement of the float, and the light blocking portion moves upward. The case of the ink cartridge is formed with a protruding portion on a side. The case is made of a material through which light can pass. The protruding portion of the case has an inner space, which is a portion of the ink chamber. The light blocking portion is positioned in the inner space of the protruding portion. The inkjet printer used with the ink cartridge includes an optical detector having a light emitter and a light receiver. When the ink cartridge is mounted to the inkjet printer, the protruding portion of the ink cartridge is positioned between the light emitter and the light receiver. When the amount of ink in the ink chamber is greater than the predetermined amount and the pivotable member is positioned in the predetermined position, light emitted from the light emitter is blocked by the light blocking portion and thus does not reach the light receiver. When the amount of ink in the ink chamber is less than the predetermined amount and the pivotable member is positioned in a position other than the predetermined position, the light blocking portion is positioned above the light emitter and the light receiver. Thus, when the amount of ink in the ink chamber is less than the predetermined amount, light emitted from the light emitter passes through the protruding portion of the case and reaches the light receiver. The inkjet printer determines whether the amount of ink in the ink chamber is sufficient based on whether the light receiver receives light.

[0005] Japanese Laid-Open Patent Publication No. 2008-93862 describes an ink cartridge including a cylinder communicating with an ink chamber and a piston positioned in the cylinder. A slide member extends from the piston, and has an opening formed therethrough. A pivotable member positioned in the ink chamber extends through the opening of the slide member. A rod extends from the piston to the outside of the cylinder. When a driving force is transmitted from the inkjet printer to the rod, the piston moves in the cylinder. When the piston moves, an end of the opening in the slide member contacts the pivotable member, and the pivotable member moves in the ink chamber together with the slide member.

[0006] Nevertheless, even in the ink cartridge and the inkjet printer described in Japanese Laid-Open Patent Publication No. 2005-125738, the inkjet printer may incorrectly determine that the amount of ink in the ink cartridge is greater than the predetermined amount in some cases in spite of the fact that the amount of ink in the ink cartridge is less than the predetermined amount. The following may be regarded as a possible cause of the incorrect determination. When the ink cartridge is transported or a user handles the ink cartridge, the ink cartridge may be shaken, and a bubble or some bubbles may be produced in ink in the ink chamber. When bubbles contact the pivotable member and a surface of a wall defining the ink chamber, the surface tension of the bubbles may hinder the movement of the pivotable member. That is, even when the amount of ink in the ink chamber is reduced to become less than the predetermined amount, the pivotable member may be caught by the bubbles adhering to the surface of the wall, and prevented from rotating. In this case, the inkjet printer may incorrectly determine that the amount of ink in the ink chamber is greater than the predetermined amount. As another possible cause of the incorrect determination, the following may be regarded. In manufacturing ink cartridge, ink may be first de-aerated to prevent the chemical property of ink from changing, and then stored in the ink chamber. To maintain de-aeration of ink, the ink chamber may be depressurized. A pair of opposing walls defining the ink chamber may be made of films having flexibility. When the ink chamber is depressurized, the opposing walls having flexibility may be deformed so as to protrude toward the inside of the ink chamber and the deformed opposing walls may sandwich the pivotable member from both sides thereof. Even if the pressure in the ink chamber is returned to atmospheric pressure when the ink cartridge is used, the opposing walls may remain deformed to sandwich the pivotable member. In this case, even when the amount of ink in the ink chamber becomes less than the predetermined amount, the pivotable member sandwiched between the opposing walls of the ink chamber cannot move. As yet another possible cause of the incorrect determination, the following may be regarded. When the ink cartridge is transported, the pivotable member may come off from the support base. In this case, even when the amount of ink in the ink chamber is

less than the predetermined amount, the pivotable member cannot move as intended, and the inkjet printer may incorrectly determine that the amount of ink in the ink chamber is greater than the predetermined amount. As still another possible cause of the incorrect determination, an ink cartridge of one type that is not intended to use with an ink jet printer of another type may be wrongly mounted to the inkjet printer. If the ink cartridge of one type does not have the pivotable member and the ink jet printer of another type has the detector to detect the pivotable member, the inkjet printer can not determine the amount of ink remaining in the ink chamber of the ink cartridge because of the type difference.

[0007] In the ink cartridge and inkjet printer described in Japanese Laid-Open Patent Publication No. 2008-93862, bubbles adhering to the pivotable member may be removed when a force is applied to the piston and the pivotable member moves. However, because a force is applied to the piston from outside of the ink cartridge, ink may leak from the ink cartridge via the cylinder. For example, when a user handles the ink cartridge, if the piston is in the innermost position in the cylinder, ink may leak to the outside of the cylinder from the ink chamber via an opening formed through the cylinder in a position closer to the outside of the cylinder than the piston is to the outside of the cylinder. Alternatively, when the user accidentally pulls the piston out of the cylinder, ink may leak to the outside the cylinder from the ink chamber via the cylinder.

SUMMARY OF THE INTENTION

[0008] Therefore, a need has arisen for a liquid ejecting system which overcome these and other shortcomings of the related art. A technical advantage of the present invention is that leakage of liquid from a liquid cartridge can be at least reduced, preferably prevented, a function of a pivotable member positioned in the liquid cartridge can be at least improved, preferably restored when there are bubbles in the liquid cartridge, and whether or not the liquid cartridge mounted to a mounting portion is normal can be determined.

[0009] According to an aspect of the invention, a liquid ejecting system according to claim 1 is provided.

[0010] The strength of the magnetic field around the ferromagnetic portion can be recognized by the strength of the force that the ferromagnetic portion receives from the magnetic field. In other words, when the strength of the magnetic field around the ferromagnetic portion is strong, the force that the ferromagnetic portion receives from the magnetic field is strong. When the strength of the magnetic field around the ferromagnetic portion is weak, the force that the ferromagnetic portion receives from the magnetic field is weak.

[0011] When the liquid cartridge is mounted to the mounting portion, the portion having the specific gravity less than the specific gravity of liquid stored in the liquid chamber attempts to float on the surface of the liquid

stored in the liquid chamber because of buoyancy. However, the pivotable member contacts the contact portion and remains in contact with the contact portion. When the strength of the magnetic field around the ferromagnetic portion changes, the force that the ferromagnetic portion receives from the magnetic field changes. When the force that the ferromagnetic portion receives from the magnetic field exceeds the buoyancy, the pivotable member moves in the second direction. Because the state of the light receiver changes according to the position of the portion of the pivotable member in the path, the state of the light receiver changes when the strength of the magnetic field around the ferromagnetic portion changes. When the state of the light receiver changes, the state determiner determines that the liquid cartridge is normal, e.g., the pivotable member correctly operates. If the movement of the pivotable member is hampered or the liquid cartridge does not comprise the pivotable member, the state of the light receiver does not change when the strength of the magnetic field around the ferromagnetic portion changes. Thus, the state determiner determines that the liquid cartridge is abnormal. As a result, the liquid ejecting system can determine whether or not the liquid cartridge is normal at an early stage of mounting the liquid cartridge to the mounting portion. Thus, a user can effectively deal with a problem at the early stage if an abnormal liquid cartridge is mounted to the mounting portion. When the movement of the pivotable member is hampered by the surface tension of bubbles contacting the pivotable member and a surface of wall defining the liquid chamber, if the force that the ferromagnetic portion receives from the magnetic field exceeds the surface tension of the bubbles, the pivotable member can move in the second direction. When the pivotable member moves, the bubbles are destroyed, and thus the pivotable member correctly operates. Namely, the function of the pivotable member is improved, e.g., restored. The magnetic field generator can move the pivotable member without contact therebetween. Thus, liquid is less likely to leak from the liquid chamber to the outside of the liquid cartridge.

[0012] The liquid ejecting system may be an ink ejecting system for forming images on recording media by ejecting ink and may be a system for adhering liquid to an object by ejecting liquid such as a system used for forming wiring patterns on boards for printed wiring boards or manufacturing liquid crystal color filters.

[0013] The two predetermined states of the light receiver are, for example, a state in which the light receiver receives the light emitted from the light emitter at an intensity greater than or equal to a specified intensity, and a state in which the light receiver receives the light emitted from the light emitter at an intensity less than the specified intensity. The state in which the light receiver receives the light emitted from the light emitter at an intensity less than the specified intensity comprises a state where the light receiver does not receive the light emitted from the light emitter at all, that is, the intensity of light

received by the light receiver is zero.

[0014] The portion of the pivotable member may be configured to prevent the light emitted from the light emitter from passing therethrough. Alternatively, the portion of the pivotable member may be configured to alter a path of the light emitted from the light emitter.

[0015] The optical detector may serve as the mount detector.

[0016] According to an aspect of the invention, a liquid ejecting system according to claim 2 is provided.

[0017] With this configuration, the state determiner can identify the cause of hampering the movement of the pivotable member. When the liquid ejecting system is configured such that: the force that the ferromagnetic portion receives from the magnetic field does not exceed the surface tension of the bubbles contacting the pivotable member and a surface of wall defining the liquid chamber when the strength of the magnetic field around the ferromagnetic portion is the second strength; and the force that the ferromagnetic portion receives from the magnetic field exceeds the surface tension of the bubbles when the strength of the magnetic field is the third strength, and if the cause of hampering the movement of the pivotable member is the surface tension of the bubbles, the state determiner determines that the state of the light receiver did not change before and after the change in the strength of the magnetic field around the ferromagnetic portion from the first strength to the second strength, and that the state of the light receiver changed before and after the change in the strength of the magnetic field around the ferromagnetic portion from the second strength to the third strength. On the other hand, if the cause of hampering the movement of the pivotable member is something other than the surface tension of bubbles, e.g., the pivotable member is sandwiched between a pair of walls defining the liquid chamber, the position of the pivotable member has been changed from its initial condition as manufactured, the pivotable member cannot move as intended, or the liquid cartridge does not comprise the pivotable member, the state determiner determines that the state of the light receiver is the same at any strength of the magnetic field.

[0018] The first strength of the magnetic field may be zero, that is, the magnetic field generator may not generate magnetic field in such a case.

[0019] According to an aspect of the invention, a liquid ejecting system according to claim 3 is provided.

[0020] With this configuration, the liquid ejecting system can store, in the storage unit, information indicating that the cause of hampering the movement of the pivotable member is the surface tension of the bubbles. The manufacturer of the liquid cartridge can find a rate of incidence of bubble generation based on the information stored in the storage unit, which may be helpful in developing a new liquid cartridge.

[0021] According to an aspect of the invention, a liquid ejecting system according to claim 4 is provided.

[0022] With this configuration, the liquid ejecting sys-

tem can store, in the storage unit, information indicating that the cause of hampering the movement of the pivotable member is something other than the surface tension of bubbles. The manufacturer of the liquid cartridge can find a main cause of hampering the pivotable member based on the information stored in the storage unit, which may be helpful in developing a new liquid cartridge.

[0023] According to an aspect of the invention, a liquid ejecting system according to claim 5 is provided.

[0024] The manufacturer of the liquid cartridge can collect used liquid cartridges and collect information stored in the storage units positioned at the liquid cartridges.

[0025] According to an aspect of the invention, a liquid ejecting system according to claim 6 is provided.

[0026] When the portion of the pivotable member having the specific gravity which is less than the specific gravity of the liquid stored in the liquid chamber moves toward the surface of liquid in the liquid chamber, i.e., moves upward, due to buoyancy, the pivotable member moves in the first direction. On the other hand, when the portion having the specific gravity which is less than the specific gravity of the liquid stored in the liquid chamber moves downward, the pivotable member moves in the second direction. Because the portion having the specific gravity which is less than the specific gravity of the liquid stored in the liquid chamber comprises the ferromagnetic portion and is positioned above the magnetic field generator, the magnetic field generator can reliably move the pivotable member in the second direction.

[0027] According to an aspect of the invention, a liquid ejecting system according to claim 7 is provided.

[0028] According to an aspect of the invention, a liquid ejecting system according to claim 8 is provided.

BRIEF DESCRIPTION OF DRAWINGS

[0029] For a more complete understanding of the present invention, the needs satisfied thereby, and the objects, features, and advantages thereof, reference now is made to the following description taken in connection with the accompanying drawings.

[0030] Fig. 1 is a schematic view showing an ink ejecting system according to a first embodiment of the invention.

[0031] Fig. 2A is a front view of an ink cartridge, and Fig. 2B is a side view of the ink cartridge.

[0032] Fig. 3 is a side view of a frame, in which a pair of sidewalls is not connected to the frame.

[0033] Fig. 4A is a cross sectional view of the ink cartridge taken along the line IVA - IVA of Fig. 2B, and Fig. 4B is a cross sectional view of the ink cartridge taken along the line IVB - IVB of Fig. 2A.

[0034] Fig. 5A is a cross sectional view of the ink cartridge corresponding to Fig. 4A, in which a pivotable member is removed, and Fig. 5B is a cross sectional view of the ink cartridge corresponding to Fig. 4B, in which the pivotable member is removed.

[0035] Fig. 6 is a perspective view of the pivotable

member.

[0036] Fig. 7 is a front view of an ink supply device, wherein two ink cartridges are mounted in two mounting portions, respectively.

[0037] Fig. 8 is a side view of the ink supply device.

[0038] Fig. 9 is a cross sectional view of the mounting portion taken along the line IX - IX of Fig. 7.

[0039] Fig. 10 is a perspective view of an optical detector.

[0040] Fig. 11 is a cross sectional view of the ink cartridge mounted to the mounting portion of Fig. 9, taken along the line IX - IX of Fig. 7, in which electric current is not flowing through a solenoid.

[0041] Fig. 12 is a block diagram showing an electrical configuration of the inkjet printer.

[0042] Fig. 13 is a cross sectional view of the ink cartridge mounted to the mounting portion similar to Fig. 11, in which electric current is flowing through the solenoid.

[0043] Fig. 14 is a flowchart of a determination process executed by a controller to determine whether the ink cartridge is normal.

[0044] Fig. 15 is a cross sectional view of the ink cartridge mounted to the mounting portion similar to Fig. 11, in which an amount of ink stored in an ink chamber is a first amount.

[0045] Fig. 16 is a cross sectional view of the ink cartridge mounted to the mounting portion similar to Fig. 11, in which the amount of ink stored in the ink chamber is a second amount.

[0046] Fig. 17 is a cross sectional view of the ink cartridge mounted to the mounting portion similar to Fig. 11, in which ink is not stored in the ink chamber.

[0047] Fig. 18 is a flowchart of a determination process executed by a controller of a second embodiment to determine whether the ink cartridge is normal.

[0048] Fig. 19A is a front view of an ink cartridge according to a third embodiment of the invention, and Fig. 19B is a side view of the ink cartridge.

[0049] Fig. 20 is a front view of an ink supply device according to the third embodiment.

[0050] Fig. 21 is a cross sectional view of the ink cartridge of the third embodiment mounted to the mounting portion of the third embodiment, similar to Fig. 11.

[0051] Fig. 22 is a block diagram showing an electrical configuration of the inkjet printer of the third embodiment.

[0052] Fig. 23 is a flowchart of a determination process executed by a controller of the third embodiment to determine whether the ink cartridge is normal.

[0053] Fig. 24 is a cross sectional view of the ink cartridge of a fourth embodiment mounted to the mounting portion of the fourth embodiment, similar to Fig. 11.

[0054] Fig. 25A is a side view of a permanent magnet, a rod, and a cam, in which the permanent magnet is positioned in a first position, Fig. 25B is a side view of the permanent magnet, the rod, and the cam, in which the permanent magnet is positioned in a second position, and Fig. 25C is a side view of the permanent magnet, the rod, and the cam, in which the permanent magnet is

positioned in a third position.

[0055] Fig. 26 is a block diagram showing an electrical configuration of the inkjet printer of the fourth embodiment.

[0056] Fig. 27 is a flowchart of a determination process executed by a controller of the fourth embodiment to determine whether the ink cartridge is normal.

DETAILED DESCRIPTION OF EMBODIMENTS

[0057] Embodiments of the present invention and their features and technical advantages may be understood by referring to Figs. 1 - 27, like numerals being used for like corresponding portions in the various drawings.

[0058] [First embodiment] A first embodiment of a liquid ejecting system, to which the present invention is applied, e.g. an ink ejecting system 1 comprising an inkjet printer 100 and an ink cartridge 10, will be described with reference to Figs. 1 - 17.

[0059] <Description of Overall configuration of ink ejecting system> An overall configuration of the ink ejecting system 1 will be described with reference to Fig. 1. As shown in Fig. 1, the ink ejecting system 1 comprises the inkjet printer 100, and at least one ink cartridge 10 as an example of a liquid cartridge. The inkjet printer 100 is configured to record an image, e.g., a monochrome image or color image, on a recording medium, e.g. a sheet of paper, with at least one ink, e.g., four inks such as a black ink, a yellow ink, a cyan ink, and a magenta ink. The inkjet printer 100 comprises a feeding device 110, a transferring device 120, and a recording device 130. The inkjet printer 100 further comprises a first tray 140 and a second tray 141 and a transfer path 142 extending from the first tray 140 to the second tray 141. The feeding device 110 is configured to feed sheets of paper accommodated in the first tray 140 one by one to transfer path 142.

[0060] The transferring device 120 comprises a first pair of transfer rollers 121 and a second pair of transfer rollers 122 positioned along the transfer path 142. The first pair of transfer rollers 121 is positioned on an upstream side of the recording device 130, and the second pair of transfer rollers 122 is positioned on a downstream side of the recording device 130 along the transfer path 142.

[0061] The inkjet printer 100 also comprises a platen 145 positioned directly below the recording device 130. The sheet of paper fed by the feeding device 120 is transferred onto the platen 145 by the first pair of transfer rollers 121. The recording device 130 is configured to record an image on the sheet of paper being transferred over the platen 145. The sheet of paper having passed over platen 145 is transferred by the second pair of transfer rollers 122 to the second tray 141, which is positioned at the downstream end of the transfer path 142.

[0062] The recording device 130 comprises a carriage 131, a recording head 132, and a head control circuit 133, which are mounted in the carriage 131. The record-

ing head 132 is formed with a plurality of nozzles 134. The recording head 132 comprises at least one sub-tank, e.g., four sub-tanks 135 storing four kinds of inks such as a black ink, a yellow ink, a cyan ink, and a magenta ink, respectively. The carriage 131 is supported by rails (not shown) such that the carriage 131 slides on the rails in a direction perpendicular to the paper plane of Fig. 1. Each of the sub-tanks 135 is configured to store ink of a corresponding color to be supplied to the nozzles 134. When a signal is input to the head control circuit 133, the head control circuit 133 controls the recording head 132 based on the signal, to eject ink from the nozzles 134.

[0063] The inkjet printer 100 comprises an ink supply device 30. The ink supply device 30 comprises at least one mounting portion, e.g., four mounting portions 300. For example, four ink cartridges 10 storing a black ink, a yellow ink, a cyan ink, and a magenta ink, respectively, are mounted to the mounting portions 300 independently and detachably. The ink supply device 30 comprises at least one flexible tube, e.g., four flexible tubes 350. Each tube 350 is attached to an ink supply tube 320 positioned in a corresponding mounting portion 300 at one end and fitted into a joint provided at a corresponding sub-tank 135 at the other end. Each ink cartridge 10 comprises an ink chamber 11, as an example of a liquid chamber. When each ink cartridge 10 is mounted to a corresponding mounting portion 300, the ink chamber 11 and the sub-tank 135 communicate with each other via the tube 350. When ink is ejected from the recording head 132, ink is accordingly supplied from the ink chamber 11 to the sub-tank 135.

[0064] <Description of ink cartridge> The structure of the ink cartridge 10 will be described with reference to Figs. 2A - 6.

[0065] As shown in Figs. 2A and 2B, the ink cartridge 10 has a substantially rectangular parallelepiped shape. A width of the ink cartridge 10 in a width direction as indicated by an arrow 12 is relatively short, and each of a height of the ink cartridge 10 in a height direction as indicated by an arrow 14, and a depth of the ink cartridge 10 in a depth direction as indicated by an arrow 13, is greater than the width of the ink cartridge 10.

[0066] The ink cartridge 10 comprises a frame 20 and a pair of sidewalls 21. The frame 20 has a substantially rectangular parallelepiped shape having a width in the width direction 12, a height in the height direction 14, and a depth in the depth direction 13. The frame 20 comprises a front wall 22, a rear wall 23 opposite to the front wall 22 in the depth direction 13, a top wall 24, and a bottom wall 25 opposite to the top wall 24 in the height direction 14. The top wall 24 is connected to the front wall 22 and the rear wall 23. Similarly, the bottom wall 25 is connected to the front wall 22 and the top wall 23.

[0067] The frame 20 is formed of a translucent resin material, e.g., a transparent material or a semi-transparent material, such that light, e.g., visible or infrared light passes therethrough. In this embodiment, the frame 20 is manufactured by injection-molding a resin material,

e.g., nylon, polyethylene, polypropylene or the like.

[0068] The sidewalls 21 are connected, e.g., welded or bonded by adhesive, to both sides of the frame 20 in the width direction 12, respectively.

[0069] As shown in Fig. 3, the ink chamber 11 is formed inside the frame 20. The ink chamber 11 is defined by the frame 20 and the pair of sidewalls 21 connected to both sides of the frame 20 in the width direction 12.

[0070] The pair of sidewalls 21 shown in Figs. 2A and 2B is formed of a resin material, e.g., nylon, polyethylene, polypropylene or the like. When the pair of sidewalls 21 is welded to both sides of the frame 20 in the width direction 12, the pair of sidewalls 21 is preferably formed of the same material as the frame 20. The pair of sidewalls 21 may be a pair of flexible films. In other words, the pair of sidewalls 21 may have a thickness allowing the pair of sidewalls 21 to deform toward the ink chamber 11 when an external force is applied to the pair of sidewalls 21. For example, the pair of sidewalls 21 may have a thickness allowing the pair of sidewalls 21 to deform toward the ink chamber 11 due to a pressure differential between the pressure inside the ink chamber 11 and the atmospheric pressure outside the ink chamber 11 when the inside of the ink chamber 11 is depressurized to be less than the atmospheric pressure.

[0071] As shown in Figs. 2A - 4B, the ink cartridge 10 comprises an ink supply portion 50 and an air communication portion 60, which are positioned at the front wall 24. The ink supply portion 50 is positioned adjacent to the bottom wall 25 of the frame 20. The air communication portion 60 is positioned adjacent to the top wall 24.

[0072] As shown in Fig. 4B, the ink supply portion 50 comprises a cylindrical ink supply chamber 51, a valve body 52 made of resin, a sealing member 53 made of rubber, a coil spring 54 made of metal, and a cap 56 made of resin. The ink supply chamber 51 extends from the front wall 22 of the frame 20 in the depth direction 13 away from the ink chamber 11. The ink supply chamber 51 comprises a first end 51A and a second end 51B opposite to the first end 51A in the depth direction 13. The first end 51A is positioned closer to the ink chamber 11 than the second end 51B is to the ink chamber 11. The ink supply chamber 51 communicates with the ink chamber 11 via the first end 51A. The second end 51B of the ink supply chamber 51 is open to the outside of the frame 20. The sealing member 53 is positioned at the second end 51B. The sealing member 53 has a cylindrical opening 53A formed therethrough in the depth direction 13. The cap 56 is welded to the frame 20. The cap 56 has an opening 56A formed therethrough in the depth direction 13. The sealing member 53 is sandwiched between a portion of the frame 20 defining the second end 51B of the ink supply chamber 51 and the cap 56 while being elastically deformed.

