



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
26.10.2022 Bulletin 2022/43

(51) International Patent Classification (IPC):
B41J 2/175^(2006.01) B41J 2/19^(2006.01)

(21) Application number: **22168785.8**

(52) Cooperative Patent Classification (CPC):
**B41J 2/17596; B41J 2/175; B41J 2/17566;
B41J 2/19**

(22) Date of filing: **19.04.2022**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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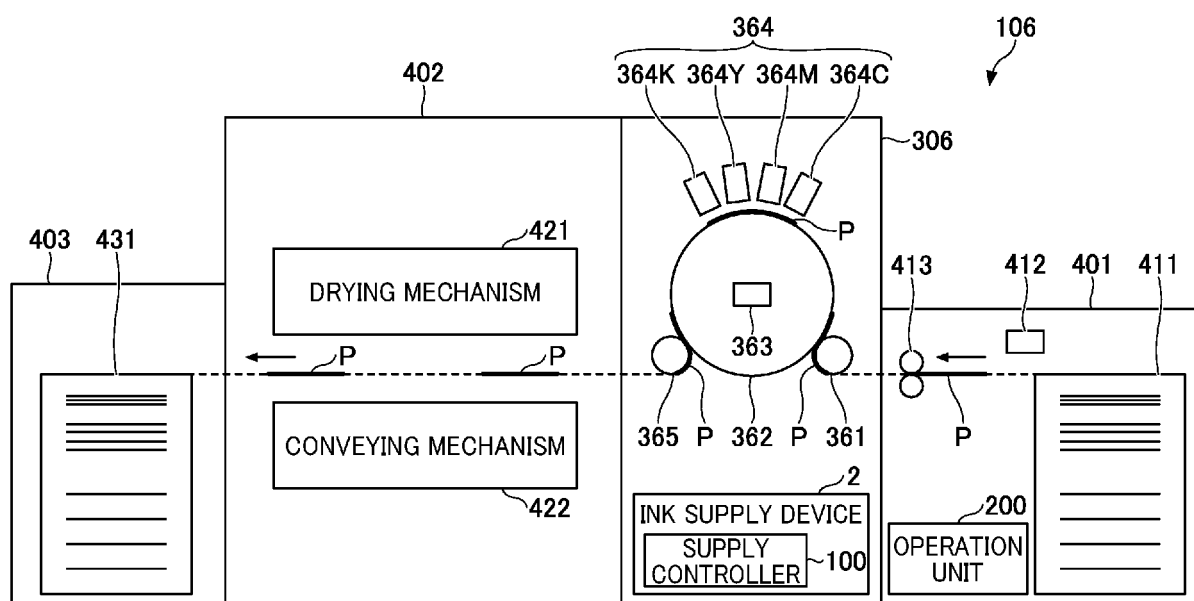
(30) Priority: **22.04.2021 JP 2021072900**

(54) **LIQUID SUPPLY DEVICE, LIQUID DISCHARGE APPARATUS, AND LIQUID SUPPLY METHOD**

(57) A liquid supply device (2, 2a, 2b) includes a channel (21), a movable portion (22), and a controller (100). Liquid is to be fed through the channel (21). The movable portion (22) moves to feed the liquid. The controller (100) controls the movable portion. The controller

(100) controls at least one of a moving speed and a moving time of the movable portion (22) in accordance with a liquid feed amount of the liquid fed through the channel (21) such that the liquid feed amount increases.

FIG. 1



Description

BACKGROUND

Technical Field

[0001] Embodiments of the present disclosure relate to a liquid supply device, a liquid discharge apparatus, and a liquid supply method.

Related Art

[0002] In the related art, for example, an inkjet printer that discharges liquid to form an image on a recording medium includes a liquid supply device including a channel through which liquid is fed and a movable portion that is movable to feed liquid.

[0003] In addition, for the purpose of discharging air bubbles and foreign matter in a channel, a configuration has been proposed in which ink is forcibly supplied and circulated in an ink channel between an ink tank and an inkjet head, and supply control is performed such that the supply amount of ink in a first period at a certain timing from the start of circulation is less than the supply amount of ink in a second period after the first period (see, for example, Japanese Unexamined Patent Application Publication No. 2012-030492).

[0004] However, in an apparatus described in Japanese Unexamined Patent Application Publication No. 2012-030492, when a component such as a channel deteriorates over time, the amount of liquid fed per unit time decreases, which may cause a shortage of the supply amount of liquid.

SUMMARY

[0005] An object of the present disclosure is to provide a liquid supply device that can prevent a shortage of a liquid supply amount.

[0006] According to an embodiment of the present disclosure, there is provided a liquid supply device that includes a channel, a movable portion, and a controller. Liquid is to be fed through the channel. The movable portion moves to feed the liquid. The controller controls the movable portion. The controller controls at least one of a moving speed and a moving time of the movable portion in accordance with a liquid feed amount of the liquid fed through the channel such that the liquid feed amount increases.

[0007] According to an embodiment of the present disclosure, there is provided a liquid supply method to be performed by a liquid supply device that includes a channel through which liquid is fed and a movable portion to move to feed the liquid. The method includes controlling the movable portion. The controlling includes controlling at least one of a moving speed and a moving time of the movable portion in accordance with a liquid feed amount of the liquid fed through the channel such that the liquid

feed amount increases.

[0008] According to the present disclosure, a liquid supply device can be provided that prevents a shortage of a liquid supply amount.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The aforementioned and other aspects, features, and advantages of the present disclosure would be better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. 1 is a diagram illustrating an overall configuration of an image forming apparatus according to an embodiment of the present disclosure;

FIG. 2 is a diagram illustrating an ink supply path according to an embodiment of the present disclosure;

FIG. 3 is a diagram illustrating an ink supply path according to another embodiment of the present disclosure;

FIG. 4A is a diagram illustrating a remaining-amount detection feeler and a remaining-amount detection sensor in a state in which ink is full;

FIG. 4B is a diagram illustrating the remaining-amount detection feeler and the remaining-amount detection sensor in a state in which the amount of ink is low;

FIG. 5 is a diagram illustrating a configuration of an ink supply device according to a first embodiment of the present disclosure;

FIG. 6 is a diagram illustrating a configuration example of a controller of the ink supply device according to the first embodiment;

FIG. 7 is a diagram illustrating a functional configuration of the controller of the ink supply device according to the first embodiment;

FIG. 8 is a diagram illustrating a control result of a liquid feed amount in a comparative example;

FIG. 9 is a diagram illustrating a first example of the control result of the liquid feed amount according to the first embodiment;

FIG. 10 is a diagram illustrating a second example of the control result of the liquid feed amount according to the first embodiment;

FIG. 11 is a diagram illustrating a third example of the control result of the liquid feed amount according to the first embodiment;

FIG. 12 is a diagram illustrating a fourth example of the control result of the liquid feed amount according to the first embodiment;

FIG. 13 is a diagram illustrating a fifth example of the control result of the liquid feed amount according to the first embodiment;

FIG. 14A is a diagram illustrating ink suction of an ink supply device according to a second embodiment of the present disclosure;

FIG. 14B is a diagram illustrating ink output of the ink supply device according to the

second embodiment; and

[0010] FIG. 15 is a diagram illustrating a configuration of an ink supply device according to a third embodiment of the present disclosure.