[0073] The valve body 52 and the coil spring 54 are positioned within the ink supply chamber 51. A protrusion 57 extends from the first end 51A of the ink supply chamber 51 toward the second end 51B. The protrusion 57 is

inserted into one end of the coil spring 54, such that the coil spring 54 is attached to the protrusion 57. The valve body 52 has a cylindrical protrusion which is inserted into the other end of the coil spring 54, such that the coil spring 54 is attached to the valve body 52. The coil spring 54 is held under compression to press the valve body 52 toward the sealing member 53. The valve body 52 is positioned in contact with the sealing member 53 to cover the opening 53A. Thus, the valve body 52 closes off communication between the ink supply chamber 51 and the outside of the ink cartridge 10 via the opening 53A.

[0074] Similarly, the air communication portion 60 comprises a cylindrical air communication chamber 61, a valve body 62 made of resin, a sealing member 63 made of rubber, a coil spring 64 made of metal, and a cap 66 made of resin. The air communication chamber 61 extends from the front wall 22 of the frame 20 in the depth direction 13 away from the ink chamber 11. The air communication chamber 61 comprises a first end 61A and a second end 61B opposite to the first end 61A in the depth direction 13. The first end 61A is positioned closer to the ink chamber 11 than the second end 61B is positioned to the ink chamber 11. The air communication chamber 61 communicates with the ink chamber 11 via the first end 61A. The second end 61B of the air communication chamber 61 is open to the outside of the frame 20. The sealing member 63 is positioned at the second end 61B. The sealing member 63 has a cylindrical opening 63A formed therethrough in the depth direction 13. The cap 66 is welded to the frame 20. The cap 66 has a conical opening 66A formed therethrough in the depth direction 13. The sealing member 63 is sandwiched between a portion of the frame 20 defining the second end 61B of the air communication chamber 61 and the cap 66 while being elastically deformed.

[0075] The valve body 62 and the coil spring 64 are positioned within the air communication chamber 61. A protrusion 67 extends from the first end 61A toward the second end 61B. The protrusion 67 is inserted into one end of the coil spring 64, such that the coil spring 64 is attached to the protrusion 67. The valve body 62 has a cylindrical protrusion which is inserted into the other end of the coil spring 64, such that the coil spring 64 is attached to the valve body 62. The coil spring 64 is held under compression to press the valve body 62 toward the sealing member 63. The valve body 62 is positioned in contact with the sealing member 63 to cover the opening 63A. Thus, the valve body 62 closes off communication between the air communication chamber 61 and the outside of the ink cartridge 10 via the opening 63A.

[0076] As shown in Figs. 2A - 4B, the frame 20 has a protrusion 70 at the front wall 22. The protrusion 70 extends from the front wall 22 in the depth direction 13 away from the rear surface 23. The protrusion 70 has a substantially rectangular parallelepiped shape having a width in the width direction 12 which is less than the width of the front wall 22. The protrusion 70 comprises a front wall 71, a pair of sidewalls 72 connected to the front wall

71, a top wall 73 connected to the front wall 71, the front wall 22, and the pair of sidewalls 72, and a bottom wall 74 positioned opposite to the top wall 73 in the height direction 14 and connected to the front wall 71, the front wall 22 and the pair of sidewalls 72. As shown in Fig. 4B, the protrusion 70 comprises an inner space 75 defined by the front wall 71, the pair of sidewalls 72, the top wall 73, and the bottom wall 74. The inner space 75 is a portion of the ink chamber 11. Because the frame 20 allows light to pass therethrough as described above, light, e.g., visible or infrared light passes through the protrusion 70.

[0077] <Description of pivotable member> As shown in Figs. 3 - 4B, the ink cartridge 10 comprises a pivotable member 90, which is positioned in the ink chamber 11. As shown in Figs. 3 - 5B, the ink cartridge 10 comprises a pair of support members 80 extending from the bottom wall 25 toward the top wall 24. The pivotable member 90 is supported by the support members 80 in the ink chamber 11.

[0078] As shown in Figs. 3 - 5B, the pair of support members 80 is aligned in the width direction 12. Each support member 80 comprises a base 81 and a support portion 82. The base 81 is connected at its lower end to the bottom wall 25, and connected at its upper end to the support portion 82. The support portion 82 has a generally C-shape in a side view.

[0079] The pivotable member 90 is formed of a resin material, e.g., nylon, polyethylene, polypropylene, polycarbonate, polyolefin, or acrylic resin, having a specific gravity which is less than the specific gravity of ink stored in the ink chamber 11, and black pigment, e.g., carbon black is added to the resin material. Because the pivotable member 90 comprises carbon black, the pivotable member 90 blocks light when irradiated with light, e.g., visible or infrared light. That is, the pivotable member 90 absorbs light and thus light can not pass through the pivotable member 90.

[0080] As shown in Fig. 6, the pivotable member 90 comprises a substantially rectangular light blocking portion 91, a float portion 92 having a substantially cylindrical shape, a connection portion 93 having a substantially rectangular parallelepiped shape, and a shaft 94 having a substantially cylindrical shape. The connection portion 93 is connected to the light blocking portion 91 at one end and to the float portion 92 at the other end. The shaft 94 extends from the connection portion 93 in the width direction 12.

[0081] As shown in Fig. 4A, the connection portion 93 of the pivotable member 90 is positioned between the pair of support members 80 in the width direction 12. The shaft 94 extends from the connection portion 93 in the width direction 12 and passes through the insides of the pair of support portions 82. The pivotable member 90 is supported by the pair of support portions 82 so as to pivot about the center axis of the shaft 94 extending in the width direction 12. The pivotable member 90 is pivotable in the ink chamber 11 according to the position of the ink surface in the ink chamber 11 in a plane substantially

parallel with the depth direction 13 and the height direction 14.

[0082] The float portion 92 has a hollow portion formed therein, such that the specific gravity of the float portion 92 is less than the specific gravity of ink stored in the ink chamber 11. The volume of the float portion 92 is greater than the sum of the volumes of the light blocking portion 91, the connection portion 93, and the shaft 94. The mass of the float portion 92 is greater than the sum of the masses of the light blocking portion 91, the connection portion 93, and the shaft 94. Therefore, the movement of the pivotable member 90 can be described from the relationship between buoyancy and gravity acting on the float portion 92. When the float portion 92 is submerged in ink in the ink chamber 11, the buoyancy acting on the float portion 92 is greater than the gravity acting on the float portion 92, and thus the float portion 92 attempts to float on the surface of ink stored in the ink chamber 11. Thus, the pivotable member 90 receives a force to allow the pivotable member 90 to pivot counterclockwise in Fig. 4B. On the other hand, when a portion of the float portion 92 is exposed from ink, the buoyancy becomes equal to the gravity. When the ink surface lowers, the float portion 92 also lowers in accordance with the lowering ink surface, and the pivotable member 90 pivots clockwise in Fig. 4B.

[0083] As shown in Fig. 4B, the light blocking portion 91 is positioned in the inner space 75 of the protrusion 70.

[0084] The float portion 92 is covered with a layer of a ferromagnet 92A by a known manner, e.g., vapor deposition, and electroless plating. The ferromagnet 92A may comprise iron, cobalt, nickel, or combination thereof.

[0085] <Description of ink supply device and mounting portion> With reference to Figs. 7 - 9, the ink supply device 30 comprising the four mounting portions 300 will be described. In the figures, two directions parallel to a horizontal plane are perpendicular to each other are referred to as an X direction and a Y direction, and a direction perpendicular to the X direction and the Y direction and parallel to the direction of gravity is referred to as a Z direction. Although Fig. 9 is a cross sectional view of the mounting portion 300, an optical detector 330, a limit switch 335, a solenoid 340, and an iron core 341 are shown in a side view for convenience, and an optical path 330D also is shown.

[0086] As shown in Figs. 7 - 9, each mounting portion 300 has a substantially parallelepiped shape. The mounting portion 300 comprises a bottom wall 301, a pair of sidewalls 302, a top wall 303, and a rear wall 304 (shown in Fig. 18 only). The sidewalls 302 extend in the Z direction from both ends of the bottom wall 301 in the X direction, respectively. The top wall 303 is connected to ends of the sidewalls 302 opposite to the bottom wall 301, and extends between the sidewalls 302. The rear wall 304 is connected to the bottom wall 301, the pair of sidewalls 302, and the top wall 303. Ends of the bottom wall 301, the pair of sidewalls 302, and the top wall 303 opposite to ends thereof connected to the rear wall 304 define an

opening 305. A recessed portion 301A is formed in a lower surface of the bottom wall 304 at an end opposite to the rear wall 304. The ink cartridge 10 is mounted to the mounting portion 300 by being inserted into the mounting portion 300 from the opening 305 toward the rear wall 304.

[0087] A cylindrical shaft 306 extends in the X direction from one of the pair of sidewalls 302 to the other. The shaft 306 is aligned with the top wall 303 in the Y direction. The shaft 306 is positioned adjacent to an end of the top wall 303 opposite to the rear wall 304.

[0088] The ink supply device 30 further comprises four doors 310, which are shaped in a substantially rectangular parallelepiped. The four doors 310 are positioned corresponding to four mounting portions 300. Each door 310 has two protrusions 311 at one end. Each protrusion 311 has an opening formed therethrough in the X direction. The shaft 306 passes through the opening formed in the each protrusion 311. The door 310 is supported by the shaft 306 so as to pivot about the shaft 306. The door 310 comprises a hook 312 at the other end. When the door 310 is closed, i.e., when the door 310 is moved toward the mounting portion 300, the hook 312 is fitted in the recessed portion 301A, and the opening 305 is covered by the door 310.

[0089] As shown in Figs. 7 and 9, the ink supply device 30 comprises four cylindrical ink supply tubes 320. In Fig. 7, two of the four ink supply tubes 320 are shown. In Fig. 9, one of the four ink supply tubes 320 is shown. The four ink supply tubes 320 are positioned corresponding to four mounting portions 300. Each ink supply tube 320 is fixed to the rear wall 304 of the mounting portion 300, and extends from the rear wall 304 toward the opening 305. The ink supply tube 320 passes through the rear wall 304 and reaches an outer surface of the rear wall 304. The ink supply tube 320 is inserted into and connected to the tube 350. To reliably connect the ink supply tube 320 to the tube 350, a round clamp or band may be tightened around the tube 350 in which the ink supply tube 320 is inserted.

[0090] As shown in Figs. 7 and 9, the ink supply device 30 comprises four cylindrical air communication tubes 325. In Fig. 7, two of the four air communication tubes 325 are shown. In Fig. 9, one of the four air communication tubes 325 is shown. The four air communication tubes 325 are positioned corresponding to four mounting portions 300. Each air communication tube 325 is fixed to the rear wall 304 of the mounting portion 300, and extends from the rear wall 304 toward the opening 305. The air communication tube 325 passes through the rear wall 304 and reaches the outer surface of the rear wall 304.

[0091] <Description of optical detector> As shown in Figs. 7 and 9, the inkjet printer 100 comprises four optical detectors 330. Two of the four optical detectors 330 are shown in Fig. 7, and one of the four optical detectors 330 is shown in Fig. 9. The four optical detectors 330 are positioned corresponding to four mounting portions 300.

As shown in Fig. 10, each optical detector 330 comprises a base 330A, a light emitter 330B, and a light receiver 330C, which are all shaped in a substantially rectangular parallelepiped. Each optical detector 330 is positioned in an opening formed through the rear wall 304 in the Y direction and fixed in the rear wall 304. The light emitter 330B extends from one end of the base 330A with respect to the X direction toward the opening 305 of the mounting portion 300. The light receiver 330C extends from the other end of the base 330A with respect to the X direction toward the opening 305 of the mounting portion 300. The light emitter 330B and the light receiver 330C are aligned in the X direction. The light emitter 330B comprises a rectangular slit formed in a surface thereof facing the light receiver 330C. The light emitter 330B emits light, e.g. visible or infrared light, via the slit toward the light receiver 330C. The light receiver 330C comprises a rectangular slit (not shown) formed in a surface thereof facing the light emitter 330B. The light receiver 330C receives light emitted from the light emitter 330B via the slit formed in the light receiver 330C. An optical path 330D is formed between the light emitter 330B and the light receiver 330C.

[0092] When the light receiver 330C receives light emitted from the light emitter 330B at an intensity greater than or equal to a predetermined intensity, the light receiver 330C outputs a voltage higher than or equal to a predetermined voltage. When the light receiver 330C receives light emitted from the light emitter 330B at an intensity less than the predetermined intensity, the light receiver 330C outputs a voltage lower than the predetermined voltage. A case where the light receiver 330C receives light emitted from the light emitter 330B at an intensity less than the predetermined intensity comprises a case where the light receiver 330C does not receive light emitted from the light emitter 330B at all, that is, a case where the intensity of light received by the light receiver 330C is zero. In addition, a case where the light receiver 330C outputs a voltage lower than the predetermined voltage comprises a case where the light receiver 330C does not output any voltage at all, that is, a case where a voltage value output by the light receiver 330C is at the ground level. In this way, the light receiver 330C assumes two predetermined states. When the light receiver 330C outputs a voltage higher than or equal to the predetermined voltage, a controller 400 of the inkjet printer 100 (which will be described later) determines that the light receiver 330C is in an ON state. When the light receiver 330C outputs a voltage lower than the predetermined voltage, the controller 400 determines that the light receiver 330C is in an OFF state.

[0093] <Description of mount detector> As shown in Figs. 7 and 9, inkjet printer 100 comprises four mount detectors, e.g. limit switches 335. Two of the four limit switches 335 are shown in Fig. 7, and one of the four limit switches 335 is shown in Fig. 9. The four limit switches 335 are positioned corresponding to four mounting portions 300. Each limit switch 335 is positioned in an

opening formed through the rear wall 304 in the Y direction and fixed in the rear wall 304. The limit switch 335 comprises a case 335A and an actuator 335B extending to the outside of the case 335A from the inside of the case 335A. The actuator 335B is movable with respect to the case 335A. A movable contact (not shown) is connected to the actuator 335B inside the case 335A. The movable contact is movable together with the actuator 335B with respect to the case 335A. A fixed contact (not shown) is fixed to the case 335A inside the case 335A. Due to displacement of the actuator 335B with respect to the case 335A, the movable contact assume a contact state where the movable contact contacts the fixed contact and a separation state where the movable contact is separated away from the fixed contact.

[0094] When the movable contact contacts the fixed contact, the limit switch 335 outputs a voltage higher than or equal to a predetermined voltage. When the movable contact is away from the fixed contact, the limit switch 335 outputs a voltage lower than the predetermined voltage. A case where the limit switch 335 outputs a voltage lower than the predetermined voltage comprises a case where the limit switch 335 does not output any voltage at all, that is, a case where a voltage value output by the limit switch 335 is at ground level. Thus, the limit switch 335 assumes two predetermined states. When the limit switch 335 outputs a voltage higher than or equal to the predetermined voltage, the controller 400 of the inkjet printer 100 (which will be described later) determines that the limit switch 335 is in an ON state. When the limit switch 335 outputs a voltage lower than the predetermined voltage, the controller 400 determines that the limit switch 335 is in an OFF state. When the ink cartridge 10 is not mounted to the mounting portion 300, the movable contact of the limit switch 335 is away from the fixed contact, and the controller 400 determines that the limit switch 335 is in the OFF state.

[0095] <Description of magnetic field generator> As shown in Fig. 9, the inkjet printer 100 comprises four magnetic field generators, e.g. four solenoids 340 and four cylindrical iron cores 341. In Fig. 9, one solenoid 340 and one iron core 341 are shown. The four solenoids 340 and iron cores 341 are positioned corresponding to the four mounting portions 300. Each solenoid 340 is wound around the iron core 341. When electric current flows through the solenoid 340, the solenoid 340 and the iron core 341 generate magnetic field. The lower surface of the bottom wall 301 is formed with a recessed portion. The solenoid 340 and the iron core 341 extend in the Z direction from the recessed portion to the outside of the bottom wall 301.

[0096] <Description of interaction between mounting portion and ink cartridge> The interaction between the ink cartridge 10 and the mounting portion 300 will be described with reference to Fig. 11. Although Fig. 11 is a cross sectional view, the optical detector 330, the limit switch 335, the solenoid 340, and the iron core 341 are shown in a side view for convenience in Fig. 11. In Fig.

11, the door 310 is closed. When the ink cartridge 10 is mounted to the mounting portion 300, the width direction 12 is aligned with the X direction, the depth direction 13 is aligned with the Y direction, and the height direction 14 is aligned with the Z direction.

[0097] As shown in Fig. 11, when the ink cartridge 10 is mounted to the mounting portion 300 and the door 310 is closed, the protrusion 70 is positioned between the light emitter 330B and the light receiver 330C of the optical detector 330, and one of the pair of sidewalls 72 faces the light emitter 330B and the other of the pair of sidewalls 72 faces the light receiver 330C. At this time, the optical path 330D crosses the pair of sidewalls 72. The optical path 330D also crosses a path along which the light blocking portion 91 moves relative to the ink chamber 11 and the optical detector 330. When the optical path 330D crosses the light blocking portion 91, the light blocking portion 91 blocks light emitted from the light emitter 330B. At this time, the controller 400 determines that the light receiver 330C is in the OFF state. When the optical path 342 does not cross the light blocking portion 91, the light emitted from the light emitter 330B passes through the pair of sidewalls 72 and reaches the light receiver 330C. At this time, the controller 400 determines that the light receiver 330C is in the ON state.

[0098] As shown in Fig. 11, when the ink cartridge 10 is mounted to the mounting portion 300, the front wall 71 of the protrusion 70 contacts the actuator 335B of the limit switch 335 to press the actuator 335B into the case 335A. At this time, the movable contact of the actuator 335B contacts the fixed contact, and the controller 400 determines that the limit switch 335 is in the ON state. Thus, the limit switch 335 detects that the ink cartridge 10 is mounted to the mounting portion 300.

[0099] As shown in Fig. 11, when the ink cartridge 10 is mounted to the mounting portion 300, the ink supply tube 320 passes through the opening 56A of the cap 56 and the opening 53A of the sealing member 53, and presses the valve body 52 toward the first end 51A of the ink supply chamber 51 against a force of the coil spring 54 pressing the valve body 52. At this time, the sealing member 53 is elastically deformed and contacts the ink supply tube 320. When pressed toward the first end 51A of the ink supply chamber 51, the valve body 52 separates from the sealing member 53. As a result, the ink supply chamber 51 communicates with the tube 350 via the ink supply tube 320. Thus, the ink chamber 11 communicates with the sub tank 135 via the ink supply chamber 51, the ink supply tube 320, and the tube 350, such that ink can be supplied from the ink chamber 11 to the sub tank 135.

[0100] As shown in Fig. 11, when the ink cartridge 10 is mounted to the mounting portion 300, the air communication tube 325 passes through the opening 66A of the cap 66 and the opening 63A of the sealing member 63, and presses the valve body 62 toward the first end 61A of the air communication chamber 61 against a force of the coil spring 64 pressing the valve body 62. At this time,

the sealing member 63 is elastically deformed and contacts the air communication tube 325. When pressed toward the first end 61A of the air communication chamber 61, the valve body 62 separates from the sealing member 63. As a result, the air communication chamber 61 communicates with a space outside the mounting portion 300 via the air communication tube 325. Thus, the ink chamber 11 communicates with the space outside the mounting portion 300 via the air communication chamber 61 and air communication tube 325, such that air can be introduced into the ink chamber 11 from the space outside of the mounting portion 300.

[0101] As shown in Fig. 11, when the ink cartridge 10 is mounted to the mounting portion 300, the float portion 92 and the ferromagnet 92A are aligned with the solenoid 340 and the iron core 341 in the Z direction. In other words, the solenoid 340 and the iron core 341 are positioned below the float portion 92 and the ferromagnet 92A.

[0102] <Description of electrical configuration> An electrical configuration of the inkjet printer 100 will be described with reference to Fig. 12.

[0103] As shown in Fig. 12, the inkjet printer 100 comprises the controller 400. The controller 400 is configured to control operations of the inkjet printer 100 and make determination in various cases. The controller 400 is configured as a microcomputer, and mainly comprises a central processing unit (CPU) 402, read-only memory (ROM) 404, random access memory (RAM) 406, electrically erasable programmable read-only memory (EEPROM) 408, and application specific integrated circuit (ASIC) 410.

[0104] The ROM 404 stores programs for the CPU 402 to control the operations of the inkjet printer 100 and programs such as a program for the CPU 402 to execute determination steps shown in Fig. 14. The RAM 406 is used as a temporary storage area or a work area when the CPU 402 executes the programs. The EEPROM 408 stores information to be maintained even after the inkjet printer 100 is turned off.

[0105] The ASIC 410 is electrically connected to the head control circuit 133, the optical detectors 330, the limit switches 335, and a solenoid drive circuit 342. Although not shown, the ASIC 410 is electrically connected to drive circuits for driving the feeding device 110 and the transferring device 120, input/output portions for inputting and outputting signals between the inkjet printer 100 and an external personal computer, an instruction input portion for a user to send an instruction, such as a print instruction, to the inkjet printer 100, and a display portion that displays information to the user.

[0106] The solenoid drive circuit 342 is electrically connected to the solenoid 340. When the controller 400 inputs a signal to the solenoid drive circuit 342, the solenoid drive circuit 342 causes electric current to flow through the solenoid 340. The controller 400 and the solenoid drive circuit 342 are examples of a magnetic field controller.

[0107] When receiving a print instruction from an external personal computer (not shown) or the instruction input portion (not shown), the controller 400 sends a signal to the head control circuit 133. The head control circuit 133 is configured to control ejection of ink from the recording head 132 based on the signal received from the controller 400.

[0108] The light emitter 330B of the optical detector 330 is configured to emit light, e.g. visible or infrared light when receiving a signal from the controller 400.

[0109] The controller 400 is configured to determine that the light receiver 330C of the optical detector 330 and the limit switch 335 are in the ON or OFF state, as needed. As shown in Fig. 14, the controller 400 determines the state of the light receiver 330C and the state of the limit switch 335 according to steps, and determines whether the ink cartridge 10 mounted to the mounting portion 300 is normal.

[0110] <Description of operation and action> The operations and actions of the embodiment configured above will be described with reference to drawings.

[0111] With reference to Figs. 11 and 13, the following descriptions will be made as to the operation of the pivotable member 90 when electric current flows through the solenoid 340. In Fig. 11, electric current does not flow through the solenoid 340.

[0112] A new ink cartridge 10 has, in the ink chamber 11, ink having such an amount that the pivotable member 90 is submerged in ink. That is, the entirety of the pivotable member 90 is positioned under the ink surface in the ink chamber 11. As shown in Fig. 11, when the ink cartridge 10 is mounted to the mounting portion 300, the float portion 92 attempts to move toward an ink surface L in the ink chamber 11. When the float portion 92 attempts to move toward the ink surface L, the pivotable member 90 attempts to move counterclockwise in Fig. 11. However, because the light blocking portion 91 contacts the bottom wall 74, the movement of the pivotable member 90 is restricted, and the pivotable member 90 maintains a position in which the light blocking portion 91 contacts the bottom wall 74. At this time, the light blocking portion 91 crosses the optical path 330D and blocks light emitted from the light emitter 330B. When the light emitter 330B emits light, the controller 400 determines that the light receiver 330C is in the OFF state. The bottom wall 74 is an example of a contact portion.

[0113] When electric current flows through the solenoid 340, the solenoid 340 and the iron core 341 generate magnetic field. When magnetic field is generated, the strength of magnetic field around the ferromagnet 92A changes. In other words, when the electric current does not flow through the solenoid 340, magnetic field is not present around the ferromagnet 92A or the strength of the magnetic field is zero (in which the influence of the earth's magnetism and magnetic field generated by other portion of the inkjet printer 100 can be ignored). When the electric current flows through the solenoid 340, magnetic field having a given strength is generated around

the ferromagnet 92A.

[0114] When the electric current does not flow through the solenoid 340, the strength of the magnetic field around the ferromagnet 92A is zero and thus a force that the ferromagnet 92A receives from the magnetic field is zero. When the current flows through the solenoid 340, the ferromagnet 92A receives a force from the magnetic field. The force received from the magnetic field exceeds the buoyancy, and the float portion 92 moves toward the solenoid 340. When the float portion 92 moves toward the solenoid 340, the pivotable member 90 moves clockwise in Fig. 11, and stops at a position where the float portion 92 contacts the bottom wall 25 as shown in Fig. 13. At this time, the light blocking portion 91 does not cross the optical path 330D and light emitted from the light emitter 330B passes through the pair of sidewalls 72 and reaches the light receiver 330C. When the light emitter 330B emits light, the controller 400 determines that the light receiver 330C is in the ON state.

[0115] When the electric current stops flowing through the solenoid 340, the magnetic field disappears, the pivotable member 90 moves counterclockwise in Fig. 13, and stops at the position where the light blocking portion 91 contacts the bottom wall 74 as shown in Fig. 11.

[0116] A process for determining the state of the ink cartridge 10 will be described with reference to Fig. 14. The controller 400 monitors the state of the limit switch 335, and starts the process shown in Fig. 14 when the limit switch 335 changed from the OFF state to the ON state. In other words, the process shown in Fig. 14 is started when it is detected that the ink cartridge 10 was mounted to the mounting portion 300. When the state of the limit switch 335 changed from the ON state to the OFF state in during the process, the controller 400 causes the display portion (not shown) of the inkjet printer 100 to display a message and prompts a user to remount the ink cartridge 10 in to mounting portion 300.

[0117] In Fig. 14, each step is abbreviated as "S". When the process is started, the controller 400 causes the light emitter 330B of the optical detector 330 to emit light, determines the state of the light receiver 330C, and stores the determined state in a storage area I in the RAM 406 in S1. Then, the controller 400 inputs a signal to the solenoid drive circuit 342 such that electric current flows through the solenoid 340 in S2. The controller 400 determines the state of the light receiver 330C and store the state of the light receiver 330C in a storage area J in the RAM 406 in S3. Then the controller 400 stops the light emission of the light emitter 330B, and compares the state of the light receiver 330C stored in the storage area I and the state of the light receiver 330C stored in the storage area J in S4. When the controller 400 determines that the state of the light receiver 330C stored in the storage area I is different from that stored in the storage area J in S4, the controller 400 determines that the ink cartridge 10 is normal in S5, and ends the process. Then, the controller 400 stops inputting a signal to the solenoid drive circuit 342 such that the electric current

stops flowing through the solenoid 340. The controller 400 waits a print instruction from the external personal computer (not shown) or the instruction input portion (not shown). When the controller 400 determines that the state of the light receiver 330C stored in the storage area I is the same as that stored in the storage area J in S4, the controller 400 determines that the ink cartridge 10 is abnormal in S6, and ends the process. In this case, the controller 400 stops inputting a signal to the solenoid drive circuit 342 such that the electric current stops flowing through the solenoid 340. Then, the controller 400 causes the display portion (not shown) of the inkjet printer 100 to display a message, and notifies a user that the ink cartridge 10 is abnormal or needs replacement. In addition, the controller 400 does not send a signal to the head control circuit 133 even when receiving the print instruction from the external personal computer or the instruction input portion.

[0118] When an ink cartridge 10 mounted to the mounting portion 300 is new and normal, that is, when the ink cartridge 10 has the pivotable member 90 and the pivotable member 90 pivots normally, the state of the light receiver 330C stored in the storage area I is the OFF state and the state of the light receiver 330C stored in the storage area J is the ON state. Thus, the controller 400 determines in the process that the ink cartridge 10 is normal. When the ink cartridge 10 mounted to the mounting portion 300 is abnormal, for example, when the movement of the pivotable member 90 is hampered or the ink cartridge 10 does not have the pivotable member 90, even if the strength of the magnetic field around the ferromagnet 92A changes, the state of the light receiver 330C remains unchanged. Namely, the state of the light receiver 330C stored in the storage area I is the same state as the state of the light receiver 344C stored in the storage area J, and the controller 400 determines in the process that the ink cartridge 10 is abnormal.

[0119] As a result of executing the process shown in Fig. 14, the controller 400 can determine whether the ink cartridge 10 is normal or abnormal at an early stage of mounting the ink cartridge 10 to the mounting portion 300. Thus, a user can effectively deal with a problem at the early stage if an abnormal ink cartridge 10 is mounted to the mounting portion 300.

[0120] When the ink cartridge 10 is mounted to the mounting portion 300, the movement of the pivotable member 90 may be hampered by the surface tension of bubbles contacting the pivotable member 90 and the front wall 22, the rear wall 23, the top wall 24 or the pair of sidewalls 21. In this case, if magnetic field is generated, the force the ferromagnet 92A receives from the magnetic field exceeds the surface tension, and the pivotable member 90 moves. Thus, the controller 400 determines that, in the above process, the ink cartridge 10 is normal. When the pivotable member 90 moves, bubbles are destroyed, and the pivotable member 90 correctly operates after that. Namely, the function of the pivotable member 90 is restored.

[0121] The solenoid 340 and the iron core 341 can move the pivotable member 90 without contact. Thus, ink is less likely to leak from the ink chamber 11 to the outside of the ink cartridge 10 as compared with a configuration in which the pivotable member 90 is moved by being contacted from the outside of the ink cartridge 10.

[0122] The controller 400 may cause the light emitter 330B to emit light during S1, S2, S3, S4, S5, and S6. The controller 400 may cause the light emitter 330B to emit light at least in S1 and S3.

[0123] In the embodiment, four ink cartridges 10 are mounted to four mounting portions 300. The above process to determine whether the ink cartridge 10 is normal is performed for each ink cartridge 10.

[0124] When the controller 400 receives a print instruction from the external personal computer (not shown) or the instruction input portion (not shown) after determining that the ink cartridge 10 is normal, the controller 400 sends a signal to the drive circuit (not shown) for driving the feeding device 110 and the transferring device 120 to cause the feeding device 110 and the transferring device 120 to supply and feed a recording sheet, and sends a signal to the head control circuit 133 to cause the recording head 132 to eject ink onto the recording sheet. At this time, ink is supplied from the ink chamber 11 to the sub tank 135. The controller 400 causes the light emitter 330B of the optical detector 330 to emit light and monitors the state of the light receiver 330C. Namely, the controller 400 periodically determines the state of the light receiver 330C.

[0125] When ink is supplied from the ink chamber 11 to the sub tank 135 and the amount of ink stored in the ink chamber 11 reaches a first amount, the ink surface L is positioned at a position shown in Fig. 15. At this time, a portion of the float portion 92 of the pivotable member 90 is exposed from the ink surface L in the air in the ink chamber 11 and the gravity and the buoyancy acting on the pivotable member 90 become equal.

[0126] When ink is further supplied from the ink chamber 11 to the sub tank 135, the pivotable member 90 rotates clockwise in Fig. 15 in accordance with the lowering ink surface L. When the amount of ink stored in the ink chamber 11 reaches a second amount, the ink surface L is positioned at a position shown in Fig. 16. At this time, the light blocking portion 91 deviates from the optical path 330D of the optical detector 330, and light emitted from the light emitter 330B passes through the pair of sidewalls 72 of the protrusion 70 and reaches the light receiver 330C. That is, the light receiver 330C changes from the OFF state to the ON state.

[0127] When the controller 400 determines that the light receiver 330C changed from the OFF state to the ON state, the controller 400 determines that the ink stored in the ink chamber 11 reaches the second amount, and starts to count the number of times that the recording head 132 ejects ink. In addition, the controller 400 causes the display portion (not shown) of the inkjet printer 100 to display a message notifying a user that remaining

amount of ink stored in the ink cartridge 10 is low.

[0128] When the number of times that the recording head 132 ejects ink reaches a predetermined number of times, the controller 400 stops the recording head 132 from ejecting ink, and causes the display portion (not shown) of the inkjet printer 100 to display a message notifying a user that, for example, the ink cartridge 10 is empty or the ink cartridge 10 should be replaced with a new one. At this time, an actual amount of ink stored in the ink chamber 11 may not be zero but preferably may be close to zero. When there is no ink in the ink chamber 11, the float portion 92 contacts the bottom wall 25 as shown in Fig. 17.

[0129] In the embodiment, the light blocking portion 91 is configured to prevent light emitted from the light emitter 330B from passing therethrough. In another embodiment, the light blocking portion 91 may be configured to alter a path of light emitted from the light emitter 330B. For example, aluminum foil may be evaporated onto the light blocking portion 91 so as to reflect light emitted from light emitter 330B.

[0130] In the embodiment, the light receiver 330C is configured to receive light emitted from the light emitter 330B when the light is not blocked by the light blocking portion 91. In another embodiment, when the light blocking portion is configured to reflect light emitted from the light emitter, the light receiver may be configured to receive light reflected by the light blocking portion.

[0131] In the embodiment, the film of the ferromagnet 92A is formed on the float portion 92 by a known manner, e.g., vapor deposition, and electroless plating. In another embodiment, the film of the ferromagnet may be bonded by an adhesive to the float portion. Alternatively, when the pivotable member is manufactured by injection-molding a resin material, the ferromagnet may be buried in the float portion.

[0132] In another embodiment, the inkjet printer 100 may not comprise the iron core 341. The inkjet printer 100 may comprise the solenoid 340 as a magnetic field generator. In this case, a magnetic field may be generated by the solenoid 340 only.

[0133] [Second embodiment] A second embodiment of a liquid ejecting system of the invention will be described with reference to Fig. 18. It is noted that elements similar to or identical with those described in the first embodiment are designated by similar numerals, and thus the description thereof can be omitted for the sake of brevity. The following description will be made mainly as to different points from the first embodiment.

[0134] The second embodiment is different from the first embodiment in that the inkjet printer 100 does not comprise the limit switch 335. In addition, the second embodiment is different from the first embodiment in a determination process executed by the controller 400.

[0135] When the ink cartridge 10 is not mounted to the mounting portion 300 and the light emitter 330B of the optical detector 330 is caused to emit light, the controller 400 determines that the state of the light receiver 330C

is in the ON state. On the other hand, when a new ink cartridge 10 is mounted in the mounting portion 300 and the light emitter 330B is caused to emit light, the light blocking portion 91 blocks the light. At this time, the controller 400 determines that the state of the light receiver 330C is in the OFF state. In other words, the optical detector 330 can detect that the ink cartridge 10 is mounted to the mounting portion 300. In this embodiment, the optical detector 330 also serves as a mount detector.

[0136] In the determination process of the second embodiment shown in Fig. 18, the controller 400 determines whether the ink cartridge 10 is normal. The controller 400 causes the light emitter 330B of the optical detector 330 to emit light, monitors the state of the light receiver 330C, and starts the determination process shown in Fig. 18 when the state of the light receiver 330C changed from the ON state to the OFF state. In other words, the determination process shown in Fig. 18 is started when it is detected that the ink cartridge 10 was mounted to the mounting portion 300.

[0137] When the determination process is started, the controller 400 inputs a signal to the solenoid drive circuit 342 such that electric current flows through the solenoid 340 in S21. Then, the controller 400 determines whether the state of the light receiver 330C is the ON state in S22. When the light receiver 330C is in the ON state in S22, the controller 400 determines that the ink cartridge 10 is normal in S23 and ends the determination process. When the light receiver 330C is in the OFF state in S22, the controller 400 determines that the ink cartridge 10 is abnormal in S24 and ends the determination process.

[0138] At the start of the determination process, the light receiver 330C is in the OFF state. When the ink cartridge 10 mounted to the mounting portion 300 is normal, that is, when the ink cartridge 10 has the pivotable member 90 and the pivotable member 90 pivots normally, if electric current flows through the solenoid 340 such that magnetic field is generated, the strength of the magnetic field around the ferromagnet 92A changes, which causes the pivotable member 90 to move and the state of the light receiver 330C changes from the OFF state to the ON state. Thus, the determination of the controller 400 in S22 as to whether the light receiver 330C is in the ON state corresponds to a determination as to whether the state of the light receiver 330C changed from the OFF state to the ON state before and after a change in the strength of the magnetic field around the ferromagnet 92A. When the state of the light receiver 330C changed from the OFF state to the ON state before and after the change in the strength of the magnetic field around the ferromagnet 92A, the controller 400 determines that the ink cartridge 10 is normal in S23. When the ink cartridge 10 is abnormal, for example, when the movement of the pivotable member 90 is hampered, even if the strength of the magnetic field around the ferromagnet 92A changes, the state of the light receiver 330C does not change remains in the OFF state. In this case, the controller 400 determines that the ink cartridge 10 is abnormal in S24.

[0139] [Third embodiment] A third embodiment of a liquid ejecting system of the invention will be described with reference to Figs. 19 - 23. It is noted that elements similar to or identical with those described in the first embodiment are designated by similar numerals, and thus the description thereof can be omitted for the sake of brevity. The following description will be made mainly as to different points from the first embodiment.

[0140] The third embodiment is different from the first embodiment in that the ink cartridge 10 comprises a storage unit 500, the inkjet printer 100 comprises a connector 502, and a solenoid drive circuit 542 instead of the solenoid drive circuit 342, and the inkjet printer 100 does not comprise the limit switch 335. In addition, the third embodiment is different from the first embodiment in a determination process executed by the controller 400.

[0141] As shown in Figs. 19A, 19B, and 21, the ink cartridge 10 comprises a storage unit 500. The storage unit 500 is fixed to an outer surface of the front wall 22 and is positioned between the protrusion 70 and the ink supply portion 50. The storage unit 500 comprises a semiconductor substrate with an EEPROM. The storage unit 500 further comprises a plurality of connection terminals 501. The connection terminals 501 are exposed to the outside of the storage unit 500. The connection terminals 501 are electrically connected to the EEPROM.

[0142] As shown in Figs. 20 and 21, the inkjet printer 100 has four connectors 502. Two of the four connectors 502 are shown in Fig. 20 and one of the four connectors 502 is shown in Fig. 21. The four connectors 502 are positioned corresponding to four mounting portions 300. Each connector 502 is positioned in an opening formed through the rear wall 304 in the Y direction and fixed in the rear wall 304. The connector 502 is positioned between the optical detector 330 and the ink supply tube 320. The connector 502 has a plurality of electrodes 503 equal in number to the connectors 501 of the storage unit 500. When the ink cartridge 10 is mounted to the mounting portion 300, the connectors 501 of the storage unit 500 contact the electrodes 503 of the connector 502.

[0143] As shown in Fig. 22, the inkjet printer 100 of the third embodiment comprises a solenoid drive circuit 542, instead of the solenoid drive circuit 342. The solenoid drive circuit 542 is electrically connected to the ASIC 410 and the solenoid 340. When the ink cartridge 10 is mounted to the mounting portion 300, the storage unit 500 is electrically connected to the ASIC 410 via the connector 502. More specifically, the EEPROM of the storage unit 500 is electrically connected to the ASIC 410 via the connection terminals 501 of the storage unit 500 and the electrodes 503 of the connector 502.

[0144] When the controller 400 does not input a signal to the solenoid drive circuit 542, the solenoid drive circuit 542 does not cause electric current to flow through the solenoid 340. When the ink cartridge 10 is mounted to the mounting portion 300 and electric current does not flow through the solenoid 340, magnetic field is not present around the ferromagnet 92A, that is, the strength

of the magnetic field around the ferromagnet 92A is zero (in which the influence of the earth's magnetism and any magnetic field generated by other portion of the inkjet printer 100 can be ignored). In this embodiment, when the electric current does not flow through the solenoid 340, the strength of the magnetic field generated around the ferromagnet 92A, which is zero strength, is referred to as a first strength. When the controller 400 inputs a first signal to the solenoid drive circuit 542, the solenoid drive circuit 542 causes electric current having a first strength to flow through the solenoid 340. In this embodiment, when the solenoid drive circuit 542 causes electric current having the first strength to flow through the solenoid 340, the strength of the magnetic field generated around the ferromagnet 92A is referred to as a second strength. The second strength of the magnetic field is stronger than the first strength of the magnetic field. When the controller 400 inputs a second signal to the solenoid drive circuit 542, the solenoid drive circuit 542 causes electric current having a second strength through the solenoid 340. In this embodiment, when the solenoid drive circuit 542 causes electric current having the second strength to flow through the solenoid 340, the strength of the magnetic field generated around the ferromagnet 92A is referred to as a third strength. The third strength of the magnetic field is stronger than the second strength of the magnetic field. When the magnetic field around the ferromagnet 92A is strong, the force that the ferromagnet 92A receives from the magnetic field is also strong. When the magnetic field around the ferromagnet 92A is weak, the force that the ferromagnet 92A receives from the magnetic field is also weak.

[0145] The second strength of the magnetic field is set such that the force that the ferromagnet 92A receives from the magnetic field does not exceed the surface tension of bubbles contacting the pivotable member 90 and the front wall 22, the rear wall 23, the top wall 24 or the pair of sidewalls 21. Thus, when the movement of the pivotable member 90 is hampered by the surface tension of the bubbles, if the strength of the magnetic field around the ferromagnet 92A is less than or equal to the second strength, the pivotable member 90 stays in a position where the light blocking portion 91 contacts the bottom wall 74 as shown in Fig. 21. However, the second strength of the magnetic field is set such that, with no bubbles in the ink chamber 11, the ferromagnet 92A receives the force from the magnetic field and the pivotable member 90 can move clockwise in Fig. 21 from the position where the light blocking portion 91 contacts the bottom wall 74. The pivotable member 90 stops moving, when the float portion 92 contacts the bottom wall 25.

[0146] The third strength of the magnetic field is set such that the force that the ferromagnet 92A receives from the magnetic field exceeds the surface tension of bubbles contacting the pivotable member 90 and the front wall 22, the rear wall 23, the top wall 24 or the pair of sidewalls 21. Thus, even when the movement of the pivotable member 90 is hampered by the surface tension

of the bubbles, if the magnetic field around the ferromagnet 92A has the third strength, the pivotable member 90 moves clockwise in Fig. 21 from the position where the light blocking portion 91 contacts the bottom wall 74. The pivotable member 90 stops moving when the float portion 92 contacts the bottom wall 25.

[0147] The second strength and the third strength of the magnetic field can be determined by examining the relationship between the strength of current flowing through the solenoid 340 and the movement of the pivotable member 90. To determine the second strength and the third strength of the magnetic field, the following tests are repeated using the ink cartridge 10 which has, in the ink chamber 11, ink having such an amount that the pivotable member 90 is submerged in ink. In one test, the ink cartridge 10 is mounted to the mounting portion 300 after bubbles are produced in the ink chamber 11, and then electric current is caused to flow through the solenoid 340 to find how much strength of electric current is needed to cause the pivotable member 90 to move. In the other test, the ink cartridge 10 is mounted to the mounting portion 300 without producing bubbles in the ink chamber 11, and then electric current is caused to flow through the solenoid 340 to find how much strength of electric current is needed to cause the pivotable member 90 to move. For example, an average of the strengths of electric current which causes the pivotable member 90 to move in the ink chamber 11 having no bubbles formed therein, but does not cause the pivotable member 90 to move in the ink chamber 11 having bubbles formed therein, is set to the first strength of the electric current. In addition, a minimum strength of electric current which causes the pivotable member 90 to move in the ink chamber 11 having bubbles formed therein, is set to the second strength of the electric current. Although the strength of the magnetic field is not directly measured, when electric current having the first strength flows through the solenoid 340, it is indirectly found that magnetic field having the second strength is generated. Similarly, when electric current having the second strength flows through the solenoid 340, it is indirectly found that magnetic field having the third strength is generated. When electric current does not flow through the solenoid 340, magnetic field having the first strength, which is zero strength, is generated.

[0148] When the ink cartridge 10 is mounted to the mounting portion 300, an electric circuit is formed between the ASIC 410 and the storage unit 500 via the connector 502, such that the controller 400 can determine that the ink cartridge 10 is mounted to the mounting portion 300. When the ink cartridge 10 is mounted to the mounting portion 300, the controller 400 can store information in the storage unit 500 via the connector 502.

[0149] In the determination process of the third embodiment shown in Fig. 23, the controller 400 determines whether the ink cartridge 10 is normal. The controller 400 starts the determination process when the controller 400 determines that the storage unit 500 was connected to

the connector 502. In other words, the controller 400 starts the determination process when it is detected that the ink cartridge 10 was mounted to the mounting portion 300. When the controller 400 determines that the storage unit 500 is disconnected from the connector 502 during the process, the controller 400 causes the display portion (not shown) of the inkjet printer 100 to display a message and prompts a user to remount the ink cartridge 10 to the mounting portion 300.

[0150] When the determination process is started, the controller 400 causes the light emitter 330B of the optical detector 330 to emit light, determines the state of the light receiver 330C, and stores the determined state of the light receiver 330C in the storage area I in the RAM 406 in S31. Then, the controller 400 inputs the first signal to the solenoid drive circuit 542 to cause the electric current having the first strength through the solenoid 340 in S32. The controller 400 determines the state of the light receiver 330C and stores the determined state in the storage area J in the RAM 406 in S33. Then, the controller 400 stops the light emission of the light emitter 330B, and compares the state of the light receiver 330C stored in the storage area I and the state of the light receiver 330C stored in the storage area J in S34. When the controller 400 determines that the state of the light receiver 330C stored in the storage area I is different from that stored in the storage area J in S34, the controller 400 determines that the ink cartridge 10 is normal in S35, and ends the process. When the controller 400 determines that the state of the light receiver 330C stored in the storage area I is the same as that stored in the storage area J in S34, the controller 400 inputs the second signal to the solenoid drive circuit 542 to cause the electric current having the second strength through the solenoid 340 in S36. Then, the controller 400 causes the light emitter 330B to emit light, determines the state of the light receiver 330C, and stores the determined state of the light receiver 330C in a storage area K in the RAM 406 in S37. The controller 400 stops the light emission of the light emitter 330B, and compares the state of the light receiver 330C stored in the storage area J and the state of the light receiver 330C stored in the storage area K in S38. When the controller 400 determines that the state of the light receiver 330C stored in the storage area J is different from the state of the light receiver 330C stored in the storage area K in S38, the controller 400 determines that the ink cartridge 10 is normal in S39. Then, in S40, the controller 400 stores, in the EEPROM of the storage unit 500, information indicating that the states of the light receiver 330C was the same in S34 but different in S38, and ends the process. When the controller 400 determines that the state of the light receiver 330C stored in the storage area J is the same as the state of the light receiver 330C stored in the storage area K in S38, the controller 400 determines that the ink cartridge 10 is abnormal in S41. Then, the controller 400 stores, in the EEPROM of the storage unit 500, information indicating that the ink cartridge 10 was abnormal, in S42, and ends the process.