[0011] The accompanying drawings are intended to depict embodiments of the present disclosure and should not be interpreted to limit the scope thereof. The accompanying drawings are not to be considered as drawn to scale unless explicitly noted.

DETAILED DESCRIPTION

[0012] In describing embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of this patent specification is not intended to be limited to the specific terminology so selected and it is to be understood that each specific element includes all technical equivalents that operate in a similar manner and achieve similar results.

[0013] Although the embodiments are described with technical limitations with reference to the attached drawings, such description is not intended to limit the scope of the disclosure and all of the components or elements described in the embodiments of this disclosure are not necessarily indispensable.

[0014] Referring now to the drawings, embodiments of the present disclosure are described below. In the drawings for explaining the following embodiments, the same reference codes are allocated to elements (members or components) having the same function or shape and redundant descriptions thereof are omitted below.

[0015] Below, embodiments of the present disclosure are described in detail with reference to the accompanying drawings. In the drawings, like reference signs denote like elements, and overlapping description may be omitted where appropriate.

[0016] Note that the embodiments described below are examples of a liquid supply device and a liquid discharge apparatus for embodying the technical idea of the present disclosure, and the present disclosure is not limited to the embodiments described below. For example, the dimension, material, and shape of components and the relative positions of the arranged components are given by way of example in the following description, and the scope of the present disclosure is not limited thereto unless particularly specified. The size, positional relation, and the like of components illustrated in the drawings may be exaggerated for clarity of description.

[0017] A liquid supply device according to an embodiment includes a channel through which liquid is fed, a movable portion that is movable to feed the liquid, and a controller that controls the movable portion. The liquid supply device is, for example, an ink supply device that supplies ink to a discharge head that discharges ink as

an example of liquid in a liquid-discharge-type image forming apparatus such as an inkjet printer.

[0018] When such a liquid supply device is used for a long period of time, a component such as an ink tube deteriorates over time. As a result, the amount of liquid fed per unit time by the liquid supply device decreases, and the amount of liquid supplied by the liquid supply device may become insufficient.

[0019] In the present embodiment, at least one of the moving speed and the moving time of the movable portion is controlled so that the liquid feed amount increases in accordance with the liquid feed amount of the liquid fed through the channel, thereby making it possible to prevent the shortage of the liquid supply amount by the liquid supply device.

[0020] Hereinafter, an embodiment will be described using an example of a liquid-discharge-type image forming apparatus that includes a liquid supply device and a liquid discharge device to discharge liquid supplied by the liquid supply device, and forms an image on a recording medium using the liquid discharged by the liquid discharge device. Note that image formation, recording, printing, printing, and printing in the terms of the embodiments are synonymous.

[0021] Further, the term "liquid" includes any liquid having a viscosity or a surface tension that can be discharged from a liquid discharge device. The "liquid" is not limited to a particular liquid and may be any liquid having a viscosity or a surface tension to be discharged from a liquid discharge device. However, preferably, the viscosity of the liquid is not greater than 30 mPa·s under ordinary temperature and ordinary pressure or by heating or cooling. Examples of the liquid include a solution, a suspension, or an emulsion that contains, for example, a solvent, such as water or an organic solvent, a colorant, such as dye or pigment, a functional material, such as a polymerizable compound, a resin, or a surfactant, a bio-compatible material, such as deoxyribonucleic acid (DNA), amino acid, protein, or calcium, or an edible material, such as a natural colorant. The above-described examples may be used for inkjet inks, for example.

[0022] The liquid discharge device is a functional component that discharges and jets liquid from nozzles. Examples of an energy source for generating energy to discharge liquid include a piezoelectric actuator (a laminated piezoelectric element or a thin-film piezoelectric element), a thermal actuator that employs a thermoelectric conversion element, such as a thermal resistor, and an electrostatic actuator including a diaphragm and opposed electrodes.

First Embodiment

Configuration Example of Image Forming Apparatus 106

[0023] FIG. 1 is a schematic diagram illustrating a configuration of an image forming apparatus 106 according to a first embodiment. In FIG. 1, the image forming ap-

paratus 106 includes a sheet feeding unit 401, an image forming unit 306, a drying unit 402, and a sheet ejection unit 403. In the image forming apparatus 106, the image forming unit 306 forms an image on a sheet P with ink. Here, the sheet P is an example of a recording medium as a sheet material fed from the sheet feeding unit 401. Ink is an example of liquid for image formation. After the ink adhering to the sheet P is dried in the drying unit 402, the sheet P is ejected from the sheet ejection unit 403.

Sheet Feeding Unit

[0024] As illustrated in FIG. 1, the sheet feeding unit 401 includes a sheet feeding tray 411 on which a plurality of sheets P are stacked, a feeding device 412 that separates and feeds the sheets P one by one from the sheet feeding tray 411, and a registration roller pair 413 that feeds the sheets P to the image forming unit 306. The feeding device 412 may be any feeding device such as a device using a roller(s) and a device using air suction. After the leading edge of the sheet P fed from the sheet feeding tray 411 by the feeding device 412 reaches the registration roller pair 413, the registration roller pair 413 is driven at a predetermined timing to feed the sheet to the image forming unit 306. In the present embodiment, the configuration of the sheet feeding unit 401 is not limited to any particular configuration as long as the sheet feeding unit 401 can feed the sheet P to the image forming unit 306.

[0025] The sheet feeding unit 401 includes an operation unit 200 that receives, for example, an operation for starting the image forming apparatus 106, an operation for starting or stopping image formation by the image forming apparatus 106, and operations for various settings of the image forming apparatus 106. However, the installation position of the operation unit 200 is not limited to the sheet feeding unit 401 and may be installed at any position.