[0151] When the ink cartridge 10 mounted to the mounting portion 300 is new and normal, that is, when the ink cartridge 10 has the pivotable member 90 and the pivotable member 90 pivots normally, the state of the light receiver 330C stored in the storage area I is the OFF state, and the state of the light receiver 330C stored in the storage area J is the ON state. Thus, the controller 400 determines that the ink cartridge 10 is normal in S35. When the movement of the pivotable member 90 is hampered by the surface tension of bubbles contacting the pivotable member 90 and the front wall 22, the rear wall 23, the top wall 24 or the pair of sidewalls 21, even if the strength of the magnetic field around the ferromagnet 92A changes from the first strength to the second strength, the state of the light receiver 330C remains unchanged. Namely, the state of the light receiver 330C stored in the storage area I is the same state as the state of the light receiver 344C stored in the storage area J. However, when the magnetic field around the ferromagnet 92A changes from the second strength to the third strength, the pivotable member 90 moves and the state of the light receiver 330C changes. In other words, the state of the light receiver 330C stored in the storage area J is different from the state of the light receiver 330C stored in the storage area K. Thus, the controller 400 determines that the ink cartridge 10 is normal in S39. In S40, the controller 400 stores, in the EEPROM of the storage unit 500, information indicating that the state of the light receiver 330C did not change before and after the magnetic field around the ferromagnet 92A changed from the first strength to the second strength and that the state of the light receiver 330C changed before and after the magnetic field around the ferromagnet 92A changed from the second strength to the third strength. The movement of the pivotable member 90 may be hampered by causes other than the surface tension of the bubbles. For example, the pivotable member 90 may be sandwiched between the pair of sidewalls 21 formed of a flexible film; the pivotable member 90 may be immovable because it comes off from the support portions 82; or the ink cartridge 10 may not have the pivotable member 90. In such cases, even when the magnetic field around the ferromagnet 92A changes from the second strength to the third strength, the state of the light receiver 330C remains unchanged. In other words, the state of the light receiver 330C stored in the storage area J is the same as the state of the light receiver 330C stored in the storage area K. Thus, the controller 400 determines that the ink cartridge 10 is abnormal in S41. In S42, the controller 400 stores information indicating that the ink cartridge 10 was abnormal in the EEPROM of the storage unit 500.

[0152] As described above, the controller 400 can identify the cause of hampering the movement of the pivotable member 90. Because the storage unit 500 is fixed to the ink cartridge 10, if a system for collecting used ink cartridges 10 and abnormal ink cartridges 10 is established as part of recycling, the manufacturer of the ink cartridges 10 can collect information stored in the storage

units 500. The manufacturer can calculate a rate of incidence of bubble generation based on the information stored in the storage units 500, which indicates that the state of the light receiver 330C did not change before and after the magnetic field around the ferromagnet 92A changed from the first strength to the second strength and that the state of the light receiver 330C changed before and after the magnetic field around the ferromagnet 92A changed from the second strength to the third strength. The manufacturer may decide a course of action for developing an ink cartridge in which bubbles are less likely to form, by comparing an actual rate of incidence of bubble generation and an estimated rate of incidence of bubble generation. In addition, the manufacturer can identify the main cause of hampering the movement of the pivotable member 90 based on the information indicating that the ink cartridge 10 was abnormal, stored in the storage units 500, as well as the above information. When the main cause is the bubble generation in the ink chamber 11, the manufacturer may decide a course of action for developing an ink cartridge in which bubbles are less likely to form. When the main cause is something other than the bubble generation, the manufacturer may decide a course of action for developing an ink cartridge, in which, for example, the pivotable member 90 is less likely to come from the support portions 82, or the pivotable member 90 is less likely to be sandwiched between the pair of sidewalls 21 if the sidewalls 21 are flexible films.

[0153] In another embodiment, the ink cartridge 10 may not necessarily comprise the storage unit 500 and the above information may be stored in the EEPROM 408 in the controller 400. If a system for collecting inkjet printers 100 which the users no longer use is established as part of recycling, the manufacturer of the inkjet printers 100 may collect information stored in the EEPROM 408 of the controller 400.

[0154] [Fourth embodiment] A fourth embodiment of a liquid ejecting system of the invention will be described with reference to Figs. 24 - 27. It is noted that elements similar to or identical with those described in the third embodiment are designated by similar numerals, and thus the description thereof can be omitted for the sake of brevity. The following description will be made mainly as to different points from the third embodiment.

[0155] The fourth embodiment is different from the third embodiment in that the inkjet printer 100 comprises a permanent magnet 600 instead of the solenoid 340 and iron core 341, and further comprises a cam 602, a motor 604, and a motor drive circuit 606 instead of solenoid drive circuit 542. In addition, the fourth embodiment is different from the third embodiment in a determination process executed by the controller 400.

[0156] As shown in Fig. 24, the inkjet printer 100 comprises a permanent magnet 600 and a rod 601, which are positioned in a recessed portion formed on a lower surface of the bottom wall 301 of the mounting portion 300. The permanent magnet 600 is an example of a mag-

netic filed generator. As the permanent magnet 600, the followings may be used: an alloy magnet including samarium and cobalt, an alloy magnet including neodymium, iron, and boron, a barium ferrite magnet, strontium ferrite magnet or the like. The permanent magnet 600 is fixed to one end of the rod 601. The inkjet printer 100 comprises a cam 602. The other end of the rod 601 contacts an outside edge of the cam 602. The cam 602 comprises a shaft 602A and is configured to rotate about the shaft 602A. When the cam 602 rotates, the rod 601 moves in the Z direction along the outside edge of the cam 602. When the rod 601 moves, the permanent magnet 600 moves in the Z direction in the recessed portion formed on the lower surface of the bottom wall 301. When the ink cartridge 10 is mounted to the mounting portion 300, the permanent magnet 600 is positioned directly below the float portion 92. Although Fig. 24 is a cross sectional view, the optical detector 330, the permanent magnet 600, the rod 601, and the cam 602 are shown in a side view for convenience in Fig. 24.

[0157] As shown in Fig. 26, the inkjet printer 100 comprises a motor 604 for driving the cam 602, and a motor drive circuit 606 for driving the motor 604. The shaft 602A of the cam 602 is coupled to a shaft of the motor 604 via a reduction gear. The motor drive circuit 606 is electrically connected to the ASIC 410 and to the motor 604, and is configured to drive the motor 604 upon receipt of a signal from the ASIC 410. When the motor 604 is driven, the cam 602 rotates.

[0158] In this embodiment, when the ink cartridge 10 is mounted to the mounting portion 300 and the permanent magnet 600 is in a first position shown in Fig. 25A, the strength of the magnetic field around the ferromagnet 92A is referred to as a first strength. When the motor 604 is driven, the cam 602 rotates counterclockwise in Fig. 25A. When the cam 602 rotates, the permanent magnet 600 moves from the first position toward the bottom wall 25 of the ink cartridge 10 and reaches a second position shown in Fig. 25B. In this embodiment, when the permanent magnet 600 is in the second position, the strength of the magnetic field around the ferromagnet 92A is referred to as a second strength. As the permanent magnet 600 is closer to the ferromagnet 92A in the second position than in the first position, the second strength of the magnetic field is stronger than the first strength of the magnetic field. When the cam 602 rotates further counterclockwise in Fig. 25B, the permanent magnet 600 moves from the second position toward the bottom wall 25 of the ink cartridge 10, and reaches a third position shown in Fig. 25C. In this embodiment, when the permanent magnet 600 is positioned in the third position, the strength of the magnetic field around the ferromagnet 92A is referred to as a third embodiment. As the permanent magnet 600 is closer to the ferromagnet 92A in the third position than in the second position, the third strength of the magnetic field is stronger than the second strength of the magnetic field. The controller 400, the cam 602, the motor 604, and the motor drive circuit 606

are examples of a magnetic field controller.

[0159] The first strength of the magnetic field is set such that, even when the movement of the pivotable member 90 is not hampered and the pivotable member 90 correctly operates, the force that the ferromagnet 92A receives from the magnetic field does not exceed the buoyancy and the pivotable member 90 does not move. At the first strength, the pivotable member 90 stays in a position where the light blocking portion 91 contacts the bottom wall 74 as shown in Fig. 24.

[0160] The second strength of the magnetic field is set such that the force that the ferromagnet 92A receives from the magnetic field does not exceed the surface tension of bubbles contacting the pivotable member 90 and the front wall 22, the rear wall 23, the top wall 24 or the pair of sidewalls 21. Thus, when the movement of the pivotable member 90 is hampered by the surface tension of the bubbles, if the magnetic field around the ferromagnet 92A is less than or equal to the second strength, the pivotable member 90 stays in the position where the light blocking portion 91 contacts the bottom wall 74 as shown in Fig. 24. However, the second strength of the magnetic field is set such that, with no bubbles in the ink chamber 11, the ferromagnet 92A receives the force from the magnetic field and the pivotable member 90 can move clockwise in Fig. 24 from the position where the light blocking portion 91 contacts the bottom wall 74. The pivotable member 90 stops moving when the float portion 92 contacts the bottom wall 25.

[0161] The third strength is set such that the force that the ferromagnet 92A receives from the magnetic field exceeds the surface tension of the bubbles contacting the pivotable member 90 and the front wall 22, the rear wall 23, the top wall 24 or the pair of sidewalls 21. Thus, even when the movement of the pivotable member 90 is hampered by the surface tension of the bubbles, if the magnetic field around the ferromagnet 92A has the third strength, the pivotable member 90 moves clockwise in Fig. 24 from the position where the light blocking portion 91 contacts the bottom wall 74. The pivotable member 90 stops moving when the float portion 92 contacts the bottom wall 25.

[0162] The first strength, the second strength, and the third strength of the magnetic field can be determined by examining the relationship between the position of the permanent magnet 600 and the movement of the pivotable member 90. To determine the first strength, the second strength, and the third strength of the magnetic field, the following tests are repeated using an ink cartridge 10 which has, in the ink chamber 11, ink having such an amount that the pivotable member 90 is submerged in ink. In one test, the ink cartridge 10 is mounted to the mounting portion 300 after bubbles are produced in the ink chamber 11, and then the permanent magnet 600 is moved to find a position causing the pivotable member 90 to move. In the other test, the ink cartridge 10 is mounted to the mounting portion 300 without producing bubbles in the ink chamber 11, and then the permanent magnet

600 is moved to find a position causing the pivotable member 90 to move. For example, a position of the permanent magnet 600 when the pivotable member 90 does not move in the ink chamber 11 having no bubble formed therein, is set to the first position. An average of positions of the permanent magnet when the pivotable member 90 moves in the ink chamber 11 having no bubble formed therein, but does not move in the ink chamber 11 having bubbles formed therein, is set to the second position. Moreover, a position of the permanent magnet 600 which is closest to the ferromagnet 92A of positions when the pivotable member 90 moves in the ink chamber 11 having bubbles formed therein, is set to the third position. Although the strength of the magnetic field is not directly measured, when the permanent magnet 600 is in the first position, it is indirectly found that magnetic field having the first strength is generated. Similarly, when the permanent magnet 600 is in the second position, it is indirectly found that magnetic field having the second strength is generated. When the permanent magnet 600 is in the third position, it is indirectly found that magnetic field having the third strength is generated.

[0163] The controller 400 starts a determination process shown in Fig. 27 when the controller 400 determines that the storage unit 500 was connected to the connector 502. In other words, the determination process shown in Fig. 27 is started when it is detected that the ink cartridge 10 was mounted to the mounting portion 300. When the controller 400 determines that the storage unit 500 is disconnected from the connector 502 during the process, the controller 400 causes the display portion (not shown) of the inkjet printer 100 to display a message and prompts a user to remount the ink cartridge 10 to the mounting portion 300.

[0164] When the determination process is started, the controller 400 causes the light emitter 330B of the optical detector 330 to emit light, determines the state of the light receiver 330C, and stores the determined state of the light receiver 330C in the storage area I in the RAM 406 in S51. The permanent magnet 600 is in the first position under normal conditions and therefore the permanent magnet 600 is in the first position when the ink cartridge 10 is initially mounted to the mounting portion 300. Thus, the state of the light receiver 330C stored in the storage area I is the state of the light receiver 330C when the permanent magnet 600 is in the first position. Then, the controller 400 inputs a signal to the motor drive circuit 606 to move the permanent magnet 600 to the second position in S52. The controller 400 determines the state of the light receiver 330C and stores the determined state in the storage area J in the RAM 406 in S53. Then, the controller 400 stops the light emission of the light emitter 330B, and compares the state of the light receiver 330C stored in the storage area I and the state of the light receiver 330C stored in the storage area J in S54. When the controller 400 determines that the state of the light receiver 330C stored in the storage area I is different from that stored in the storage area J in S54, the controller

400 determines that the ink cartridge 10 is normal in S55, and ends the process. When the controller 400 determines that the state of the light receiver 330C stored in the storage area I is the same as that stored in the storage area J in S54, the controller 400 inputs a signal to the motor drive circuit 606 to move the permanent magnet 600 to the third position in S56. Then, the controller 400 causes the light emitter 330B to emit light, determines the state of the light receiver 330C, and stores the determined state of the light receiver 330C in the storage area K in the RAM 406 in S57. The controller 400 stops the light emission of the light emitter 330B, and compares the state of the light receiver 330C stored in the storage area J and the state of the light receiver 330C stored in the storage area K in S58. When the controller 400 determines that the state of the light receiver 330C stored in the storage area J is different from the state of the light receiver 330C stored in the storage area K in S58, the controller 400 determines that the ink cartridge 10 is normal in S59. Then, in S60, the controller 400 stores, in the EEPROM of the storage unit 500, information indicating that the states of the light receiver 330C were the same in S54 but different in S58, and ends the process. When the controller 400 determines that the state of the light receiver 330C stored in the storage area J is the same as the state of the light receiver 330C stored in the storage area K in S58, the controller 400 determines that the ink cartridge 10 is abnormal in S61. Then, the controller 400 stores, in the EEPROM of the storage unit 500, information indicating that the ink cartridge 10 was abnormal, in S62, and ends the process. After ending the process, the controller 400 sends a signal to the motor drive circuit 604 to move the permanent magnet 600 to the first position.

[0165] When the ink cartridge 10 mounted to the mounting portion 300 is new and normal, that is, when the ink cartridge 10 has the pivotable member 90 and the pivotable member 90 pivots normally, the state of the light receiver 330C stored in the storage area I is the OFF state, and the state of the light receiver 330C stored in the storage area J is the ON state. Thus, the controller 400 determines that the ink cartridge 10 is normal in S55. When the movement of the pivotable member 90 is hampered by the surface tension of bubbles contacting the pivotable member 90 and the front wall 22, the rear wall 23, the top wall 24 or the pair of sidewalls 21, even if the strength of the magnetic field around the ferromagnet 92A changes from the first strength to the second strength, the state of the light receiver 330C remains unchanged. Namely, the state of the light receiver 330C stored in the storage area I is the same state as the state of the light receiver 344C stored in the storage area J. However, when the magnetic field around the ferromagnet 92A changes from the second strength to the third strength, the pivotable member 90 moves and the state of the light receiver 330C changes. In other words, the state of the light receiver 330C stored in the storage area J is different from the state of the light receiver 330C

stored in the storage area K. Thus, the controller 400 determines that the ink cartridge 10 is normal in S59. In S60, the controller 400 stores, in the EEPROM of the storage unit 500, information indicating that the state of the light receiver 330C did not change before and after the magnetic field around the ferromagnet 92A changed from the first strength to the second strength and that the state of the light receiver 330C changed before and after the magnetic field around the ferromagnet 92A changed from the second strength to the third strength. The movement of the pivotable member 90 may be hampered by causes other than the surface tension of the bubbles. For example, the pivotable member 90 may be sandwiched between the pair of sidewalls 21 formed of a flexible film; the pivotable member 90 may be immovable because it comes off from the support portions 82; or the ink cartridge 10 may not have the pivotable member 90. In such cases, even when the magnetic field around the ferromagnet 92A changes from the second strength to the third strength, the state of the light receiver 330C remains unchanged. In other words, the state of the light receiver 330C stored in the storage area J is the same as the state of the light receiver 330C stored in the storage area K. Thus, the controller 400 determines that the ink cartridge 10 is abnormal in S61. In S62, the controller 400 stores information indicating that the ink cartridge 10 was abnormal in the EEPROM of the storage unit 500.

[0166] The ink ejecting systems of the above embodiments may be applied to not only a system for forming images on recording media by ink ejection but also a system for adhering liquid to an object by ejecting the liquid, for example, for forming wiring patterns on boards for printed wiring boards or manufacturing liquid crystal color filters.

[0167] While the invention has been described in connection with exemplary embodiments, it will be understood by those skilled in the art that other variations and modifications of the exemplary embodiments described above may be made. It is intended that the specification and the described examples are considered merely as exemplary of the invention.

Claims

1. A liquid ejecting system (1) comprising:

a liquid cartridge (10) comprising a liquid chamber (11) configured to store liquid, a pivotable member (90) positioned in the liquid chamber, and a contact portion (74), wherein the pivotable member comprises a portion (92) having a specific gravity which is less than a specific gravity of the liquid stored in the liquid chamber, such that the pivotable member is configured to pivot according to a position of a surface of the liquid in the liquid chamber, and the pivotable member comprises a ferromagnetic portion (92A),

wherein the contact portion is positioned to contact the pivotable member when the pivotable member moves in a first direction;
 a mounting portion (300) to which the liquid cartridge is removably mounted;
 a mount detector (330, 335) configured to detect that the liquid cartridge is mounted to the mounting portion;
 an optical detector (330) positioned at the mounting portion, the optical detector comprising:

a light emitter (330B) configured to emit light in a direction crossing a path along which a portion of the pivotable member of the liquid cartridge mounted to the mounting portion moves relative to the liquid chamber, and
 a light receiver (330C) configured to assume two predetermined states according to a position of the portion of the pivotable member in the path;

a magnetic field generator (340, 341, 600) positioned at the mounting portion, and configured to generate magnetic field such that, when the liquid cartridge is mounted to the mounting portion, the ferromagnetic portion receives a force from the magnetic field and the force causes the pivotable member to move in a second direction opposite to the first direction;
 a magnetic field controller (400, 342, 542, 602, 604, 606) configured to control the magnetic field generator, when the mount detector detects that the liquid cartridge is mounted to the mounting portion, such that a strength of the magnetic field around the ferromagnetic portion changes for the force which the ferromagnetic portion receives from the magnetic field to change; and
 a state determiner (400) configured to determine whether the state of the light receiver changed before and after a change in the strength of the magnetic field around the ferromagnetic portion, and determine that:

the liquid cartridge is normal when the state determiner determines that the state of the light receiver changed before and after the change in the strength of the magnetic field around the ferromagnetic portion; and
 the liquid cartridge is abnormal when the state determiner determines that the state of the light receiver did not change before and after the change in the strength of the magnetic field around the ferromagnetic portion.

2. The liquid ejecting system of claim 1, wherein the magnetic field controller controls the magnetic field

generator such that the strength of the magnetic field around the ferromagnetic portion changes between a first strength, a second strength which is stronger than the first strength, and a third strength which is stronger than the second strength,
 wherein the state determiner is configured to determine whether the state of the light receiver changed before and after the change in the strength of the magnetic field around the ferromagnetic portion from the first strength to the second strength, and determine that the liquid cartridge is normal when the state determiner determines that the state of the light receiver changed before and after the change in the strength of the magnetic field around the ferromagnetic portion from the first strength to the second strength,
 wherein the state determiner is configured to determine whether the state of the light receiver changed before and after the change in the strength of the magnetic field around the ferromagnetic portion from the second strength to the third strength, and determine that:

the liquid cartridge is normal when the state of the light receiver changed before and after the change in the strength of the magnetic field around the ferromagnetic portion from the second strength to the third strength; and
 the liquid cartridge is abnormal when the state of the light receiver did not change before and after the change in the strength of the magnetic field around the ferromagnetic portion from the second strength to the third strength.

3. The liquid ejecting system of claim 2, further comprising a storage unit (500, 408), wherein when the state determiner determines that the state of the light receiver did not change before and after the change in the strength of the magnetic field around the ferromagnetic portion from the first strength to the second strength, and that the state of the light receiver changed before and after the change in the strength of the magnetic field around the ferromagnetic portion from the second strength to the third strength, the state determiner stores a result of the determination in the storage unit accordingly.
4. The liquid ejecting system of claim 3, wherein when the state determiner determines that the liquid cartridge is abnormal, the state determiner stores a result of the determination in the storage unit accordingly.
5. The liquid ejecting system of claim 3 or 4, wherein the storage unit is positioned at the liquid cartridge, such that the storage unit is removable from the mounting portion together with the liquid cartridge.

6. The liquid ejecting system of one of claims 1 to 6, wherein the portion having the specific gravity which is less than the specific gravity of the liquid stored in the liquid chamber comprises the ferromagnetic portion, and
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wherein, when the liquid cartridge is mounted to the mounting portion, the magnetic field generator is positioned below the portion having the specific gravity which is less than the specific gravity of the liquid stored in the liquid chamber.
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7. The liquid ejecting system of one of claims 1 to 6, wherein the magnetic field generator comprises a solenoid (340), and
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wherein the magnetic field controller is configured to control the magnetic field generator by changing a strength of electric current flowing through the solenoid, such that the strength of the magnetic field around the ferromagnetic portion changes.
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8. The liquid ejecting system of one of claims 1 to 6, wherein the magnetic field generator comprises a permanent magnet (600), and
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wherein the magnetic field controller is configured to control the magnetic field generator by changing a position of the permanent magnet relative to the ferromagnetic portion, such that the strength of the magnetic field around the ferromagnetic portion changes.
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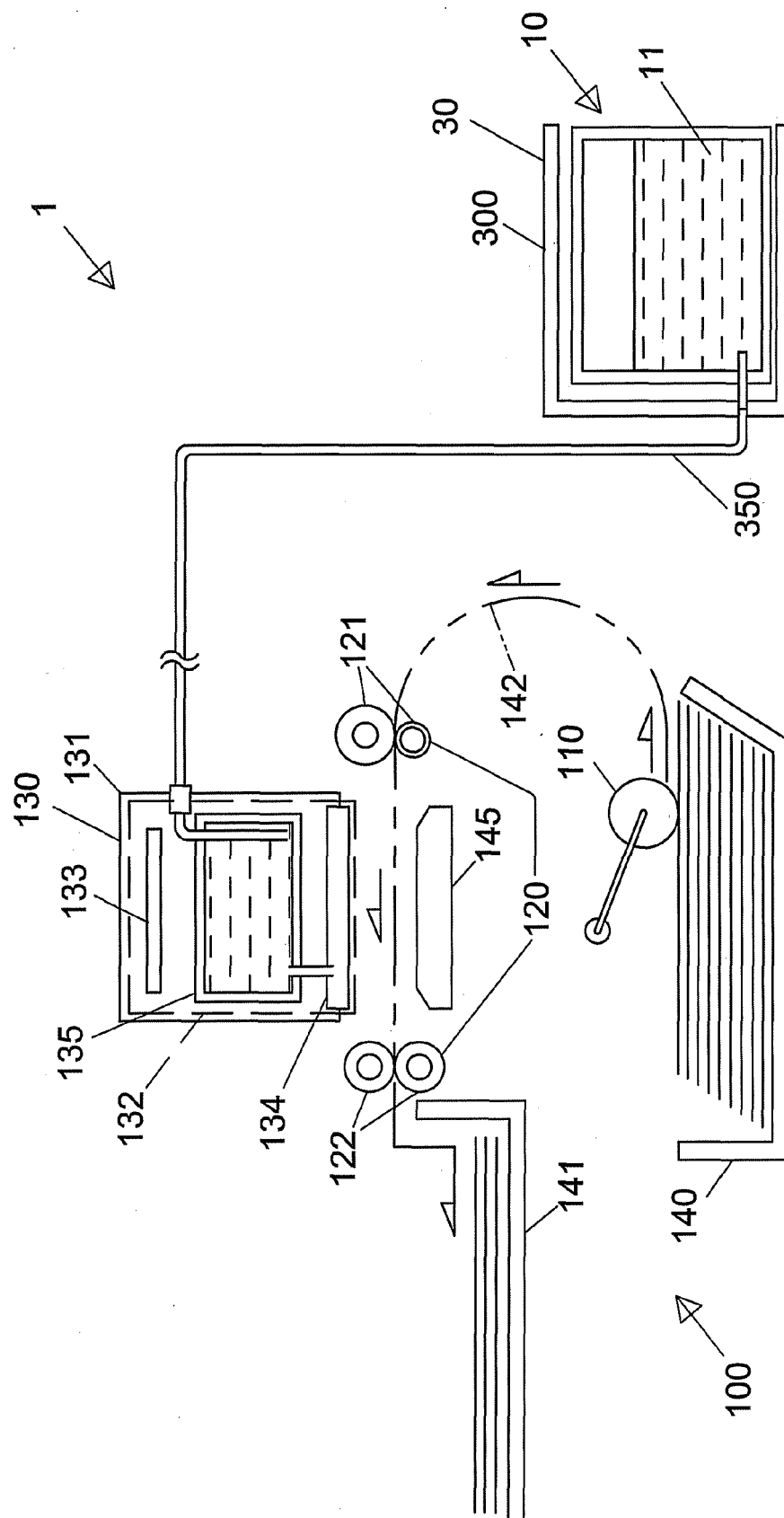