Image Forming Unit

[0026] As illustrated in FIG. 1, the image forming unit 306 includes a receiving cylinder 361, a sheet carrying drum 362, an ink discharge unit 364, and a delivery cylinder 365. The receiving cylinder 361 receives the fed sheet P. The sheet carrying drum 362 carries the sheet P conveyed by the receiving cylinder 361 on its outer peripheral surface. The ink discharge unit 364 discharges ink toward the sheet P carried by the sheet carrying drum 362. The delivery cylinder 365 delivers the sheet P carried by the sheet carrying drum 362 to the drying unit 402. The image forming unit 306 includes an ink supply device 2.

[0027] The leading end of the sheet P conveyed from the sheet feeding unit 401 to the image forming unit 306 is gripped by a sheet gripper disposed on the surface of the receiving cylinder 361. The sheet P is conveyed along with the movement of the surface of the receiving cylinder

361. The sheet P conveyed by the receiving cylinder 361 is delivered to the sheet carrying drum 362 at a position facing the sheet carrying drum 362.

[0028] A sheet gripper is also disposed on the surface of the sheet carrying drum 362, and the leading end of the sheet is gripped by the sheet gripper. Multiple suction holes are dispersedly formed on the surface of the sheet carrying drum 362. A suction device 363 generates a suction air flow toward the inside of the sheet carrying drum 362 in each suction hole. The leading end of the sheet P transferred from the receiving cylinder 361 to the sheet carrying drum 362 is gripped by the sheet gripper. The sheet P is sucked onto the surface of the sheet carrying drum 362 by the suction air flow and is conveyed along with the movement of the surface of the sheet carrying drum 362.

[0029] The ink supply device 2 is an example of a liquid supply device that supplies ink to the ink discharge unit 364. The ink supply device 2 includes a supply controller 100. The supply controller 100 is an example of a control device that controls a movable portion included in the ink supply device 2. The supply controller 100 controls the movable portion to control the supply of ink by the ink supply device 2.

[0030] The ink discharge unit 364 is an example of a liquid discharge device that discharges ink of four colors of C (cyan), M (magenta), Y (yellow), and K (black) to form an image and includes individual liquid discharge heads 364C, 364M, 364Y, and 364K for each ink. The configuration of the liquid discharge heads 364C, 364M, 364Y, and 364K is not limited to any particular configuration and may be any configuration that can discharge. In some embodiments, the liquid discharge device may include a liquid discharge head that discharges special ink such as white, gold, and silver or a liquid discharge head that discharges a surface coating liquid that does not form an image.

[0031] Discharge operations of the liquid discharge heads 364C, 364M, 364Y, and 364K of the ink discharge unit 364 are controlled by drive signals corresponding to image information. When the sheet P carried on the sheet carrying drum 362 passes through a region facing the ink discharge unit 364, color inks are discharged from the liquid discharge heads 364C, 364M, 364Y, and 364K to form an image corresponding to the image information. In the present embodiment, the configuration of the image forming unit 306 is not limited to any particular configuration as long as an image is formed by applying liquid onto the sheet P. In the following description, the liquid discharge heads 364C, 364M, 364Y, and 364K may be collectively referred to as the ink discharge unit 364 unless particularly distinguished from each other.

Drying Unit

[0032] As illustrated in FIG. 1, the drying unit 402 includes a drying mechanism 421 and a conveying mechanism 422. The drying mechanism 421 dries ink adhering

to the sheet P in the image forming unit 306. The conveying mechanism 422 conveys a sheet P conveyed from the image forming unit 306. The sheet P conveyed from the image forming unit 306 is received by the conveyance mechanism 422, then conveyed so as to pass through the drying mechanism 421, and delivered to the sheet ejection unit 403. When the sheet P passes through the drying mechanism 421, ink on the sheet P is subjected to a drying process. Accordingly, liquid components such as moisture in the ink are evaporated, the ink is fixed on the sheet P, and curling of the sheet P is prevented.

Sheet Ejection Unit

[0033] The sheet ejection unit 403 includes a sheet ejection tray 431 on which a plurality of sheets P are stacked. The sheet P conveyed from the drying unit 402 is sequentially stacked and held on the sheet ejection tray 431. In the present embodiment, the configuration of the sheet ejection unit 403 is not limited to any particular configuration and may be any configuration that can eject the sheet P.

Other functional units

[0034] As described above, the image forming apparatus 106 according to the present embodiment includes the sheet feeding unit 401, the image forming unit 306, the drying unit 402, and the sheet ejection unit 403. However, other functional units may be added as appropriate. For example, a pre-processing unit that performs pre-processing of image formation may be added between the sheet feeding unit 401 and the image forming unit 306. Alternatively, a post-processing unit that performs post-processing of image formation may be added between the drying unit 402 and the sheet ejection unit 403.

[0035] An example of the pre-processing device performs a processing liquid applying operation to apply processing liquid onto the sheet P so as to reduce bleeding by reacting with ink. However, the content of the pre-processing operation is not limited particularly. Examples of the post-processing unit include a sheet reversing-and-conveying process for reversing a sheet on which an image has been formed by the image forming unit 306 and sending the sheet to the image forming unit 306 again to form images on both sides of the sheet, a process for binding a plurality of sheets on which images have been formed, a correction mechanism that corrects sheet deformation, and a cooling mechanism that cools the sheet.

Example of Ink Supply Path

[0036] FIG. 2 is a diagram illustrating an example of an ink supply path in the image forming apparatus 106. The ink supply path refers to a path through which ink is fed and supplied between an ink cartridge and a discharge head in the image forming unit 306.

[0037] As illustrated in FIG. 2, the image forming unit

306 includes an ink cartridge 1, a flow-velocity measuring device 13, an ink supply device 2, an ink discharge unit 364, a suction pump 4, and a waste liquid tank 5. The ink cartridge 1 further includes a supply opening-and-closing solenoid 11 and an ink-end detection sensor 12. The ink discharge unit 364 includes a head tank 31, a remaining-amount detection feeler 32, a remaining-amount detection sensor 33, and a suction cap 34.

[0038] The ink cartridge 1 is an example of a storage unit that stores ink. The ink cartridge 1 is replaceably installed. When ink in the ink cartridge 1 is in an empty state (an ink end state) or a state close to empty (a near end state), the ink cartridge 1 is replaced with a new ink cartridge 1 that is in a state of being full of ink. The ink stored in the ink cartridge 1 is sent and supplied to a head tank 31 as an example of an in-head storage unit by the ink supply device 2 under the control of the supply controller 100.