Fig. 1

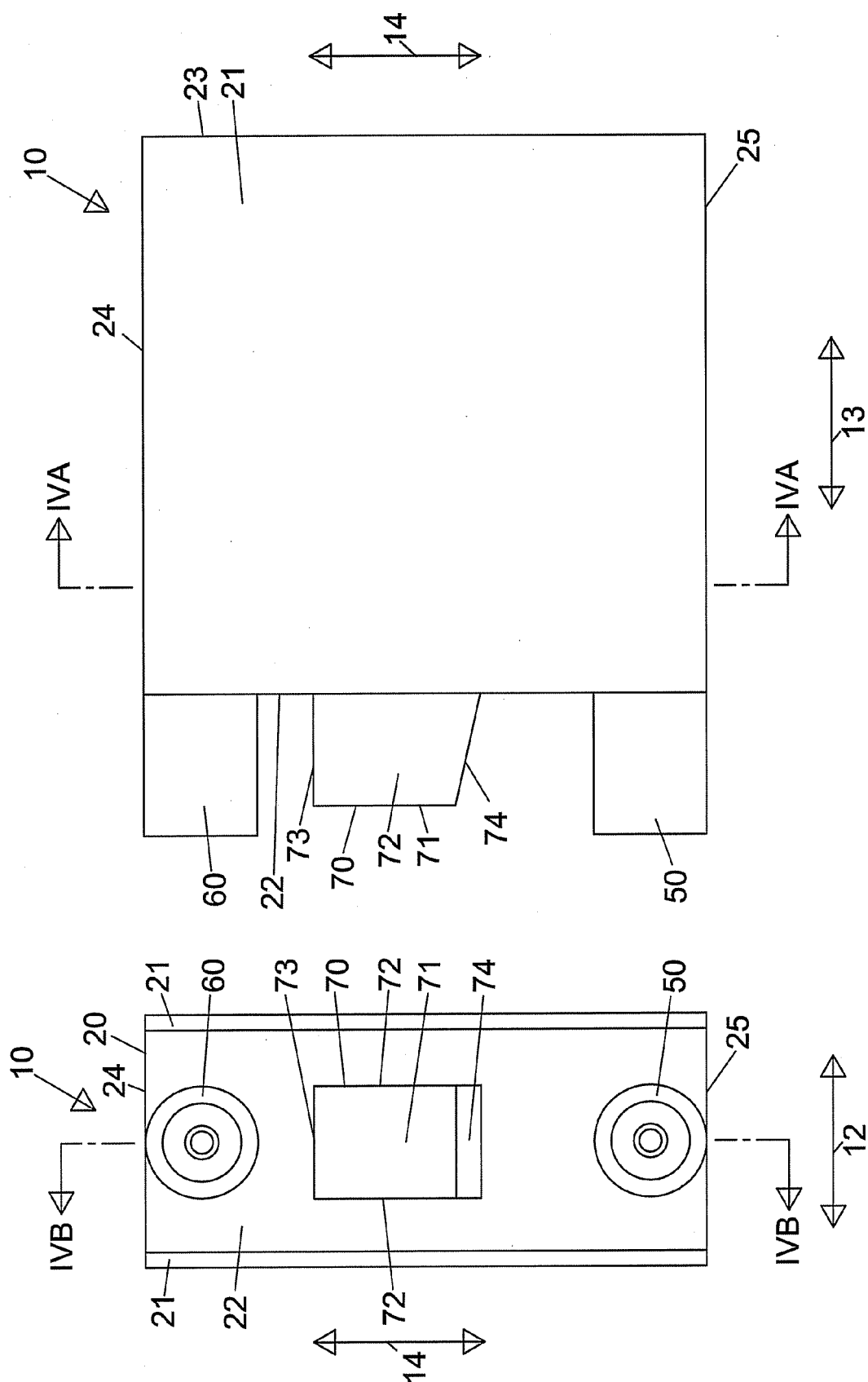


Fig. 2(B)

Fig. 2(A)

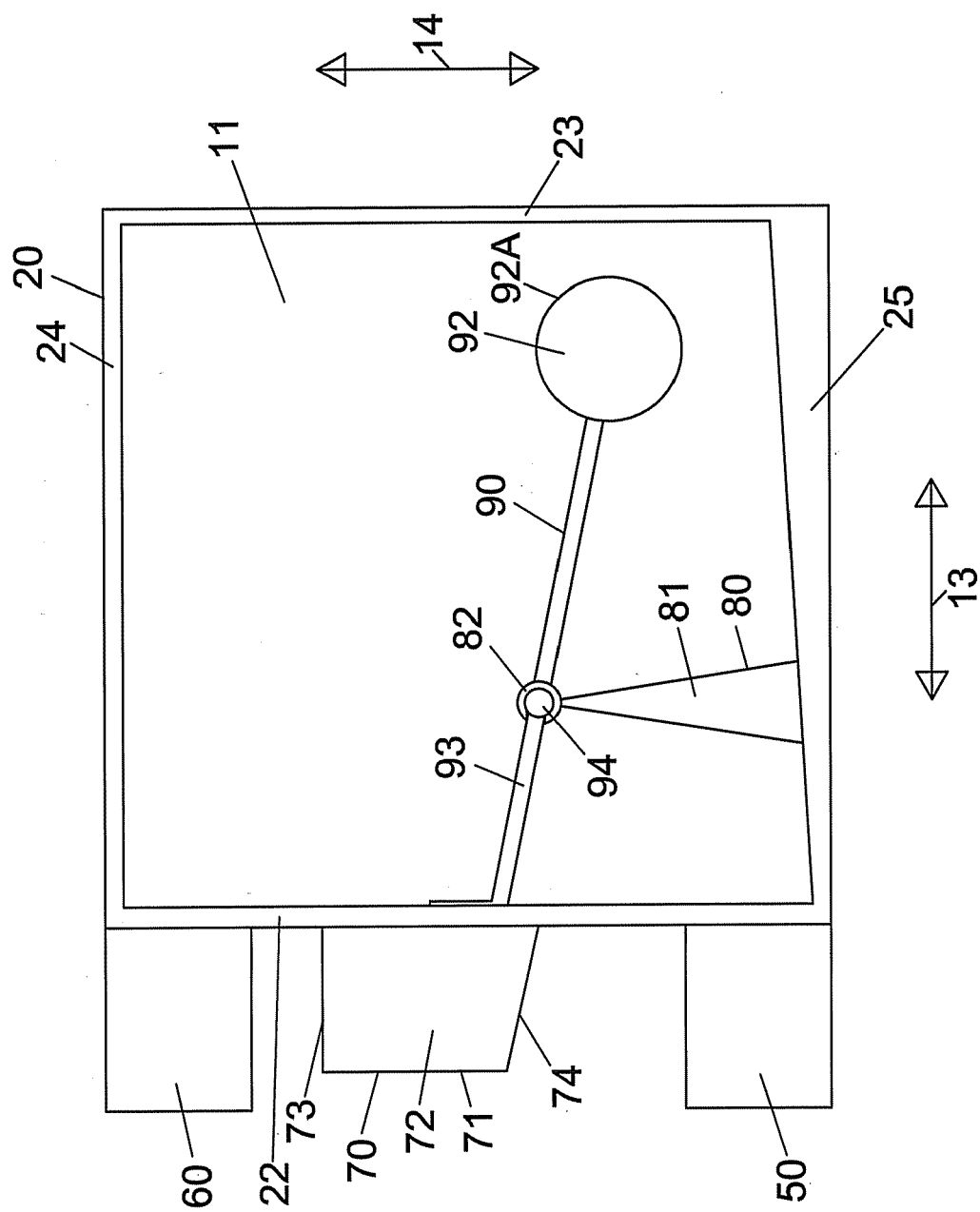


Fig. 3

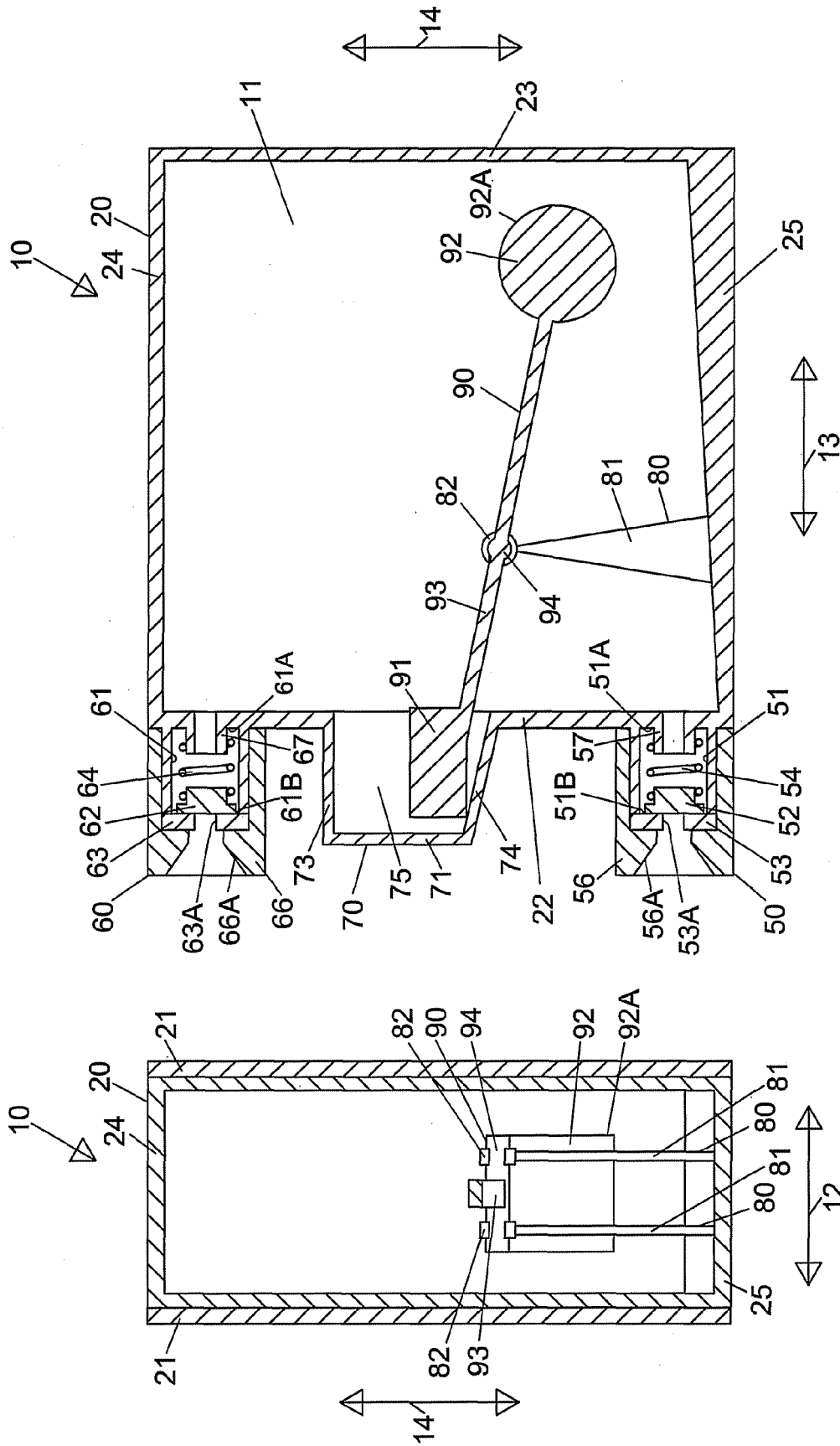


Fig. 4(B)

Fig. 4(A)

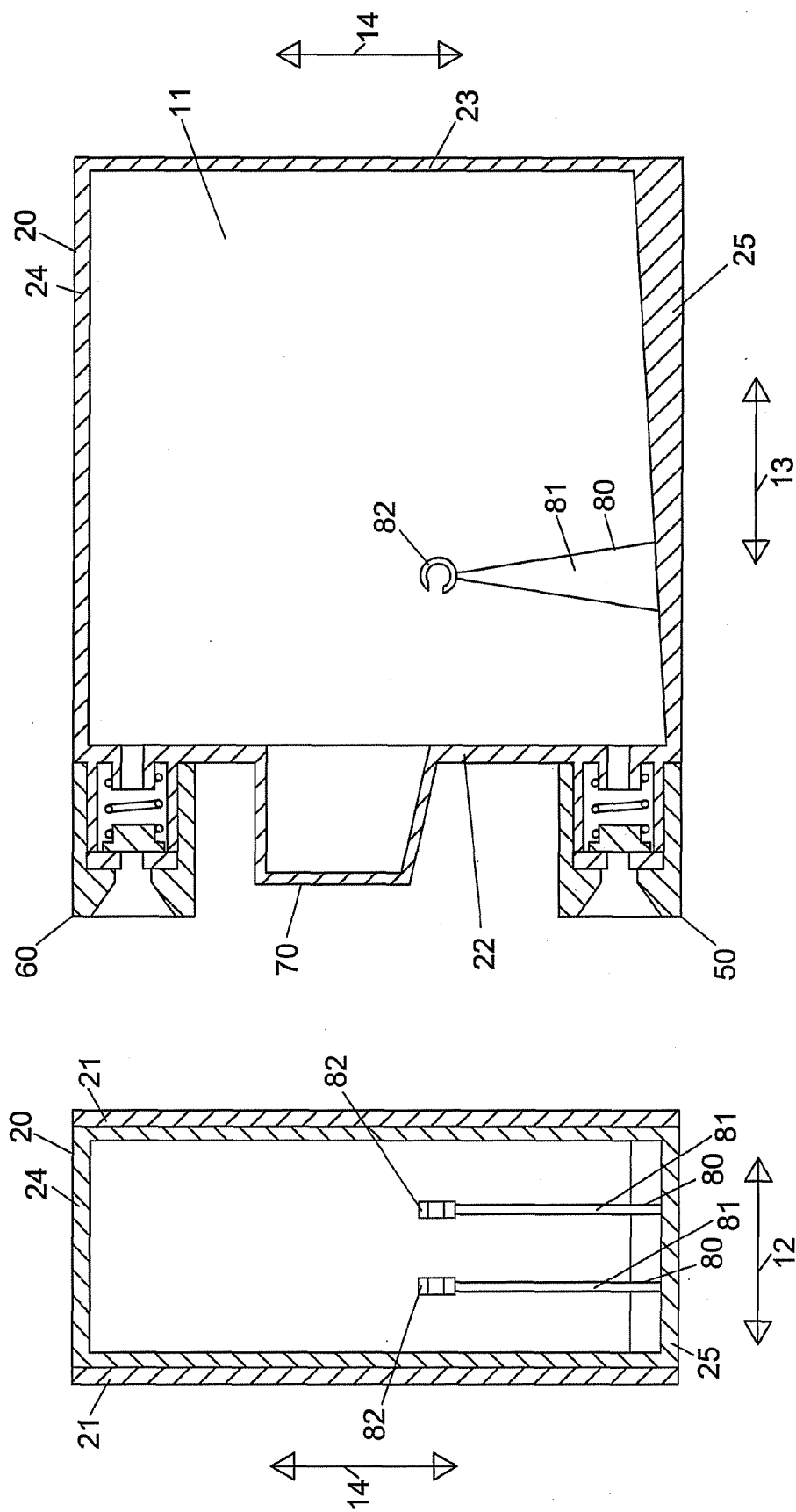


Fig. 5(B)

Fig. 5(A)