[0039] The flow-velocity measuring device 13 is disposed between the head tank 31 and the ink-end detection sensor 12 and measures the flow velocity of the ink supplied from the ink supply device 2 to the ink discharge unit 364 that is a supply destination. The flow-velocity measuring device may be either a device capable of measuring the flow velocity from the outside of the path or a device capable of measuring the flow velocity inside the path.

[0040] The head tank 31 includes the remaining-amount detection feeler 32 and the remaining-amount detection sensor 33, which can be used to detect the amount of ink (amount of liquid) in the head tank 31. The head tank 31 has a function of forming a predetermined negative pressure in order to normally discharge ink by the ink discharge unit 364.

[0041] A plurality of nozzle holes are disposed in a portion of the ink discharge unit 364 that faces the sheet. The ink discharge unit 364 discharges ink in the head tank 31 as ink droplets from the nozzle orifices under the control of the supply controller 100. Ink droplets discharged by the ink discharge unit 364 land on the sheet P and adhere to the sheet, thereby forming an image on the sheet.

[0042] When the ink in the head tank 31 increases in viscosity or contains bubbles, the ink discharge unit 364 may not appropriately discharge ink. For this reason, maintenance of the ink discharge unit 364 is performed. When maintenance is performed, the suction cap 34 is attached to the portion where the nozzle orifices of the ink discharge unit 364 are disposed, and the ink in the head tank 31 is sucked out through the nozzle holes by the suction pump 4. Thus, for example, the ink containing air bubbles and the thickened ink are removed, and the ink in the ink discharge unit 364 is replaced with fresh ink. The sucked ink is sent to the waste liquid tank 5 as waste liquid.

[0043] The opening-and-closing solenoid 11 and the ink-end detection sensor 12 are disposed between the ink cartridge 1 and the ink supply device 2. The opening-

and-closing solenoid 11 opens and closes a solenoid under the control of the supply controller 100 to switch between supply and supply-stop of ink from the ink cartridge 1. The ink-end detection sensor 12 detects that the ink cartridge 1 is empty of ink, and outputs the detection result to the supply controller 100.

[0044] The ink cartridge 1 has an integrated-circuit (IC) chip in which information such as ink type, color, date of manufacture, ink remaining amount, and ink end state is stored. For example, the ink cartridge 1 is attached to the image forming unit 306 in an ink full state when the ink cartridge 1 is new. When ink is discharged from the ink cartridge 1 in image formation and the ink cartridge 1 reaches an ink end state in ink is empty, the ink cartridge 1 is replaced with a new one. The cumulative number of replacement times of the ink cartridge 1 is managed by the supply controller 100.

[0045] The amount of ink discharged by the ink discharge unit 364 can be managed by the supply controller 100 based on the counted cumulative number of discharges of ink droplets.

[0046] FIG. 3 is a diagram illustrating another example of an ink supply path in the image forming apparatus 106. The ink supply path illustrated in FIG. 3 further includes a circulation path 6 for circulating ink in addition to the ink supply path illustrated in FIG. 2.

[0047] For example, depending on the type of ink such as white ink, ink components such as pigment may settle in the ink supply path. The circulation path 6 circulates the ink in the ink supply path at predetermined time intervals in order to prevent such sedimentation of the ink components.

[0048] The circulation path 6 includes an on-off valve 61. Opening and closing of the on-off valve 61 are controlled by the supply controller 100 in order to control liquid feeding of ink in the circulation path 6.

[0049] The ink is circulated in the circulation path 6 between the ink supply device 2 and the head tank 31. The supply controller 100 drives the ink supply device 2 in a state where the opening-and-closing solenoid 11 is closed and the on-off valve 61 is opened, thereby circulating ink between the channel downstream from the ink supply device 2 and the head tank 31.

[0050] In a type of ink such as white ink in which sedimentation of ink components is likely to occur and circulation of ink is necessary, the ink supply device 2 is driven at predetermined intervals and the driving frequency increases. Accordingly, for example, an ink tube included in the ink supply device 2 is likely to deteriorate. The deterioration of the ink tube may cause a decrease in the liquid feed amount.

[0051] On the other hand, in a type of ink in which sedimentation of ink components is less likely to occur, circulation of ink is not so necessary. Since the ease of sedimentation of the ink component can be distinguished by the type of ink, the supply controller 100 preferably controls whether to use the circulation path 6 based on the type of ink.

[0052] The remaining-amount detection feeler 32 and the remaining-amount detection sensor 33 in the head tank 31 detect the remaining amount of ink in the head tank 31. FIGS. 4A and 4B are diagrams illustrating the configurations and operations of the remaining-amount detection feeler 32 and the remaining-amount detection sensor 33. FIG. 4A illustrates a case where an ink cartridge is full of ink. FIG. 4B illustrates a case where the ink cartridge is depleted of ink.

[0053] As illustrated in FIG. 4, a flexible head tank film 31a is disposed on a part of the head tank 31. When the ink in the head tank 31 increases, the head tank film 31a expands as illustrated in FIG. 4A. When the ink in the head tank 31 decreases, the head tank film 31a contracts as illustrated in FIG. 4B.

[0054] The remaining-amount detection feeler 32 is pressed against the head tank film 31a. The remaining-amount detection feeler 32 is, for example, a light plastic piece formed in a band shape and has a fixed end on a fulcrum 32a and a free end on the remaining-amount detection sensor 33.

[0055] The remaining-amount detection sensor 33 includes an upper-limit sensor 33a and a lower-limit sensor 33b. Each of the upper-limit sensor 33a and the lower-limit sensor 33b is an optical sensor having a light emitter and a light receiver and outputs a detection signal indicating that the remaining-amount detection feeler 32 is interposed between the light emitter and the light receiver.

[0056] The free end of the remaining-amount detection feeler 32 moves in accordance with expansion and contraction of the head tank film 31a. The state in which the head tank 31 is full of ink is detected based on a detection signal output when the free end of the remaining-amount detection feeler 32 is interposed between the light emitter and the light receiver in the upper-limit sensor 33a. On the other hand, the state in which ink in the head tank 31 is empty is detected based on a detection signal output when the free end of the remaining-amount detection feeler 32 is interposed between the light emitter and the light receiver in the lower-limit sensor 33b.

Configuration Example of Ink Supply Device 2

[0057] FIG. 5 is a diagram illustrating an example of a configuration of the ink supply device 2. As illustrated in FIG. 5, the ink supply device 2 includes an ink tube 21, a ring 22, an eccentric cam 23, a stepping motor 150, and a supply controller 100. In the present embodiment, the ink supply device 2 employs a tube pump system.

[0058] The ink tube 21 is an example of a channel through which ink is fed. The material of the ink tube 21 may be, for example, a thermoplastic elastomer.

[0059] The ring 22 is an annular member rotatable about a predetermined rotation axis and is disposed such that an outer peripheral portion of the ring 22 is in contact with the ink tube 21. The ring 22 is an example of a movable portion that rotates to feed ink, and is an example

of a rotating body. Rotation is an example of mobility of the movable portion.

[0060] The eccentric cam 23 is coupled to the ring 22 such that the central axis of the eccentric cam 23 substantially coincides with the central axis of the ring 22. The eccentric cam 23 is attached to the rotary shaft of the stepping motor 150 so that the central axis of the eccentric cam 23 is eccentric to the rotation axis of the stepping motor 150.

[0061] When the stepping motor 150 is driven to rotate, the eccentric cam 23 rotates to rotate the ring 22. Since the center axis of the eccentric cam 23 is eccentric with respect to the rotation axis of the stepping motor 150, the ring 22 eccentrically rotates, and a region in which the ink tube 21 is pressed by the ring 22 moves with the rotation. Accordingly, the ink in the ink tube 21 is volumetrically moved, thus allowing the ink to be fed.

[0062] The ink supply device 2 can increase the amount of liquid to be fed by increasing the rotation speed or time of the ring 22. The rotation speed is an example of a moving speed, and the rotation time is an example of a moving time.

[0063] Each of the ring 22 and the eccentric cam 23 may be made of, for example, a resin material.

[0064] The stepping motor 150 is a driving device that rotates the ring 22 via the eccentric cam 23. The stepping motor 150 is electrically connected to the supply controller 100 and driven under the control of the supply controller 100. However, the driving unit is not limited to the stepping motor, and may be, for example, a direct current (DC) motor.

Hardware Configuration Example of Supply Controller 100

[0065] FIG. 6 is a block diagram illustrating an example of a hardware configuration of the supply controller 100. As illustrated in FIG. 6, the supply controller 100 is implemented by a computer and includes a central processing unit (CPU) 101, a read only memory (ROM) 102, a random access memory (RAM) 103, a hard disk drive (HDD) 104, and an external device connection interface (I/F) 105.

[0066] The CPU 101 executes control processing including various types of computing processing. The ROM 102 stores programs used to drive the CPU 101, such as an initial program loader (IPL). The RAM 103 is used as a working area for the CPU 101. The HDD 104 stores various types of data such as programs.

[0067] The external device connection I/F 105 is an interface for connecting various external devices. The external devices in this case are, for example, devices such as the ink discharge unit 364, the ink-end detection sensor 12, and the remaining-amount detection sensor 33.

Functional Configuration Example of Supply Controller 100

[0068] FIG. 7 is a block diagram illustrating an example of a functional configuration of the supply controller 100. As illustrated in FIG. 7, the supply controller 100 includes an information acquisition unit 110, a rotation control unit 120, and a reset unit 130. The information acquisition unit 110 includes a cumulative-rotation-count information acquisition unit 111, a cumulative-supply-time information acquisition unit 112, a cumulative-replacement-count information acquisition unit 113, a flow-velocity information acquisition unit 114, a cumulative-discharge-amount information acquisition unit 115, an ink-type information acquisition unit 116, a selection-value reception unit 117, and a liquid-feed-time information acquisition unit 118. These functions are implemented by the CPU 101 in FIG. 6 executing a program stored in, for example, the ROM 102 or the HDD 104.

[0069] The cumulative-rotation-count information acquisition unit 111 acquires cumulative-rotation-count information, i.e., information on the cumulative number of rotations of the ring 22. For example, the cumulative-rotation-count information acquisition unit 111 can acquire the cumulative-rotation-count information of the ring 22 based on the information on rotation of the stepping motor 150.

[0070] The cumulative-supply-time information acquisition unit 112 acquires cumulative supply time information, i.e., information on cumulative supply time during which the ink supply device 2 has supplied ink to the ink discharge unit 364. For example, the cumulative-supply-time information acquisition unit 112 can acquire the cumulative supply time information by counting the number of clocks of the CPU 101 and measuring the elapsed time while the ink supply device 2 is supplying ink.

[0071] The cumulative-replacement-count information acquisition unit 113 acquires cumulative replacement count information, i.e., information on the cumulative number of times of replacement of the ink cartridge 1. For example, the cumulative-replacement-count information acquisition unit 113 can detect that the ink cartridge 1 has been replaced by referring to the IC chip of the ink cartridge 1, and can acquire the cumulative replacement count information by counting the number of detected replacements.

[0072] The flow-velocity information acquisition unit 114 acquires flow velocity information, i.e., information on the flow velocity of ink supplied from the ink supply device 2 to the ink discharge unit 364. For example, the flow-velocity information acquisition unit 114 can acquire the flow velocity information of ink by inputting a measurement value of the ink flow velocity from the flow-velocity measuring device 13.

[0073] The cumulative-discharge-amount information acquisition unit 115 acquires cumulative discharge amount information from the ink discharge unit 364. For example, the cumulative-discharge-amount information

acquisition unit 115 can acquire the cumulative discharge amount information by counting the number of times of discharge of ink by the ink discharge unit 364 and multiplying the cumulative count number by the amount of ink per discharge.

[0074] The ink-type information acquisition unit 116 acquires ink type information, i.e., information on the type of ink supplied by the ink supply device 2. For example, the ink-type information acquisition unit 116 can acquire the ink type information supplied by the ink supply device 2 by referring to the IC chip of the ink cartridge 1.

[0075] The selection-value reception unit 117 receives a selection value of at least one of the rotation speed and the rotation time of the ring 22 selected by the operator of the ink supply device 2. For example, the selection-value reception unit 117 can receive a selection value input by an operator of the ink supply device 2 using the operation unit 200. The operator refers to a person who operates the ink supply device 2. Examples of the operator include a user of the ink supply device 2, a user of the image forming apparatus 106, a service person of the ink supply device 2, and a service person of the image forming apparatus 106.

[0076] The liquid-feed-time information acquisition unit 118 acquires liquid-feed-time information until the amount of ink stored in the head tank 31 reaches a full state from the lower limit value by liquid feeding from the ink supply device 2. For example, the liquid-feed-time information acquisition unit 118 can acquire the liquid-feed-time information by measuring the period of time from the time when the detection signal indicating the lower limit is output to the time when the detection signal indicating the upper limit is output in the remaining-amount detection sensor 33.

[0077] The rotation control unit 120 controls at least one of the rotation speed and the rotation time of the ring 22 such that the liquid feed amount increases gradually or stepwisely in accordance with the liquid feed amount of the ink fed through the ink tube 21.