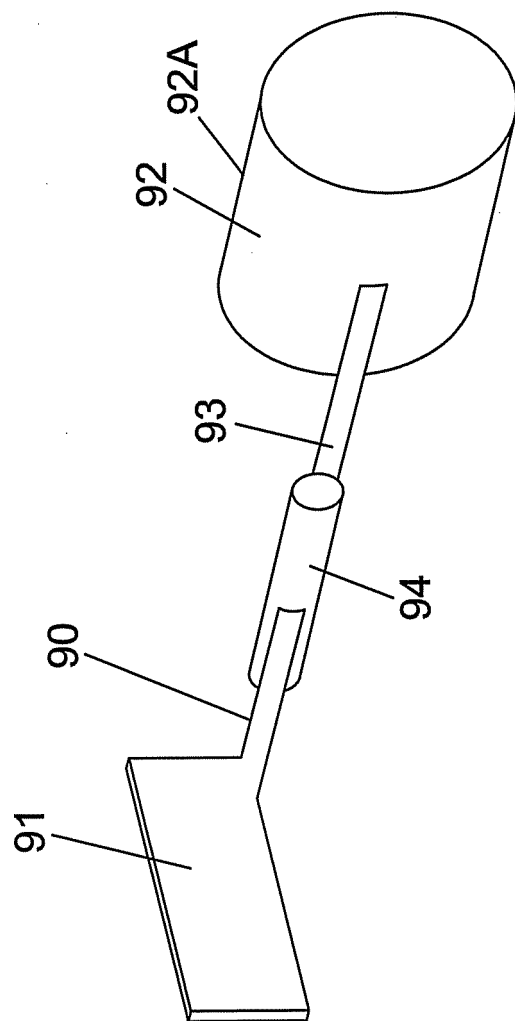


Fig. 6

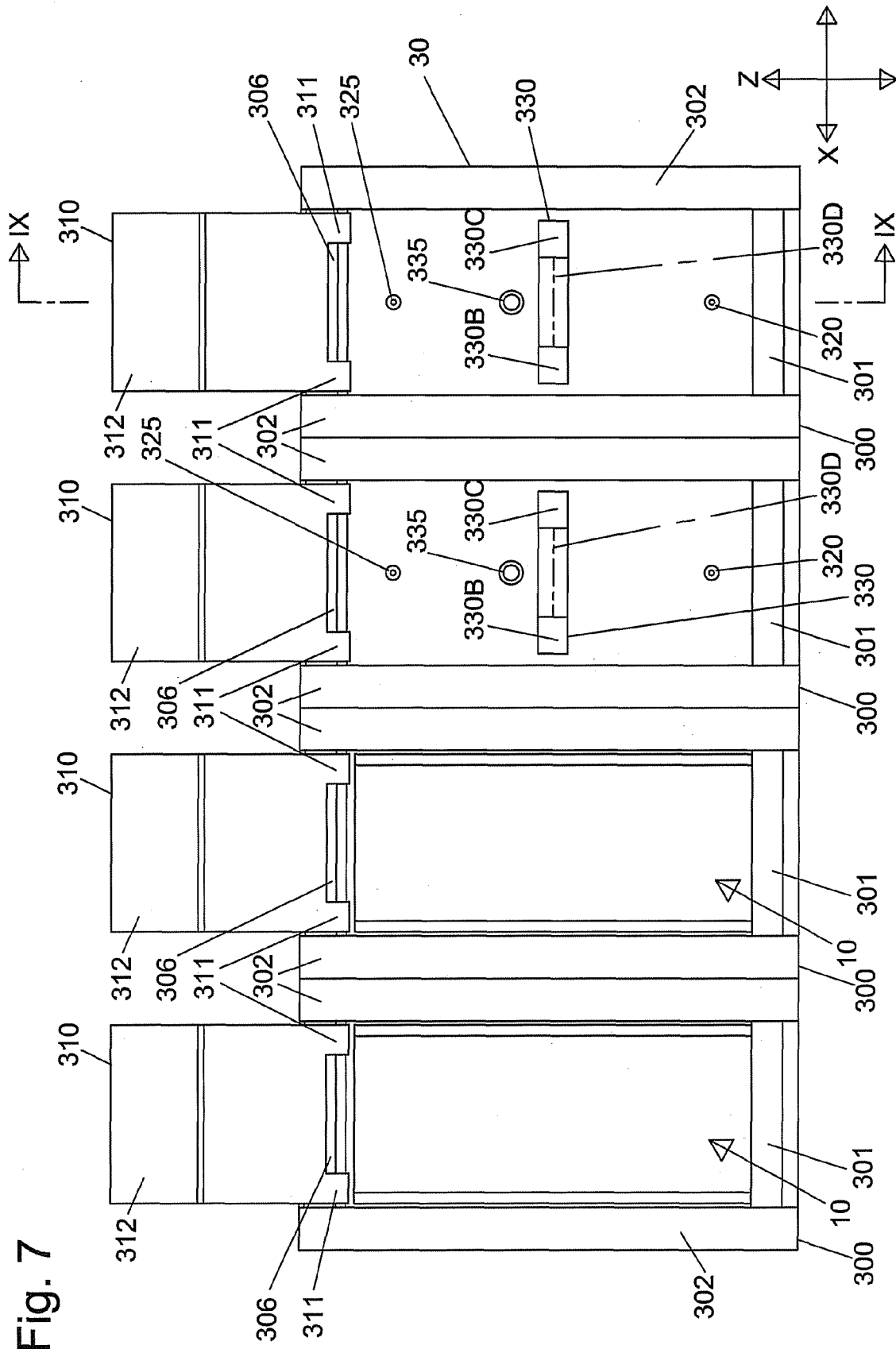
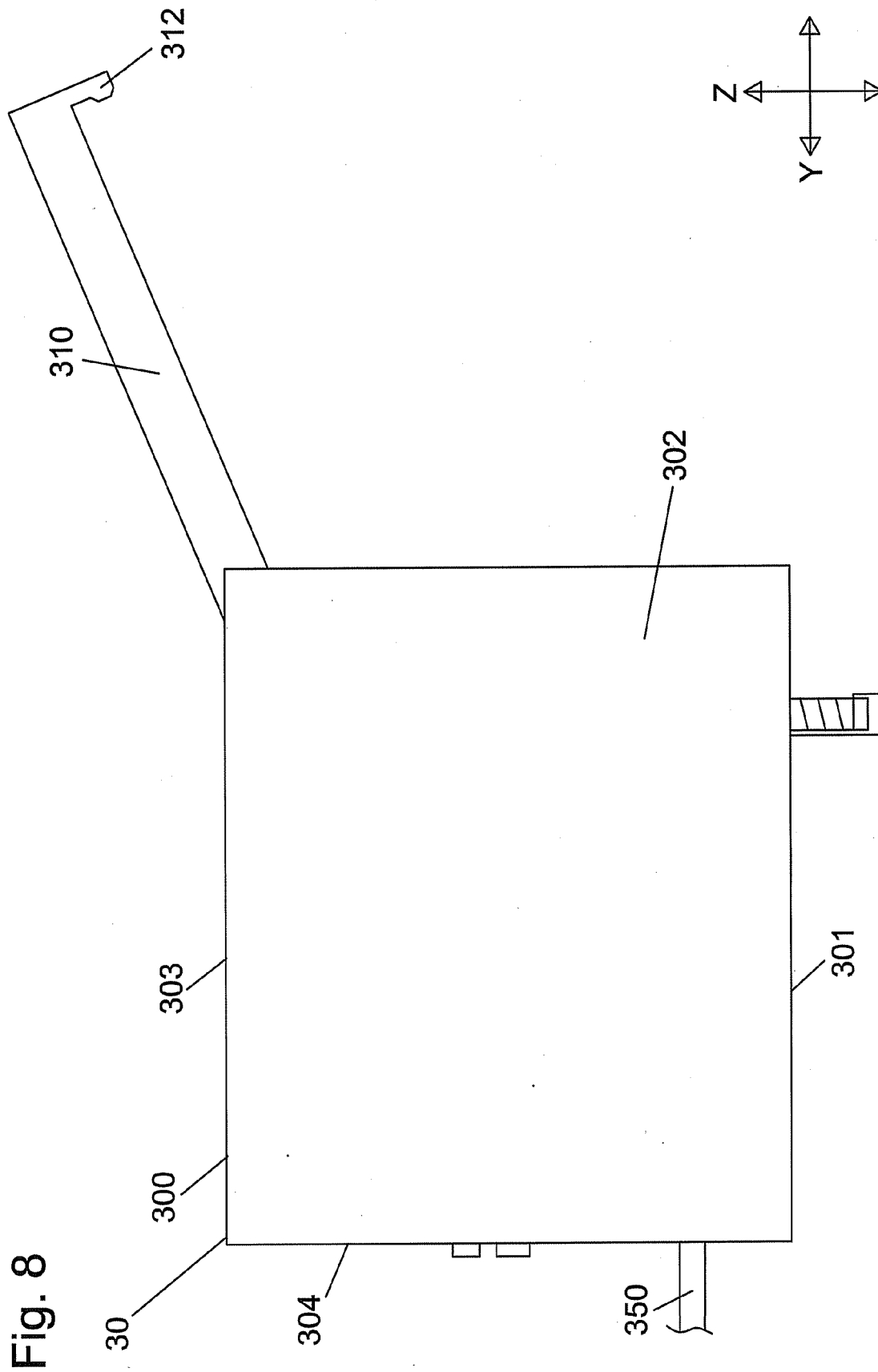
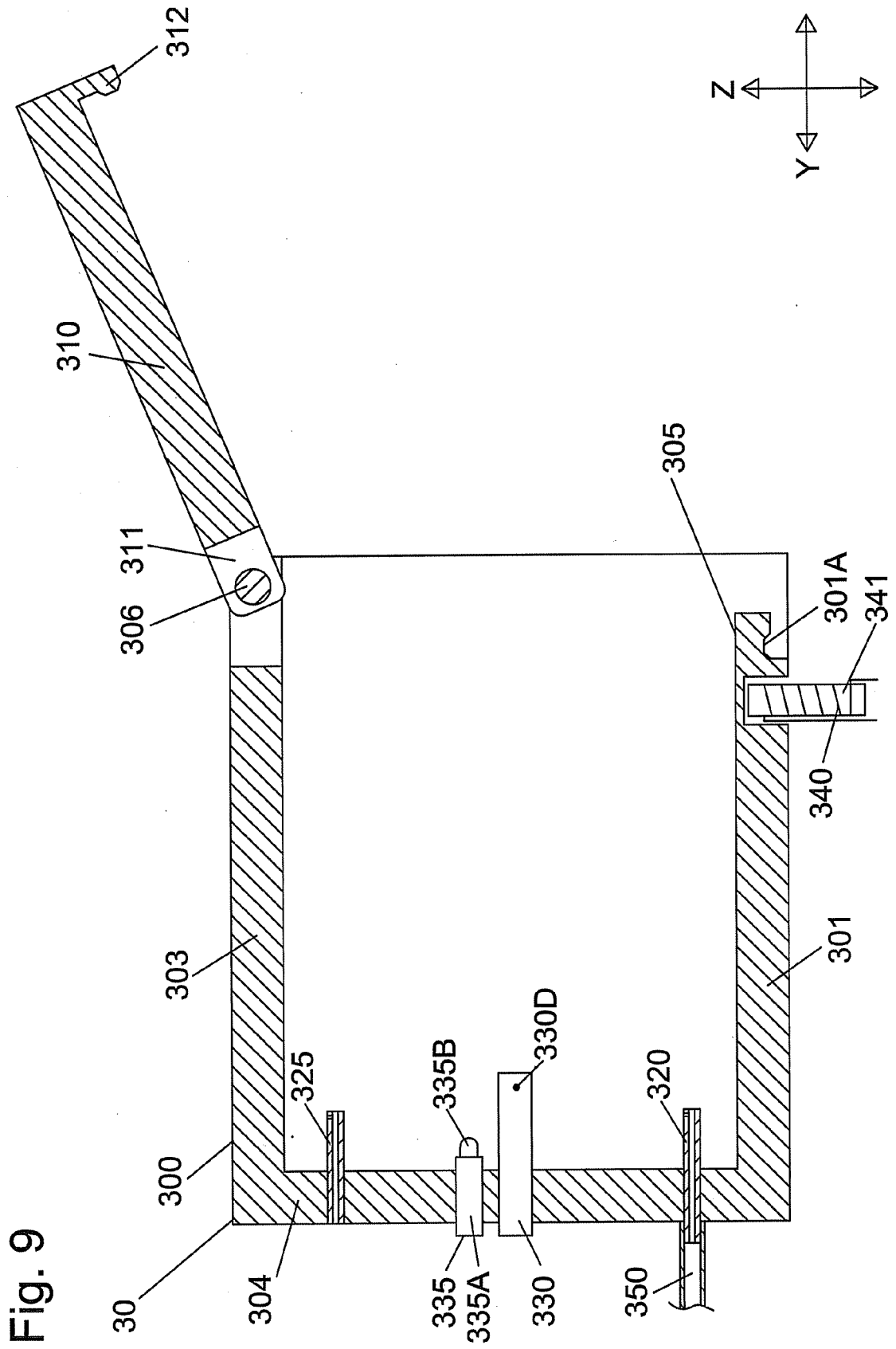