[0078] For example, the rotation control unit 120 can control at least one of the rotation speed and the rotation time of the ring 22 by controlling the driving of the stepping motor 150, based on each piece of information acquired by the information acquisition unit 110 according to the liquid feed amount of ink, such that the liquid feed amount increases gradually or stepwisely.

[0079] When the ink supply device 2 is replaced, the reset unit 130 returns at least one of the rotation speed and the rotation time of the ring 22 to the initial state. For example, when information indicating that the ink supply device 2 has been replaced is acquired based on an operation performed by the operator using the operation unit 200, the reset unit 130 can reset at least one of the rotation speed and the rotation time of the ring 22 controlled so as to increase the liquid feed amount in accordance with the liquid feed amount of the ink and return the ring 22 to the initial state.

Example of Control Result

[0080] Next, with reference to FIGS. 8 to 13, a description is given of a control result of the liquid feed amount by the ink supply device. FIG. 8 is a diagram illustrating a control result of the liquid feed amount by an ink supply device 2X according to a comparative example. FIGS. 9 to 13 are diagrams illustrating first to fifth examples of the control result of the liquid feed amount by the ink supply device 2 according to the present embodiment.

[0081] In FIGS. 8, 9, and 11 to 13, the horizontal axis indicates the cumulative supply time of ink by the ink supply device in units of level. The first vertical axis on the left side indicates the amount of feed liquid in units of milliliters per second (ml / s), and the second vertical axis on the right side indicates the rotation speed of the ring in units of level. In FIG. 10, the horizontal axis indicates the cumulative supply time of ink by the ink supply device in units of level, the first vertical axis on the left side indicates the amount of feed liquid per operation of the ink supply device in units of milliliters (ml), and the second vertical axis on the right side indicates the rotation time of the ring in units of second (sec).

[0082] As the level of the cumulative supply time, the lifetime (i.e., mechanical durability period) required for the ink supply device is set to level 5. For example, the lifetime required for the ink supply device is five years, and the level "1" of the cumulative supply time corresponds to one year.

[0083] Further, in FIGS. 8 to 13, the solid line graph indicates the liquid feed amount, the one dot chain line graph indicates the minimum necessary liquid feed amount, and the two dot chain line graph indicates the upper-limit liquid feed amount. The broken line graphs in FIGS. 8, 9 and 11 to 13 indicate the rotation speed of the ring, and the broken line graph in FIG. 10 indicates the rotation time of the ring. The minimum necessary liquid feed amount is, for example, 0.05 ml / s.

[0084] As illustrated in FIG. 8, in the ink supply device 2X according to the comparative example, the liquid feed amount decreases as the cumulative supply time is longer, and the liquid feed amount falls below the line of the minimum necessary liquid feed amount at a time point of approximately level 3.

[0085] When ink is supplied for a long period of time, the ink tube is repeatedly compressed by the ring, so that the ink tube deteriorates and the restoring force of returning to the cylindrical shape is gradually lost. Accordingly, the volume of ink in the ink tube may not be moved, and the amount of ink supplied by the ink supply device may decrease.

[0086] If the liquid feed amount is less than the minimum necessary liquid feed amount, the ink amount may be insufficient when an image having a large area ratio is formed on the sheet P by the ink discharge unit 364. Accordingly, for example, blurring may occur in the formed image.

[0087] In the control result of the ink supply device 2

according to the present embodiment illustrated in FIG. 9, the liquid feed amount decreases as the cumulative supply time increases. However, the liquid feed amount increases by increasing the rotation speed of the ring 22 by one each time the level of the cumulative supply time increases by one. In other words, the rotation speed of the ring 22 is increased in a stepwise manner such that the amount of ink fed through the ink tube 21 increases in accordance with the amount of ink fed. In FIG. 10, the rotation time of the ring 22 is increased stepwise such that the amount of ink fed through the ink tube 21 is increased in accordance with the amount of ink fed.

[0088] As a result of the control illustrated in FIGS. 9 and 10, the minimum necessary liquid feed amount is ensured over the entire lifetime required for the ink supply device 2. From the viewpoint of ease of control, it is preferable to make the rotation time of the ring 22 constant when controlling the rotation speed of the ring 22, and to make the rotation speed of the ring 22 constant when controlling the rotation time of the ring 22. However, embodiments of the present disclosure are not limited to such control, and at least one of the rotation speed and the rotation time of the ring 22 may be controlled. Hereinafter, a case where the rotation speed of the ring 22 is controlled will be exemplified, but the same applies to a case where the rotation time is controlled.

[0089] FIG. 11 illustrates a control result in the case where the rotation speed of the ring 22 is increased only once within the lifetime required for the ink supply device 2. When the number of times of increase of the rotation speed of the ring 22 is set to be only once, the control can be further simplified, thus allowing the man-hour and cost of development of the supply controller 100 to be reduced. However, the number of times of change for increasing the rotation speed of the ring 22 is not limited to one, and may be any number as long as the number is one or more within the lifetime required for the ink supply device 2.

[0090] In a case where the rotation time of the ring 22 in the ink supply device 2 is changed in at least two stages, it is preferable that the rotation time in the change in the subsequent stage is longer than the rotation time in the change in the previous stage among the two or more stages. Thus, the liquid feed amount can be increased in the case where the cumulative supply time is longer, thus allowing the necessary liquid feed amount to be ensured more reliably.

[0091] FIG. 12 illustrates a control result in a case where the ink supply device 2 fails and is replaced with a new ink supply device 2 within a lifetime required for the ink supply device 2. A time point K illustrated in FIG. 12 represents a time point when the ink supply device 2 is replaced with a new one.

[0092] If the liquid feed amount is increased every time the level of the cumulative supply time increases by one as illustrated in FIGS. 9 to 11 after the ink supply device 2 is replaced with a new one, there is a concern that the liquid feed amount may increase too much. For this rea-

son, when the ink supply device 2 is replaced, the reset unit 130 in the ink supply device 2 returns at least one of the rotation speed and the rotation time of the ring 22 to the initial state at the time point K. Such a configuration can prevent the liquid feed amount from increasing too much.

[0093] FIG. 13 illustrates a case where the rotation speed of the ring 22 is exponentially increased in accordance with the cumulative supply time. Since the deterioration of the ink tube 21 progresses as the cumulative supply time is longer, the decrease in the liquid feed amount can be made smaller by exponentially increasing the speed than by increasing the speed by a fixed amount at predetermined time intervals.