Fig. 7





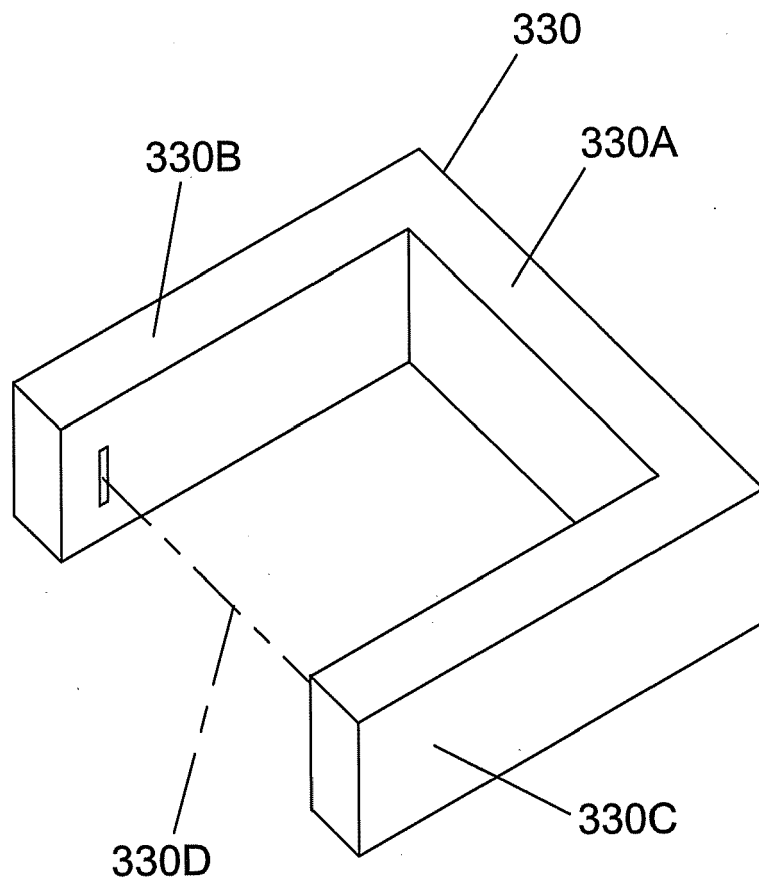


Fig. 10

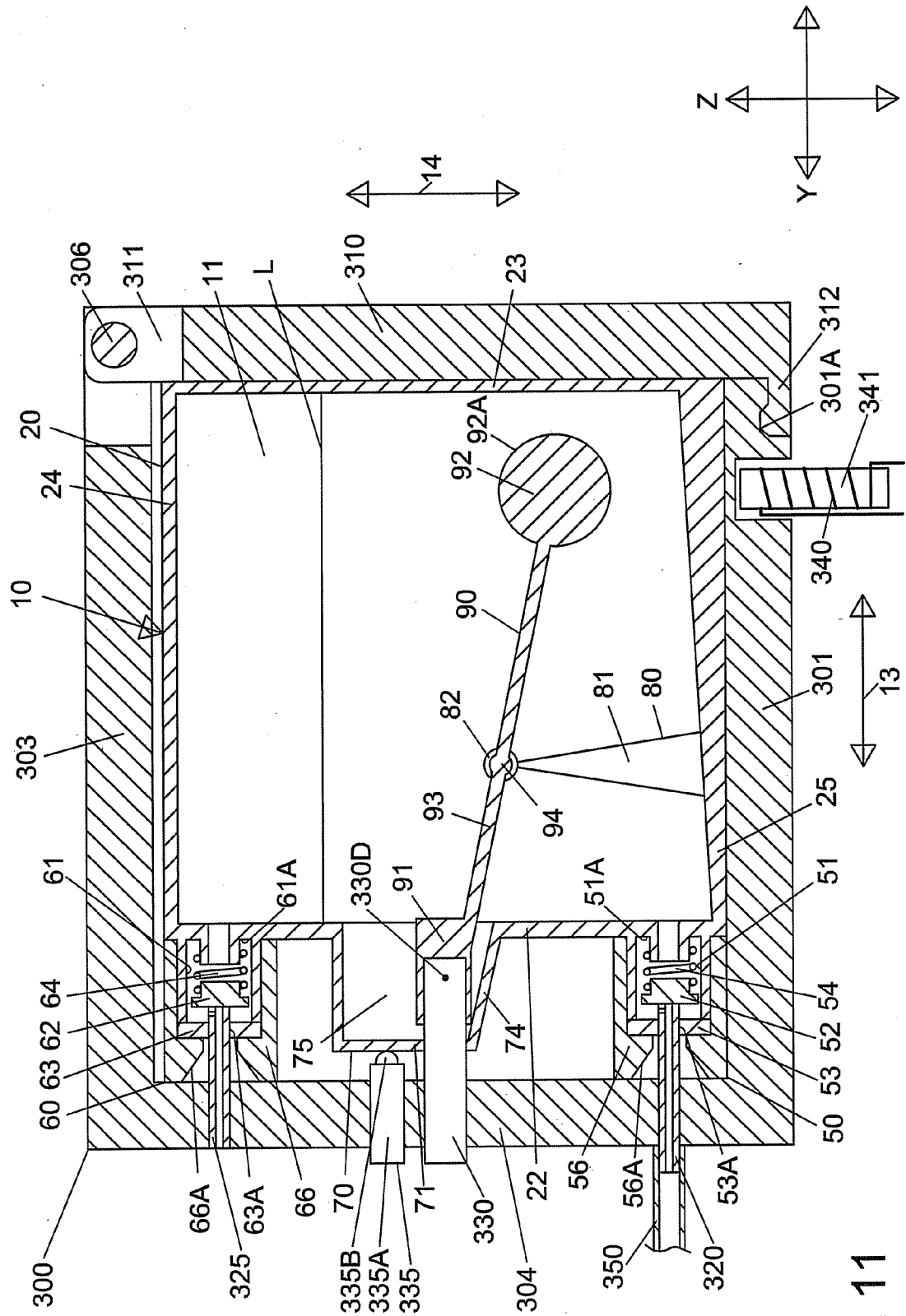


Fig. 11

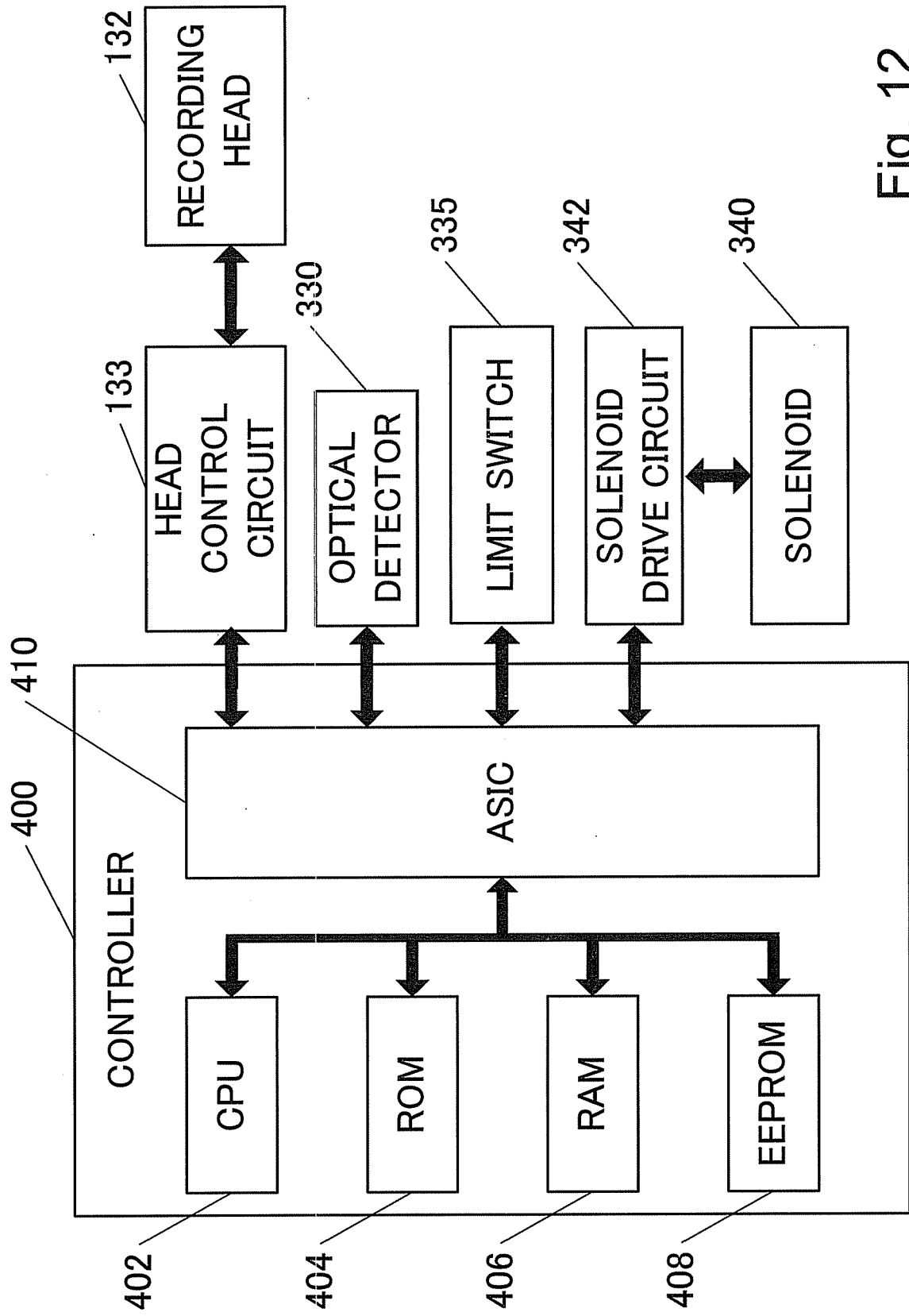


Fig. 12

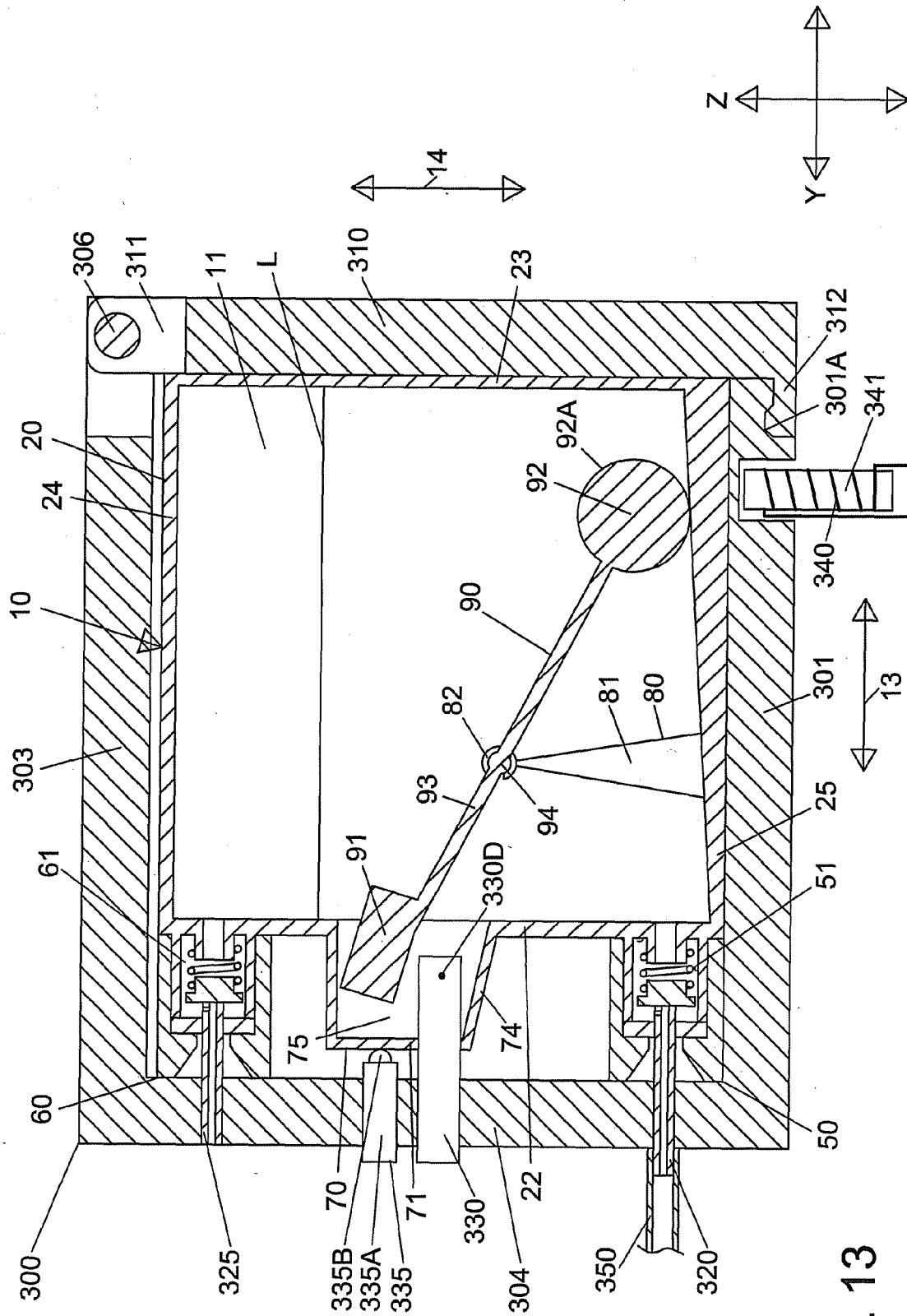


Fig. 13

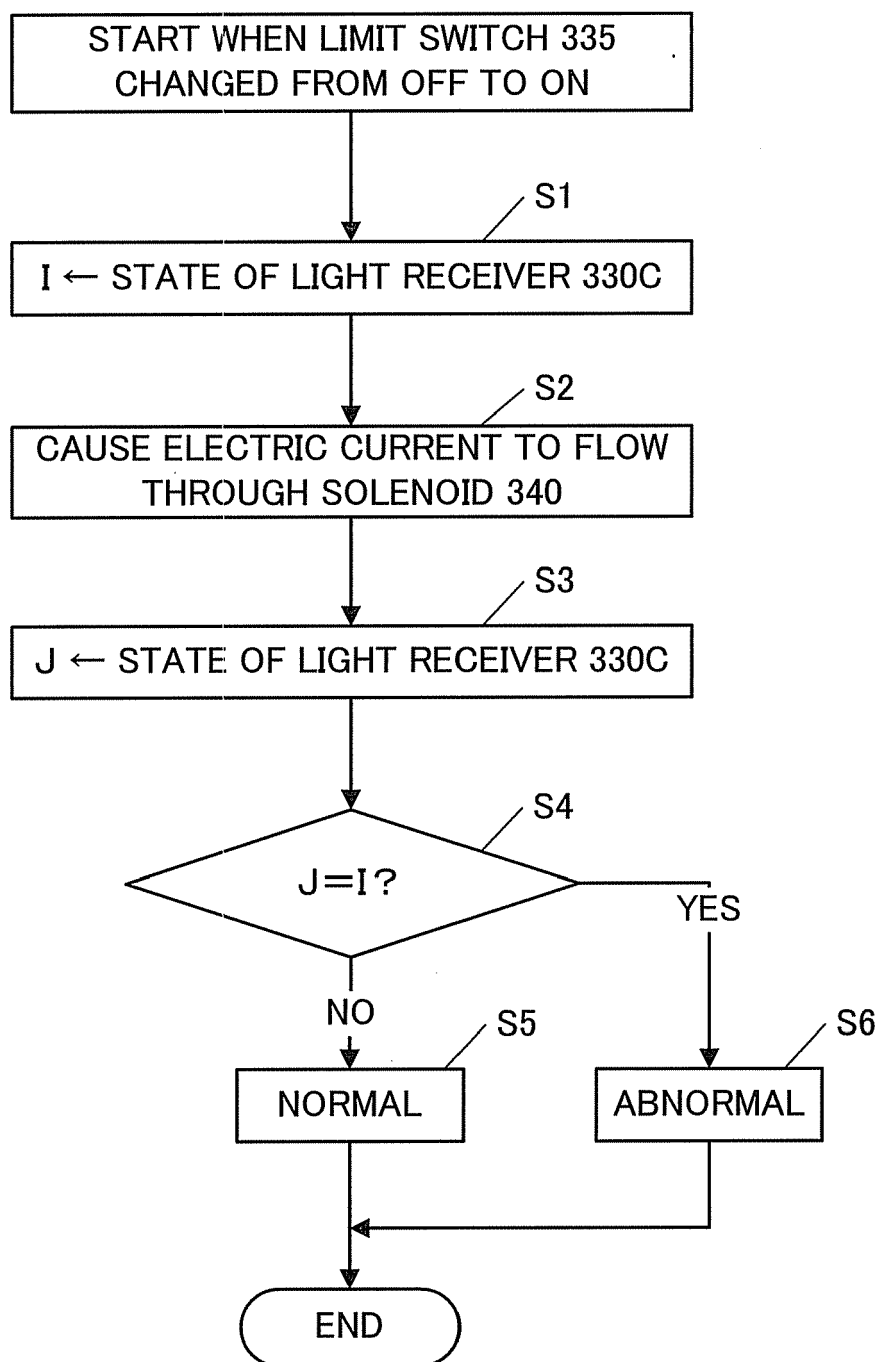


Fig. 14

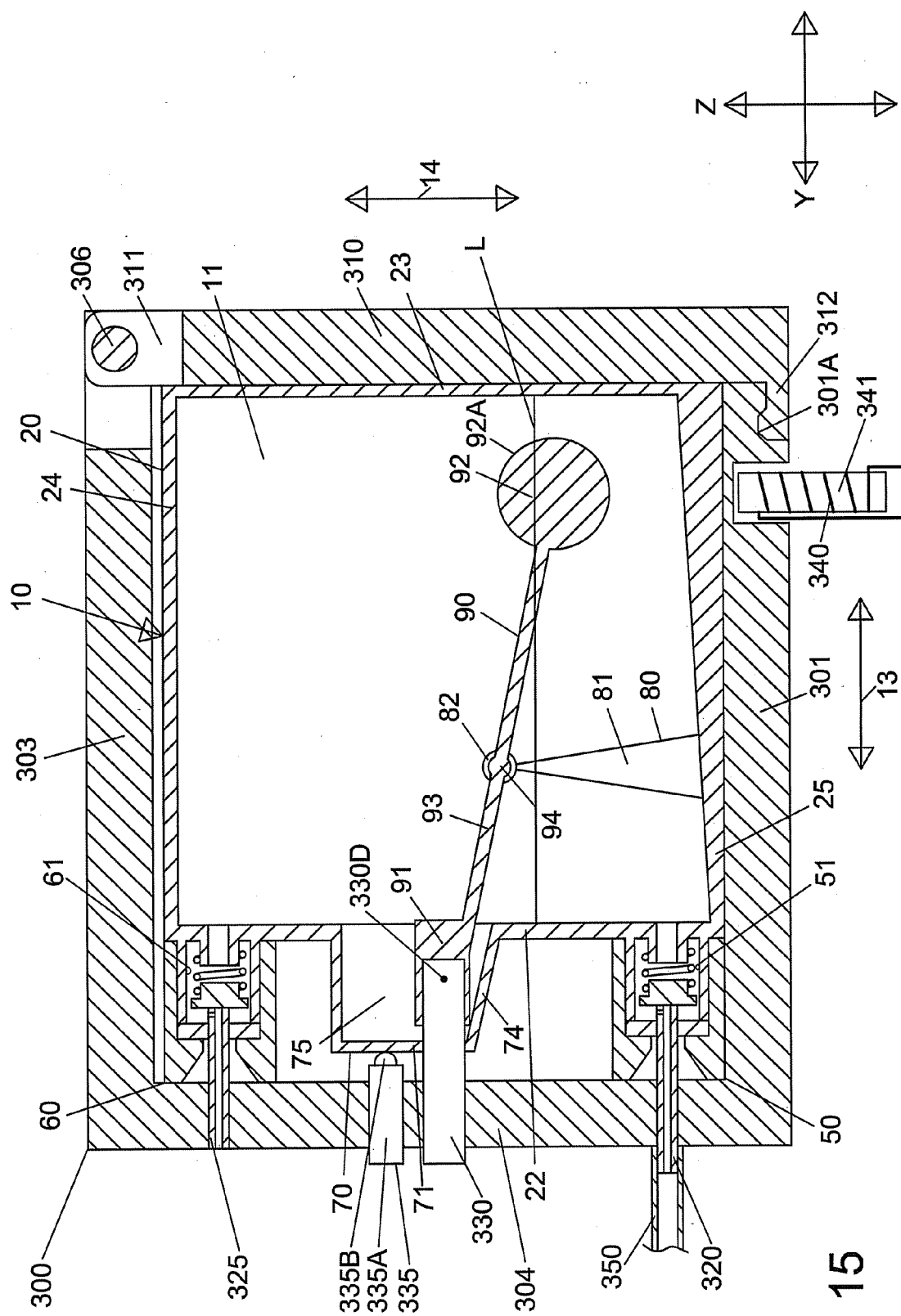


Fig. 15

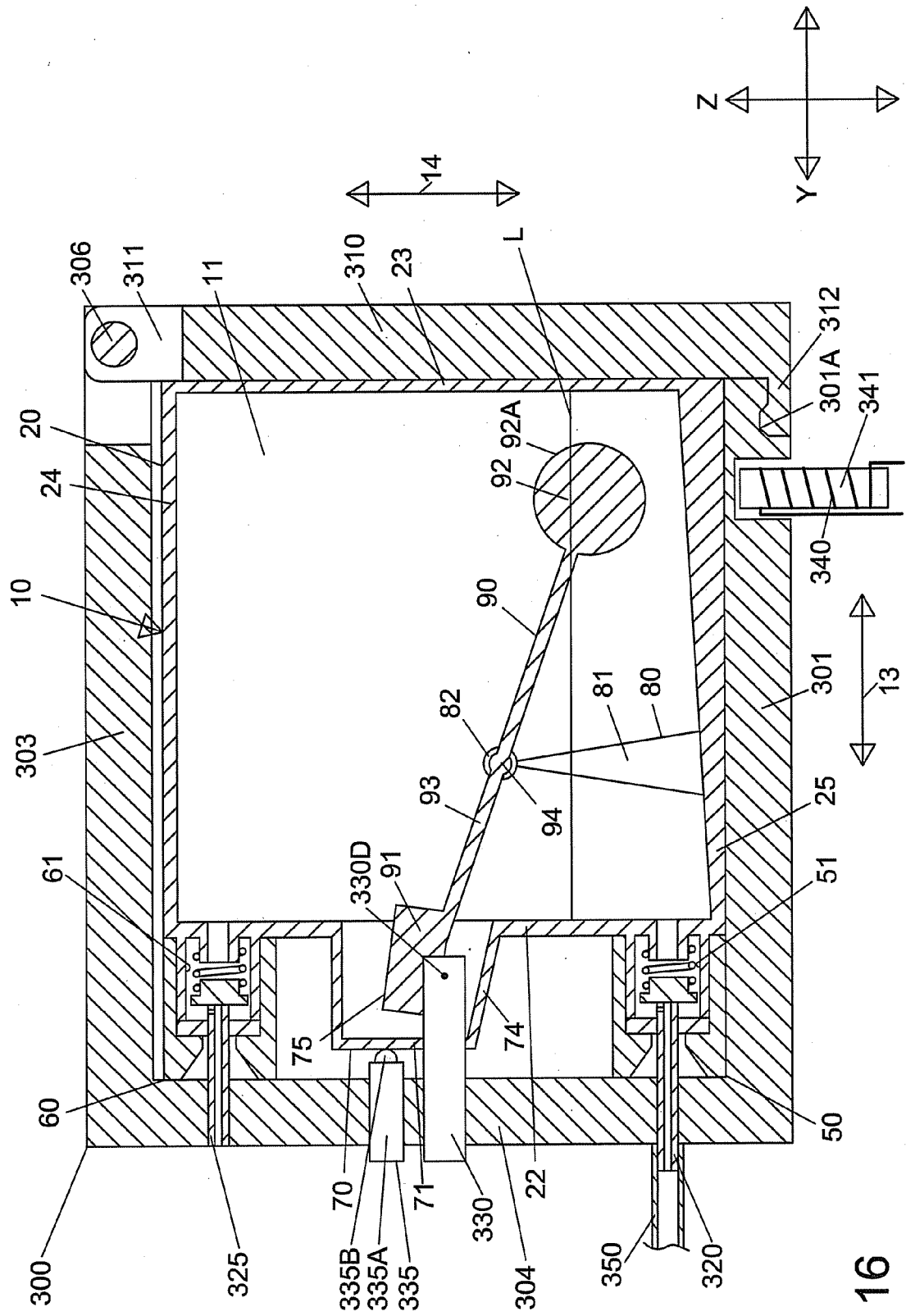


Fig. 16

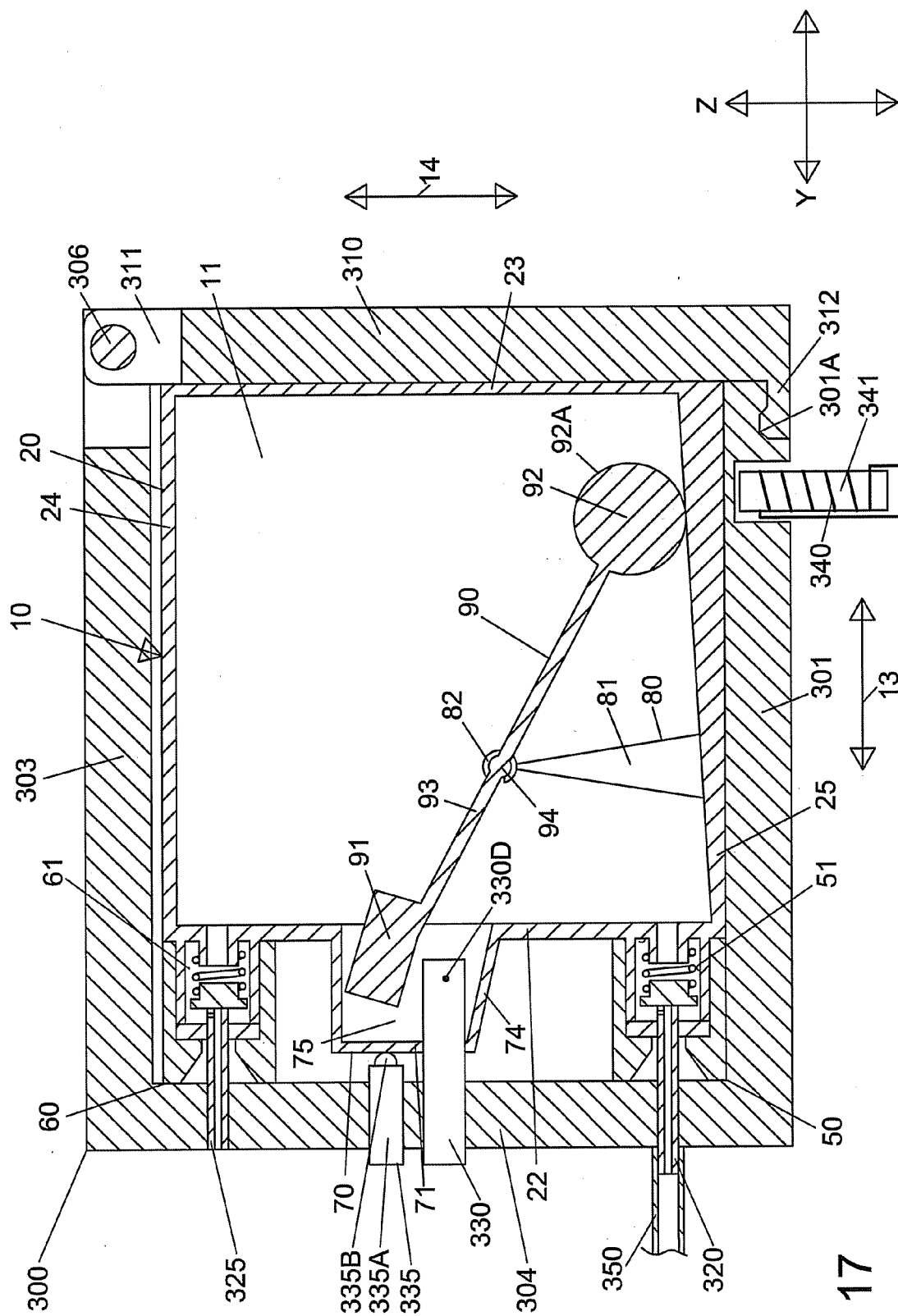


Fig. 17

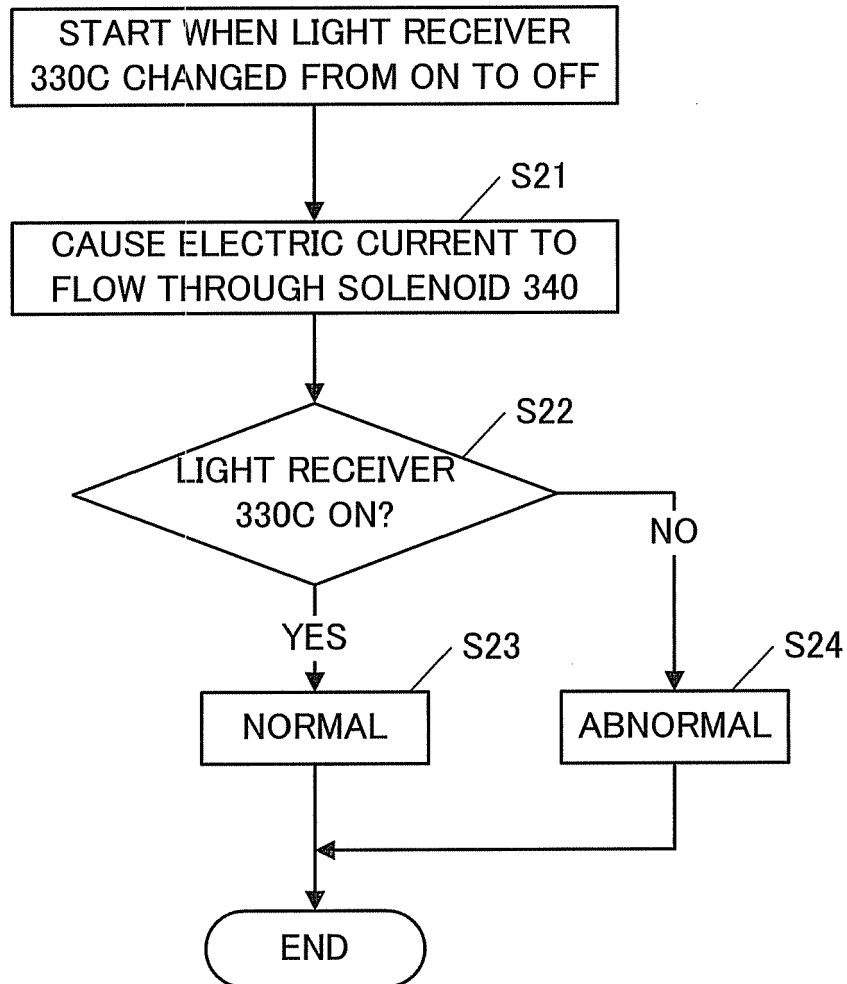


Fig. 18

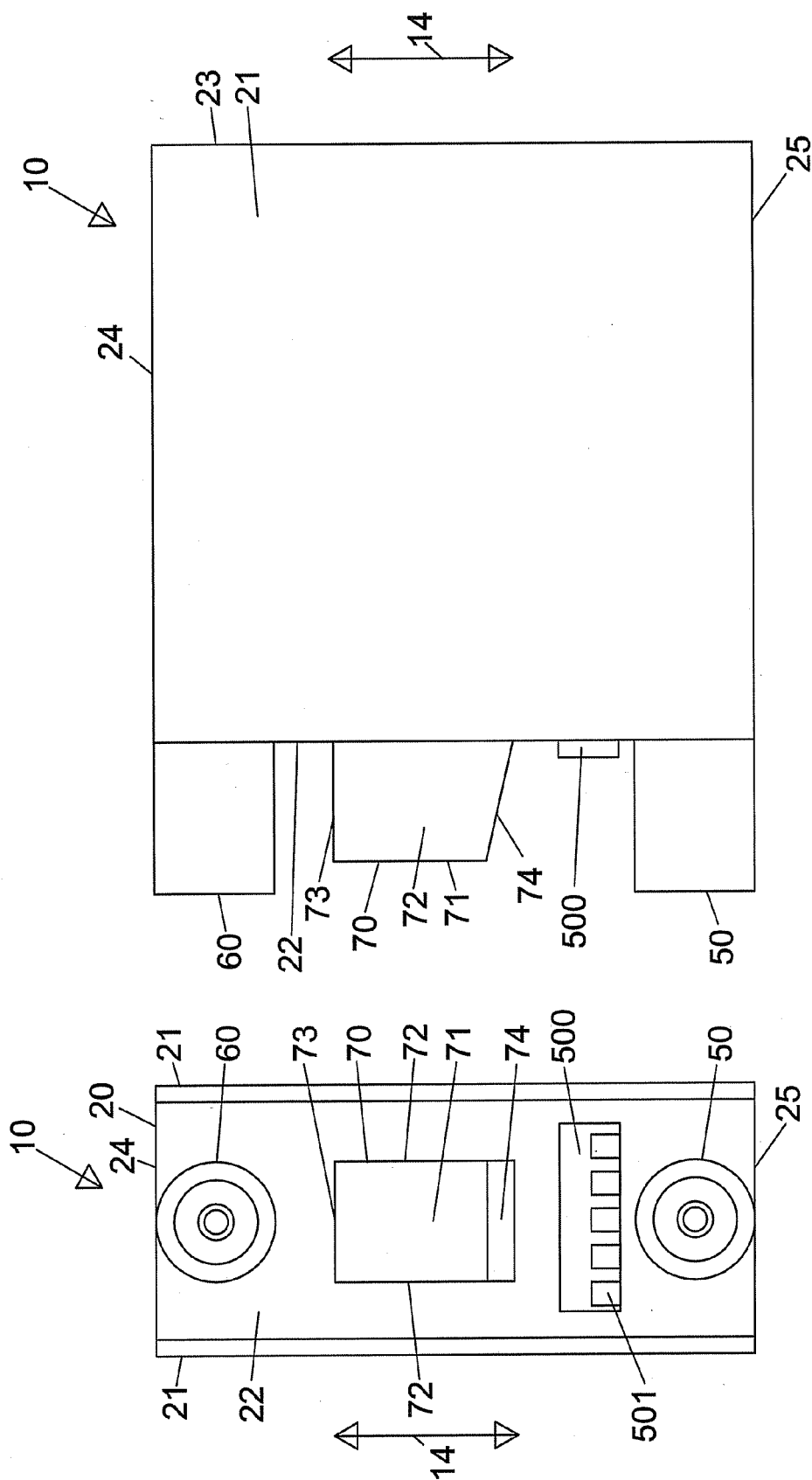
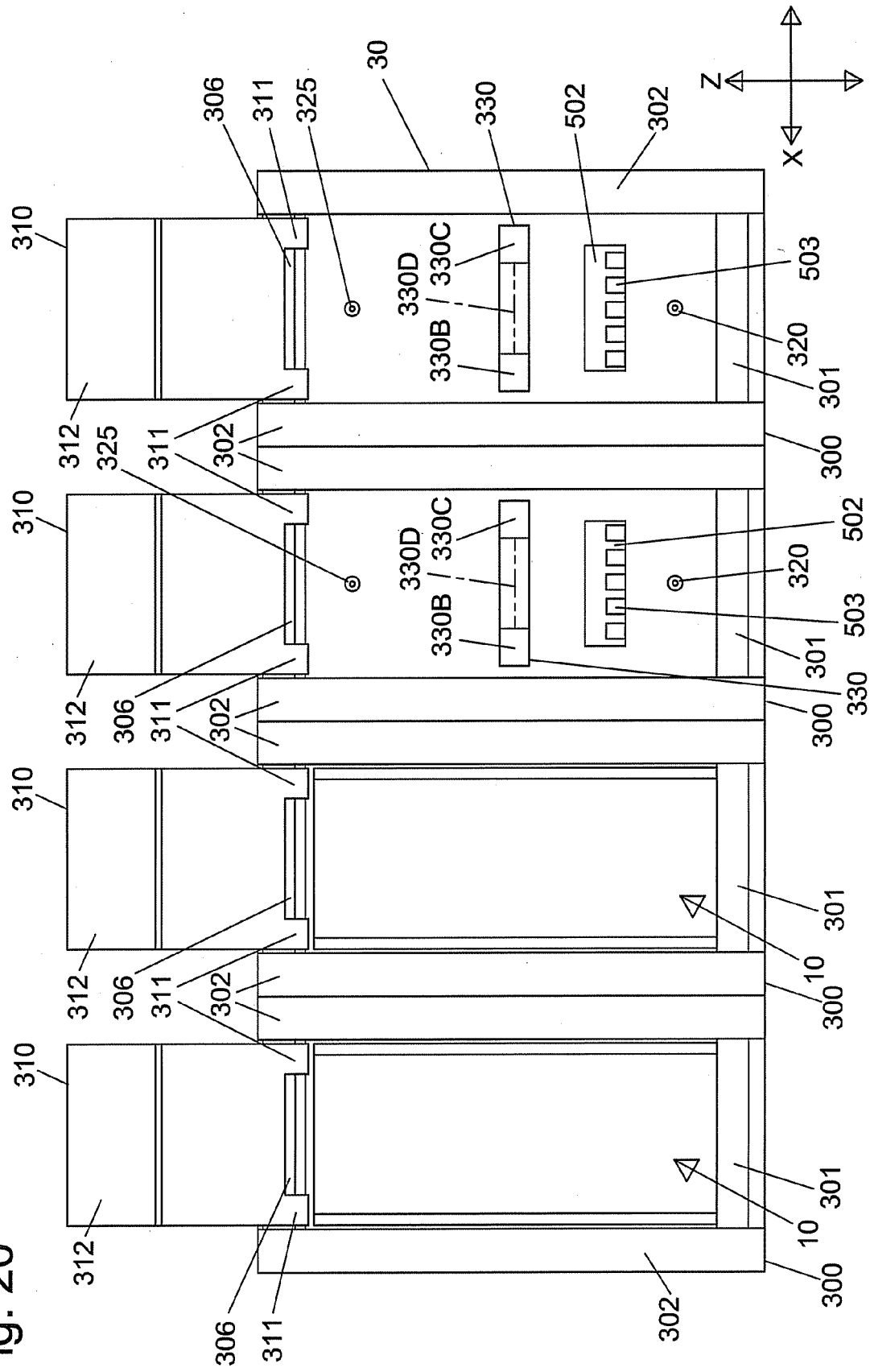


Fig. 19(B)

Fig. 19(A)

Fig. 20



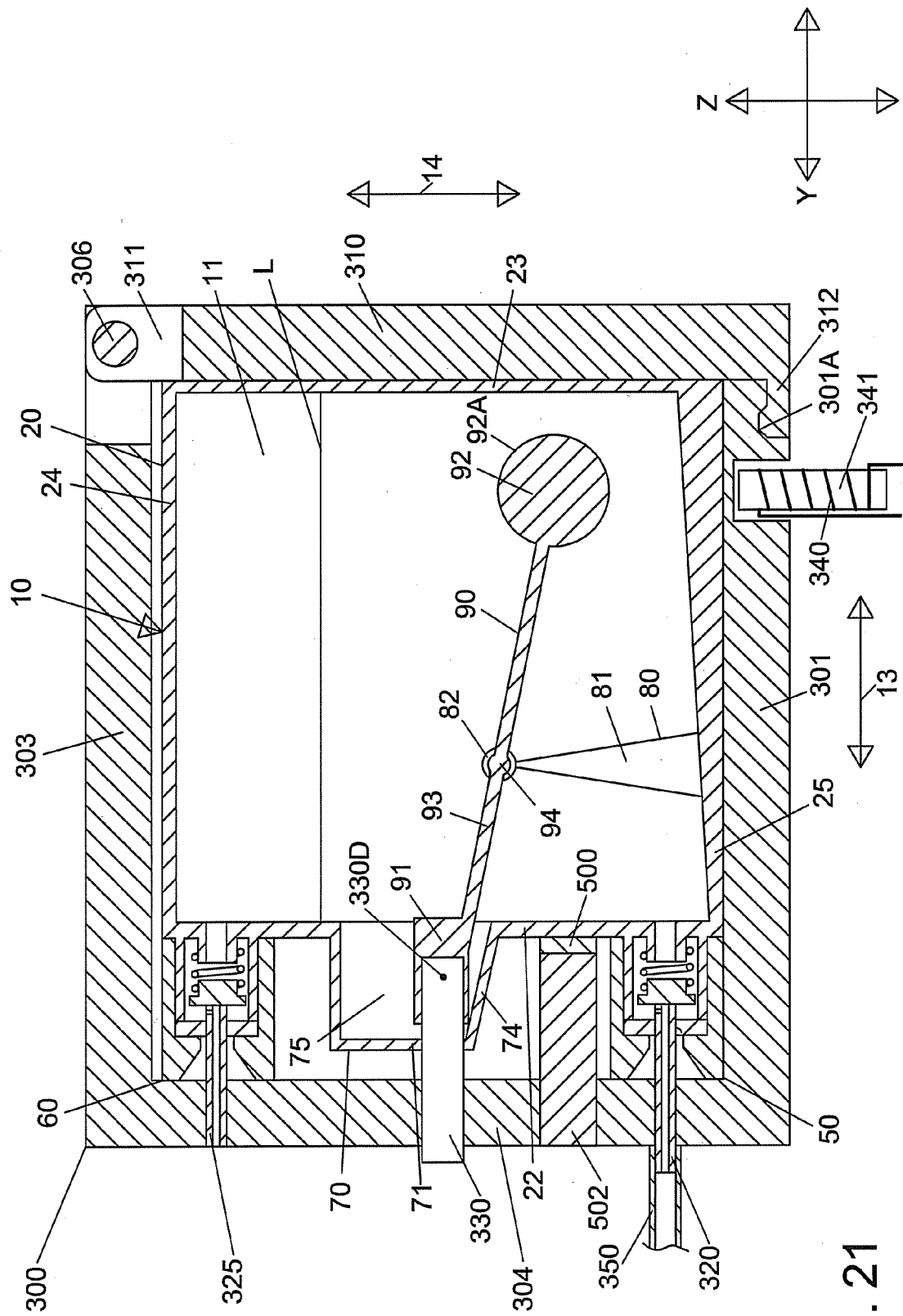


Fig. 21

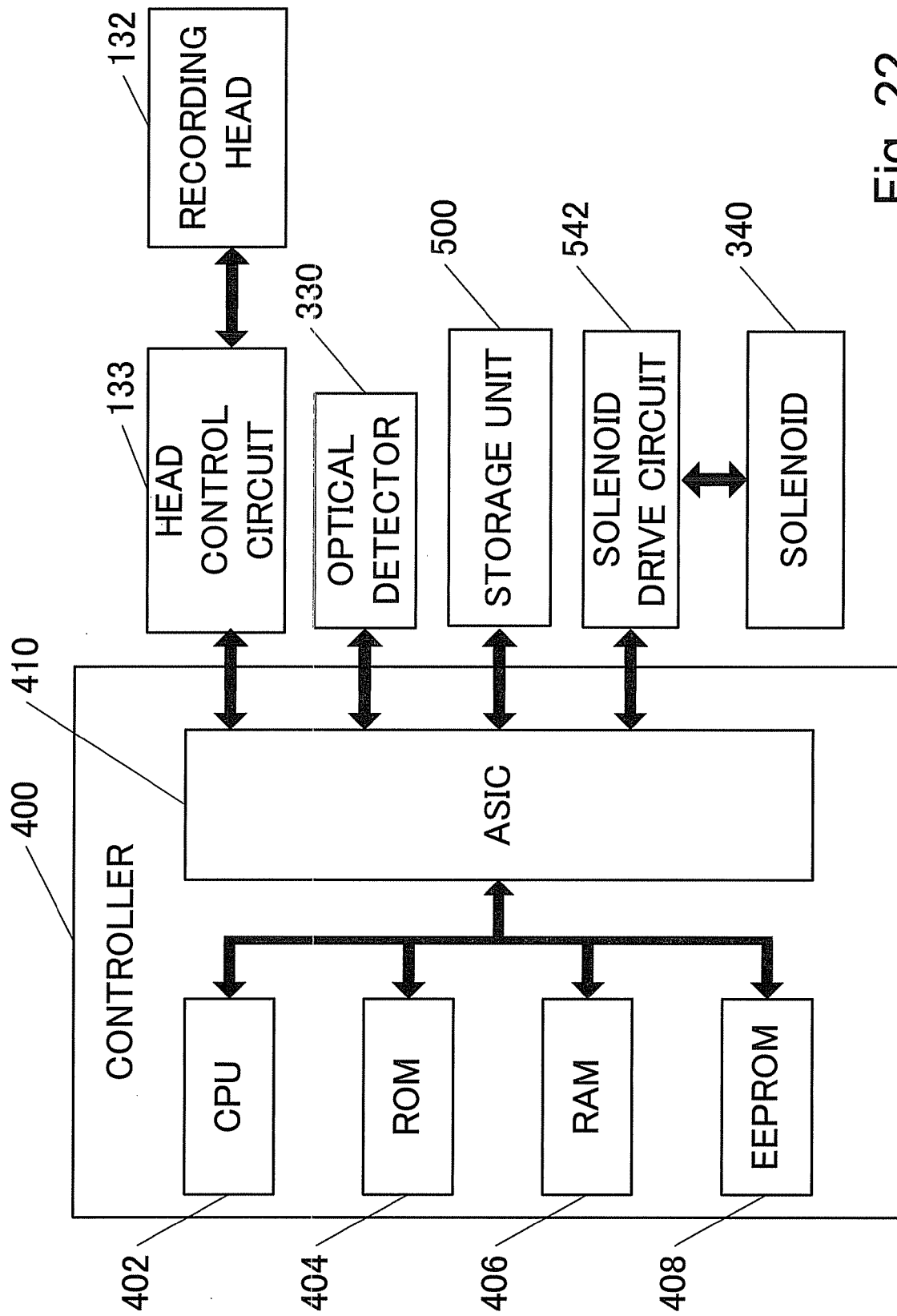
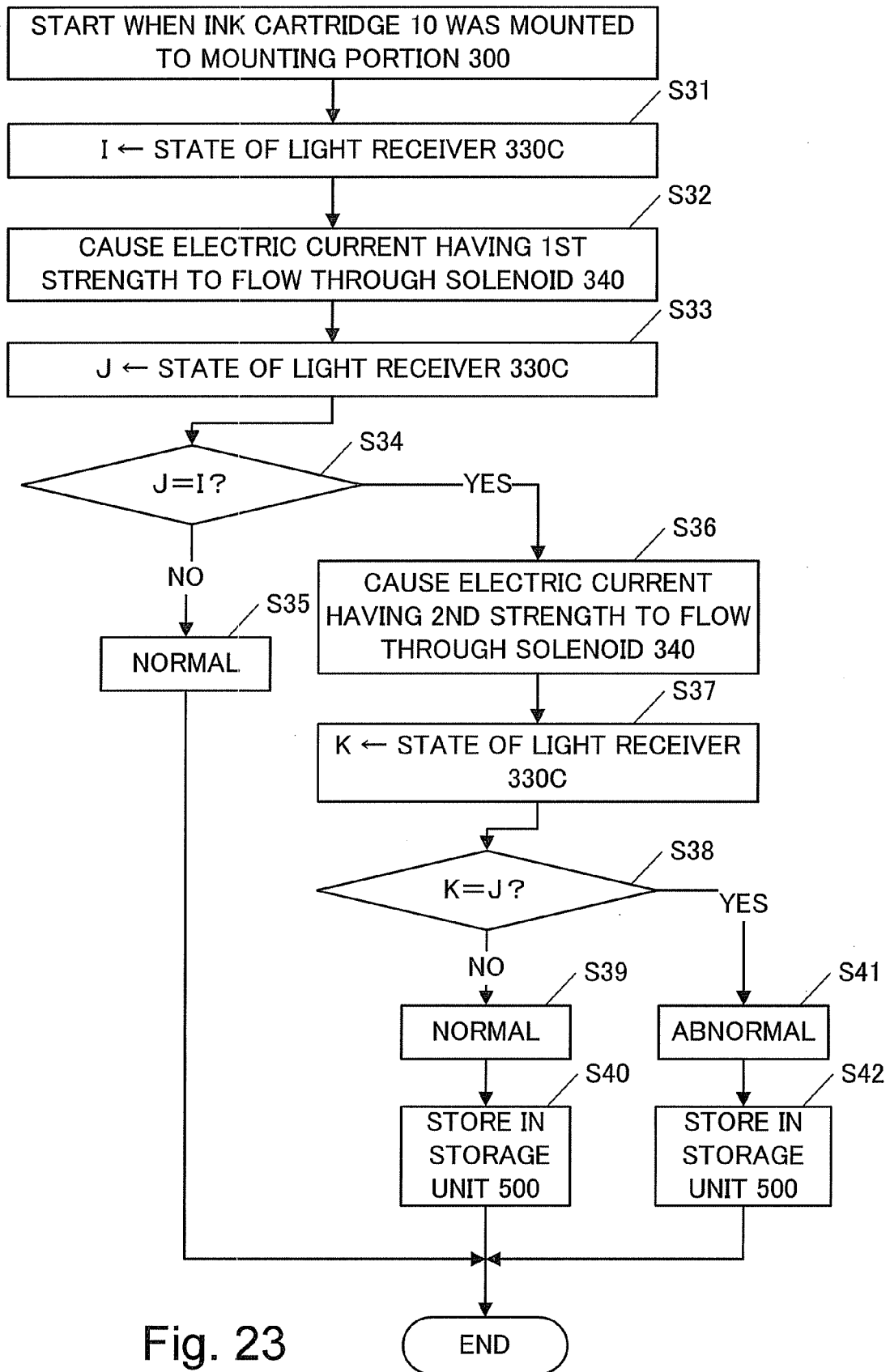


Fig. 22



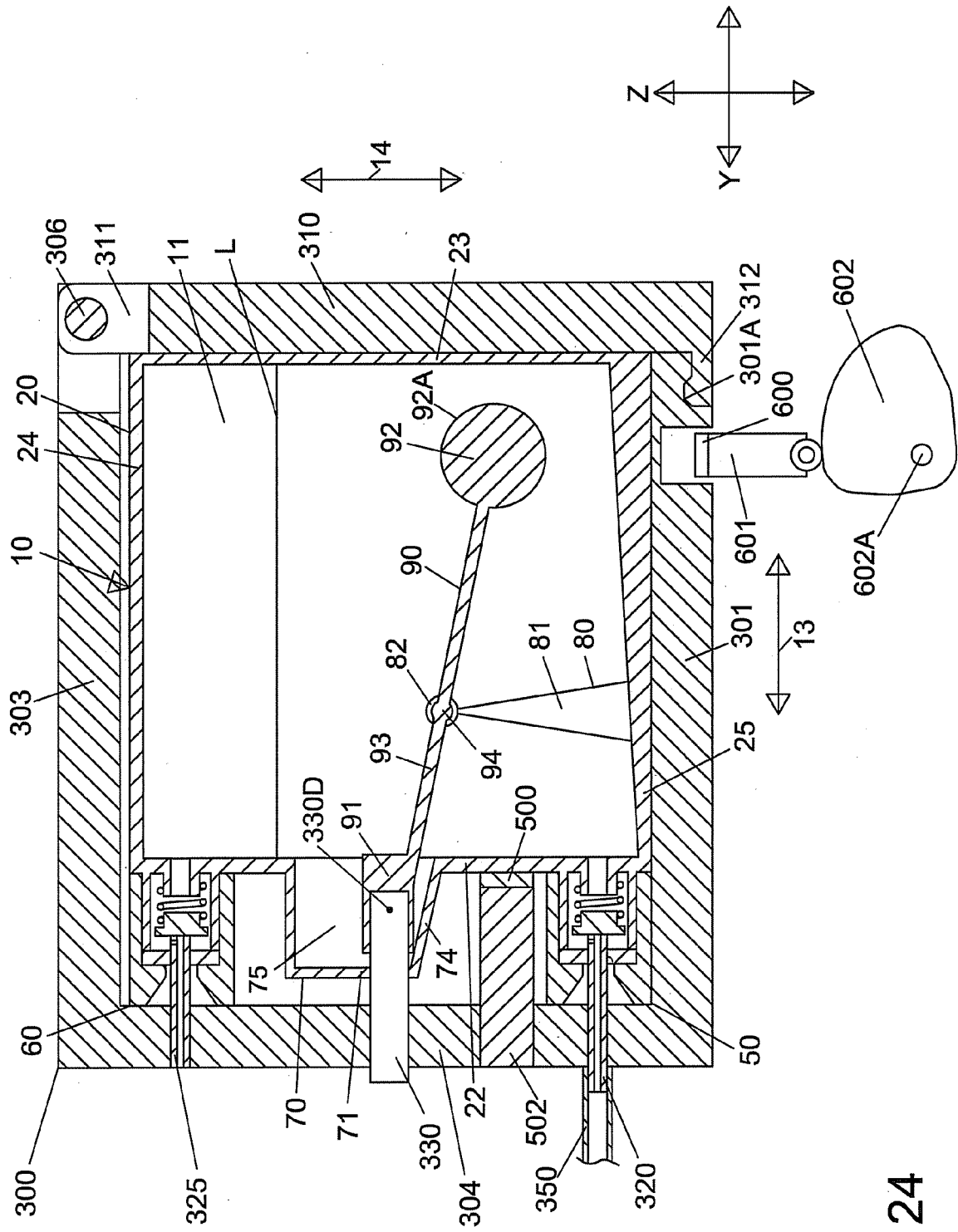


Fig. 24

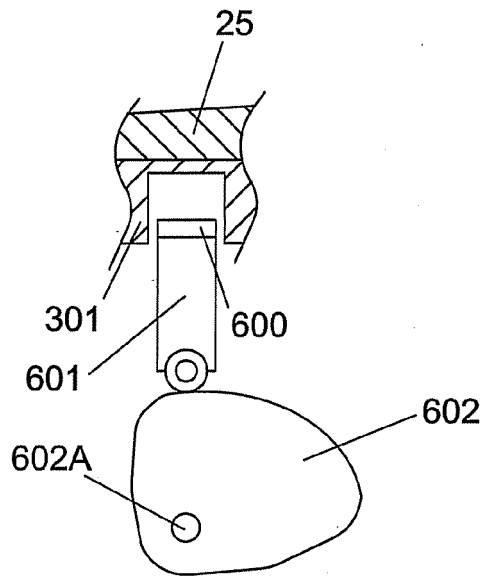


Fig. 25(A)

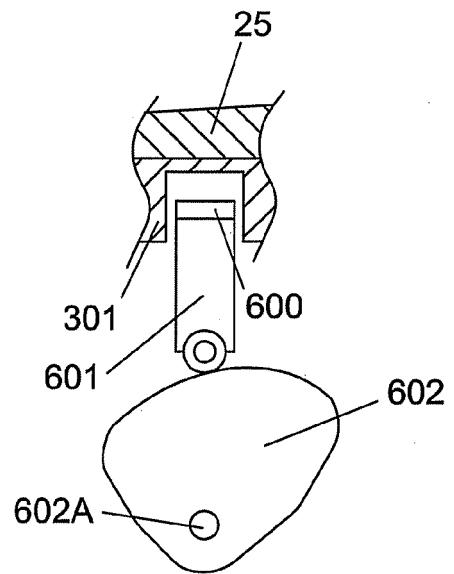


Fig. 25(B)

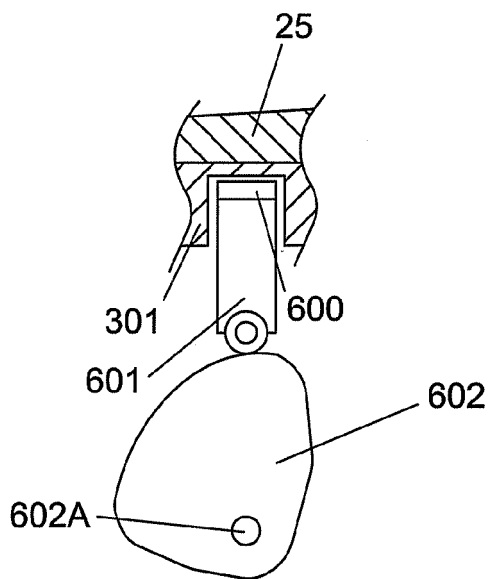


Fig. 25(C)

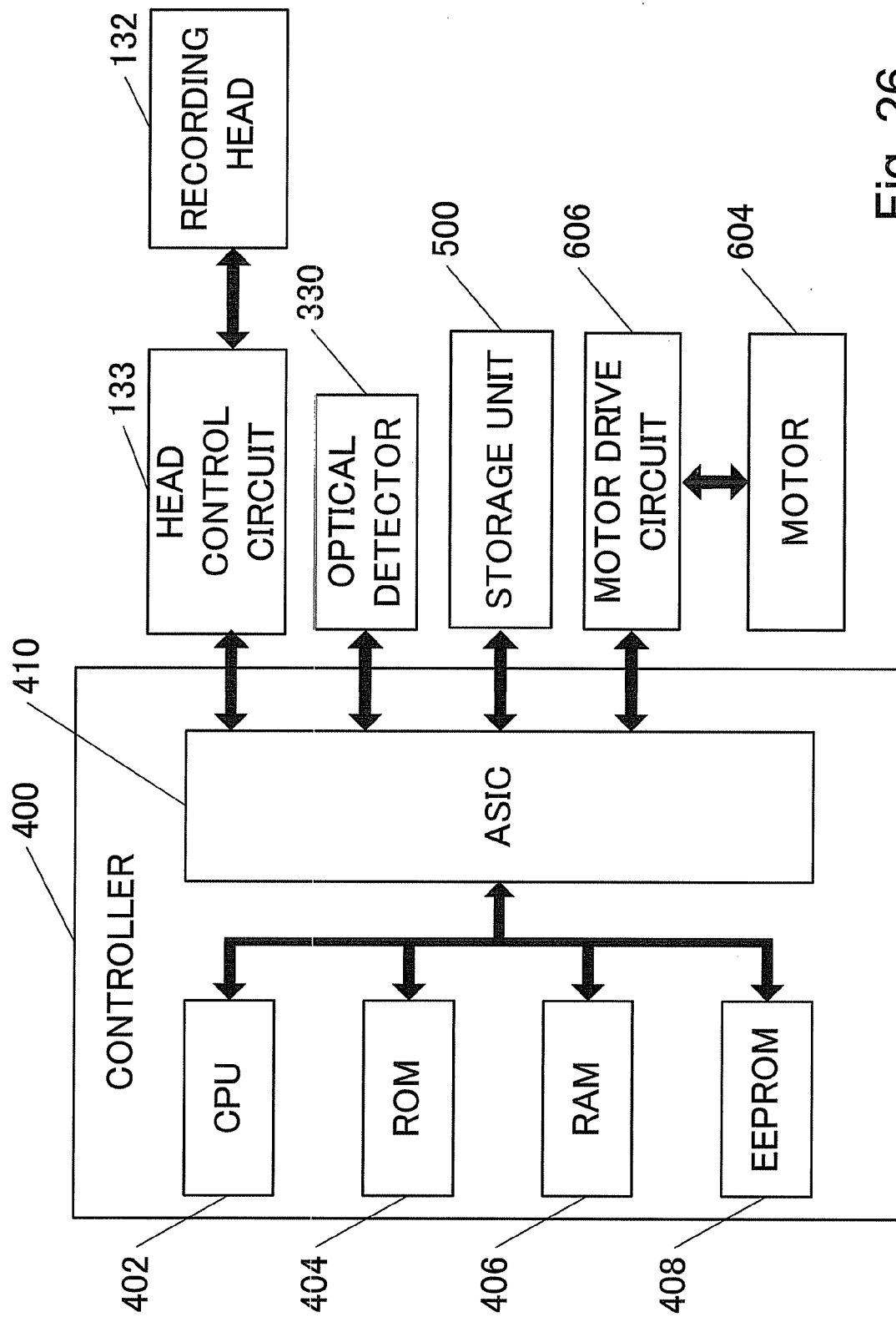
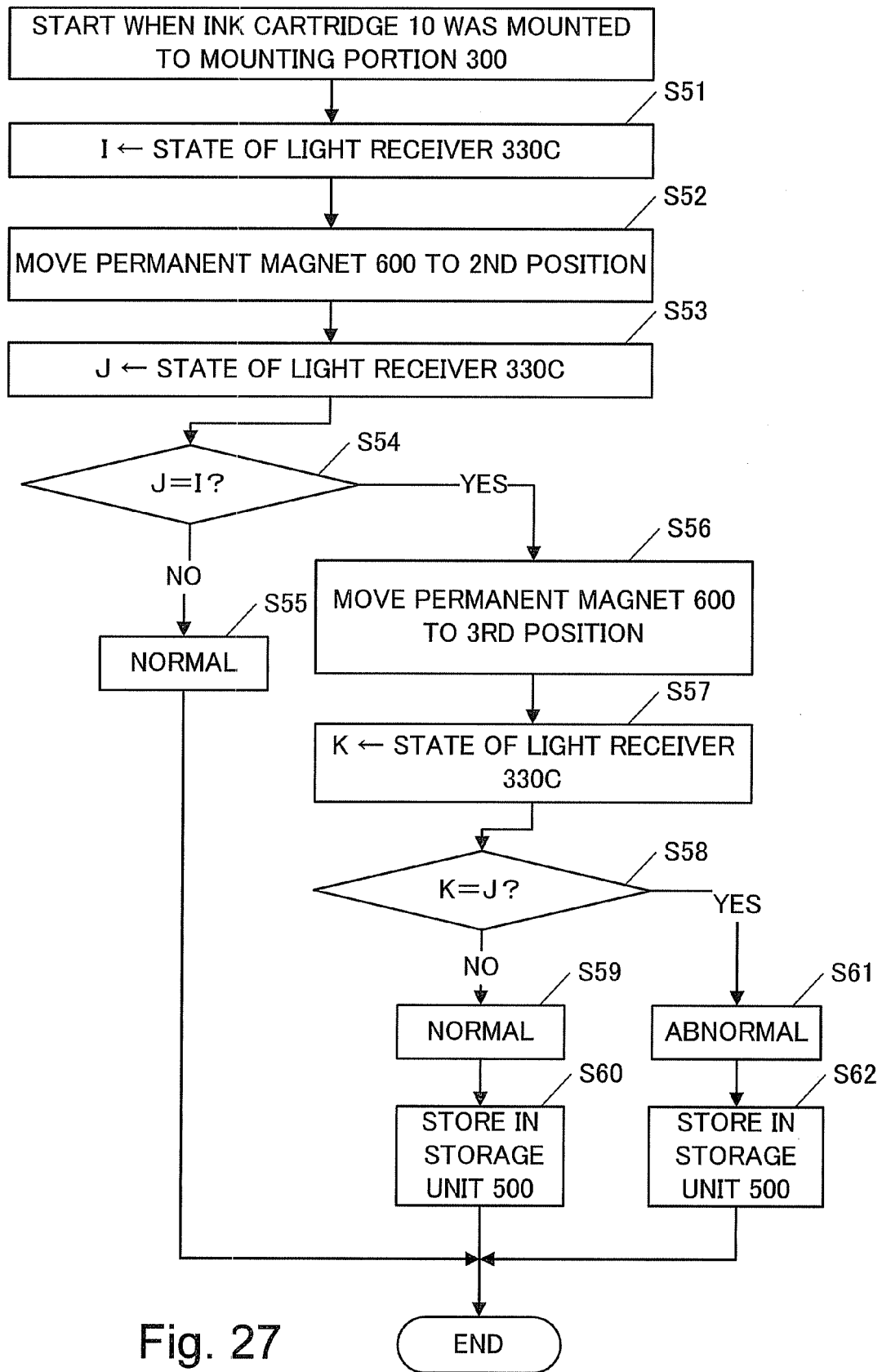


Fig. 26



REFERENCES CITED IN THE DESCRIPTION

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