[0094] In FIGS. 9 to 13, the control results in which the supply controller 100 automatically increases the rotation speed of the ring 22 or extends the rotation time are illustrated. In addition, the rotation speed or the rotation time may be manually changed by the selection-value reception unit 117 receiving a selection value by an operator.

[0095] For example, in the control result of FIG. 9 described above, the example has been described in which the level of the rotation speed of the ring 22 is increased by 0.5 every time the level of the cumulative supply time increases by one. Alternatively, this increase may be performed manually. For example, the level of the rotation speed of the ring 22 may be increased as illustrated in Example 1 or Example 2 below. Example 1: Every time the level of the cumulative supply time increases by 1.5, the level of the rotation speed of the ring 22 is increased by 0.7. Example 2: Every time the level of the cumulative supply time increases by 0.5, the level of the rotation speed of the ring 22 is increased by 0.3.

[0096] The level of the rotation time of the ring 22 in the control result of FIG. 10 may also be manually increased.

Operational Effects of Ink Supply Device 2

[0097] As described above, the ink supply device 2 serving as the liquid supply device according to the present embodiment includes the ink tube 21 (an example of the channel) to which ink (an example of liquid) is fed, the ring 22 (an example of the movable portion) that rotates (moves) to feed the ink, and the supply controller 100 (an example of the controller) that controls the ring 22. The supply controller 100 controls at least one of the rotation speed (moving speed) and the rotation time (moving time) of the ring 22 such that the liquid feed amount increases in accordance with the liquid feed amount of the ink fed in the ink tube 21.

[0098] Accordingly, even in a case where the ink supply device 2 is used for a long period of time and the channel such as the ink tube deteriorates over time, increasing the liquid supply amount of the ink can prevent the shortage of the ink supply amount by the ink supply device 2. In addition, the necessity of changing the ma-

terial of the ink tube 21 to a material that does not easily deteriorate or replacing the deteriorated ink supply device 2 can be obviated, thus preventing an increase in development process and cost.

[0099] In the present embodiment, the supply controller 100 controls at least one of the rotation speed and the rotation time of the ring 22 in a stepwise manner in accordance with the liquid feed amount so that the liquid feed amount increases. Accordingly, at least one of the rotation speed and the rotation time of the ring 22 is not constantly controlled, thus preventing the shortage of the ink supply amount by the ink supply device 2 while simplifying the control.

[0100] In addition, in the present embodiment, at least one of the rotation speed and the rotation time of the ring 22 is controlled based on at least one of the cumulative number of rotations of the ring 22, the cumulative supply time of ink by the ink supply device 2, the number of times of replacement of the ink cartridge 1, and the cumulative discharge amount by the ink discharge unit 364. These pieces of information can be acquired by counting by software. Thus, the shortage of the ink supply amount by the ink supply device 2 can be prevented based on the acquired information without increasing the component cost.

[0101] In the present embodiment, at least one of the rotation speed and the rotation time of the ring 22 is controlled based on the flow velocity of the ink supplied from the ink supply device 2 to the ink discharge unit 364. The control is based on the flow velocity of the ink directly related to the liquid feeding amount, thus reliably detecting a decrease in the liquid feeding amount and preventing the shortage of the ink supply amount by the ink supply device 2.

[0102] In the present embodiment, a selection value of at least one of the rotation speed and the rotation time selected by the operator of the ink supply device 2 is received, and at least one of the rotation speed and the rotation time of the ring 22 is controlled based on the received selection value. At least one of the rotation speed and the rotation time can be manually selected by the operator. Accordingly, even when the liquid feed amount by the ink supply device 2 is less than the minimum necessary liquid feed amount, the liquid feed amount can be reliably changed to be equal to or more than the minimum necessary liquid feed amount.

[0103] In the present embodiment, when the ink supply device 2 is replaced, at least one of the rotation speed and the rotation time of the ring 22 is returned to the initial state. Such a configuration can prevent the liquid feed amount from being excessive even when the ink supply device 2 is replaced with a new one due to a failure.

[0104] Further, in the present embodiment, at least one of the rotation speed and the rotation time of the ring 22 is controlled based on the type of ink discharged by the ink discharge unit 364. Depending on the type of ink, a sufficient liquid feed amount can be obtained without changing the rotation speed or the rotation time of the

ring 22. Accordingly, the control can be simplified without performing unnecessarily complicated control.

[0105] In the present embodiment, the ink discharge unit 364 includes the head tank 31 that stores ink therein, and controls at least one of the rotation speed and the rotation time of the ring 22 based on the liquid feed time until the ink amount stored in the head tank 31 reaches a full state from the lower limit value by the liquid feeding from the ink supply device 2. Such liquid-feed-time information can be acquired by counting by software, thus preventing the shortage of the ink supply amount by the ink supply device 2 based on the acquired information without increasing the component cost.

15 Other Embodiments

[0106] In the above-described first embodiment, the ink supply device 2 of the tube pump type is described. In some embodiments, the ink supply device may use another type such as a diaphragm type or a piston pump type.

[0107] FIGS. 14A and 14B are diagrams illustrating an example of a diaphragm-pump-type ink supply device 2a according to a second embodiment. FIG. 14A is a diagram illustrating ink suction. FIG. 14B is a diagram illustrating ink discharge. As illustrated in FIG. 14A, the ink supply device 2a includes a diaphragm 24, a pump shaft 25, check valves 26a and 26b, an inlet 27, and an outlet 28.

[0108] The diaphragm 24 repeats expansion and contraction in accordance with reciprocating translation of the pump shaft 25 using, for example, a motor as a driving source. As illustrated in FIG. 14A, when the diaphragm 24 expands, the volume in the ink supply device 2a increases, the check valve 26a closes, and the check valve 26b opens, so that ink is sucked into the ink supply device 2a through the inlet 27.

[0109] As illustrated in FIG. 14B, when the diaphragm 24 contracts, the volume in the ink supply device 2a decreases, the check valve 26a opens, and the check valve 26b closes, so that ink is sent out to the outside of the ink supply device 2a through the outlet 28.

[0110] The diaphragm 24 corresponds to an example of the movable portion and an example of a translation body. A path from the inlet 27 to the outlet 28 corresponds to an example of the channel.

[0111] The ink supply device 2a can send ink from the inlet 27 side to the outlet 28 side by repeating the operation described above. Although a rubber material or the like can be applied as the material of the diaphragm 24, the liquid feed amount decreases due to deterioration over time of the rubber constituting the diaphragm 24. In this case, at least one of the translation speed and the translation time at which the expansion and contraction of the diaphragm 24 are performed is controlled so that the liquid supply amount increases according to the liquid supply amount of the ink. Thus, an effect similar to that of the first embodiment can be obtained.

[0112] FIG. 15 is a diagram illustrating an example of a configuration of a piston-pump type ink supply device 2b according to a third embodiment. As illustrated in FIG. 15, the ink supply device 2b includes a cylinder 71, a piston 72, a connecting rod 73, a crankshaft 74, a drive shaft 75, a ball 76a, a ball 76b, an inlet 78, and an outlet 79.

[0113] The piston 72 is connected to the crankshaft 74 via the connecting rod 73. When the crankshaft 74 is rotated by the rotation of the drive shaft 75, the piston 72 reciprocates between a bottom dead center 72a and a top dead center 72b in the cylinder 71.

[0114] When the piston 72 reaches the bottom dead center 72a, the ball 76a opens and the ball 76b closes, so that ink is sucked into the ink supply device 2b through the inlet 78. When the piston 72 moves to the top dead center 72b, the ball 76a closes and the ball 76b opens, so that ink is sent out to the outside of the ink supply device 2b through the outlet 79.

[0115] The piston 72 corresponds to an example of the movable portion and an example of the translation body, and a path from the inlet 78 to the outlet 79 corresponds to an example of the channel.

[0116] The ink supply device 2b can send ink from the inlet 78 side to the outlet 79 side by repeating the operation described above. A sealing material such as rubber is used in a contact portion between the cylinder 71 and the piston 72, and the liquid feed amount decreases due to deterioration over time caused by wearing of the sealing material. In this case, at least one of the translation speed and the translation time of the piston 72 is obtained so that the liquid feed amount increases in accordance with the liquid feed amount of the ink. Thus, an effect similar to those of the first embodiment can be obtained.

[0117] Although some embodiments have been described above, embodiments of the present invention are not limited to the above-described embodiments specifically disclosed, and various modifications and changes can be made without departing from the scope of the claims.

[0118] The numbers such as ordinal numbers and numerical values that indicates quantity are all given by way of example to describe the technologies to implement the embodiments of the present disclosure, and no limitation is indicated to the numbers given in the above description. In addition, the above-describe connections among the components are examples for specifically describing the technology of the present invention, and connections for implementing functions of the present invention are not limited to the above-described examples.

[0119] Embodiments also include a liquid supply method. For example, a liquid supply method according to an embodiment of the present disclosure is a liquid supply method using a liquid supply device having a channel through which liquid is fed and a movable portion that is movable to feed the liquid, and includes a control step of controlling the movable portion. With such a liquid supply method, an effect similar to that of the above-described

liquid supply device can be obtained.

[0120] Each function of the embodiments described above can be implemented by one or more processing circuits. Here, the "processing circuit" in the present specification includes a processor programmed to execute each function by software like a processor implemented by an electronic circuit, and a device such as an application specific integrated circuit (ASIC), a digital signal processor (DSP), a field programmable gate array (FPGA), or a conventional circuit module designed to execute each function described above.

Claims

1. A liquid supply device (2, 2a, 2b), comprising:
 - a channel (21) through which liquid is to be fed;
 - a movable portion (22) configured to move to feed the liquid; and
 - a controller (100) configured to control the movable portion,
 - wherein the controller (100) is configured to control at least one of a moving speed and a moving time of the movable portion (22) in accordance with a liquid feed amount of the liquid fed through the channel (21) such that the liquid feed amount increases.
2. The liquid supply device according to claim 1, wherein the controller (100) is configured to control the at least one of the moving speed and the moving time in a stepwise manner in accordance with the liquid feed amount such that the liquid feed amount increases.
3. The liquid supply device according to claim 1 or 2,
 - wherein the movable portion (22) is a rotating body, and
 - wherein the controller is configured to control at least one of a rotation speed and a rotation time of the rotating body.
4. The liquid supply device according to claim 3, wherein the controller (100) is configured to control the at least one of the moving speed and the moving time based on a cumulative number of rotations of the rotating body.
5. The liquid supply device according to claim 1 or 2,
 - wherein the movable portion is a translation body, and
 - wherein the controller (100) is configured to control at least one of a translation speed and a translation time of the translation body.

6. The liquid supply device according to any one of claims 1 to 5,
wherein the controller (100) is configured to control the at least one of the moving speed and the moving time based on at least one of a cumulative supply time of the liquid by the liquid supply device.
7. The liquid supply device according to any one of claims 1 to 6,
wherein the liquid supply device is configured to supply the liquid stored in a storage unit (1) to a supply destination,
wherein the storage portion is replaceable disposed, and
wherein the controller is configured to control the at least one of the moving speed and the moving time based on a cumulative number of times of replacement of the storage unit.
8. The liquid supply device according to any one of claims 1 to 7, further comprising a selection-value reception unit (117) configured to receive a selection value of the at least one of the moving speed and the moving time selected by an operator of the liquid supply device,
wherein the controller is configured to control the at least one of the moving speed and the moving time based on the selection value.
9. The liquid supply device according to any one of claims 1 to 8,
wherein the controller is configured to return the at least one of the moving speed and the moving time to an initial state when the liquid supply device is replaced.
10. A liquid discharge apparatus (110), comprising:
the liquid supply device according to any one of claims 1 to 7; and
a liquid discharge device (341) configured to discharge the liquid supplied from the liquid supply device.
11. The liquid discharge apparatus according to claim 10,
wherein the controller is configured to control the at least one of the moving speed and the moving time based on a flow velocity of the liquid supplied from the liquid supply device to the liquid discharge device.
12. The liquid discharge apparatus according to claim 11,
wherein the controller is configured to control the at least one of the moving speed and the moving time based on at least one of a cumulative discharge
- amount of the liquid by the liquid discharge device and a type of the liquid discharged by the liquid discharge device.
13. The liquid discharge apparatus according to claim 11 or 12,
wherein the liquid discharge device includes an in-head storage unit (31) configured to store the liquid, and
wherein the controller is configured to control the at least one of the moving speed and the moving time based on a liquid feeding time until an amount of the liquid stored in the in-head storage unit reaches a full state from a lower limit value by liquid feeding from the liquid supply device.
14. A liquid supply method to be performed by a liquid supply device that includes a channel (21) through which liquid is fed and a movable portion (22) to move to feed the liquid, the method comprising controlling the movable portion,
wherein the controlling includes controlling at least one of a moving speed and a moving time of the movable portion in accordance with a liquid feed amount of the liquid fed through the channel such that the liquid feed amount increases.

FIG. 1

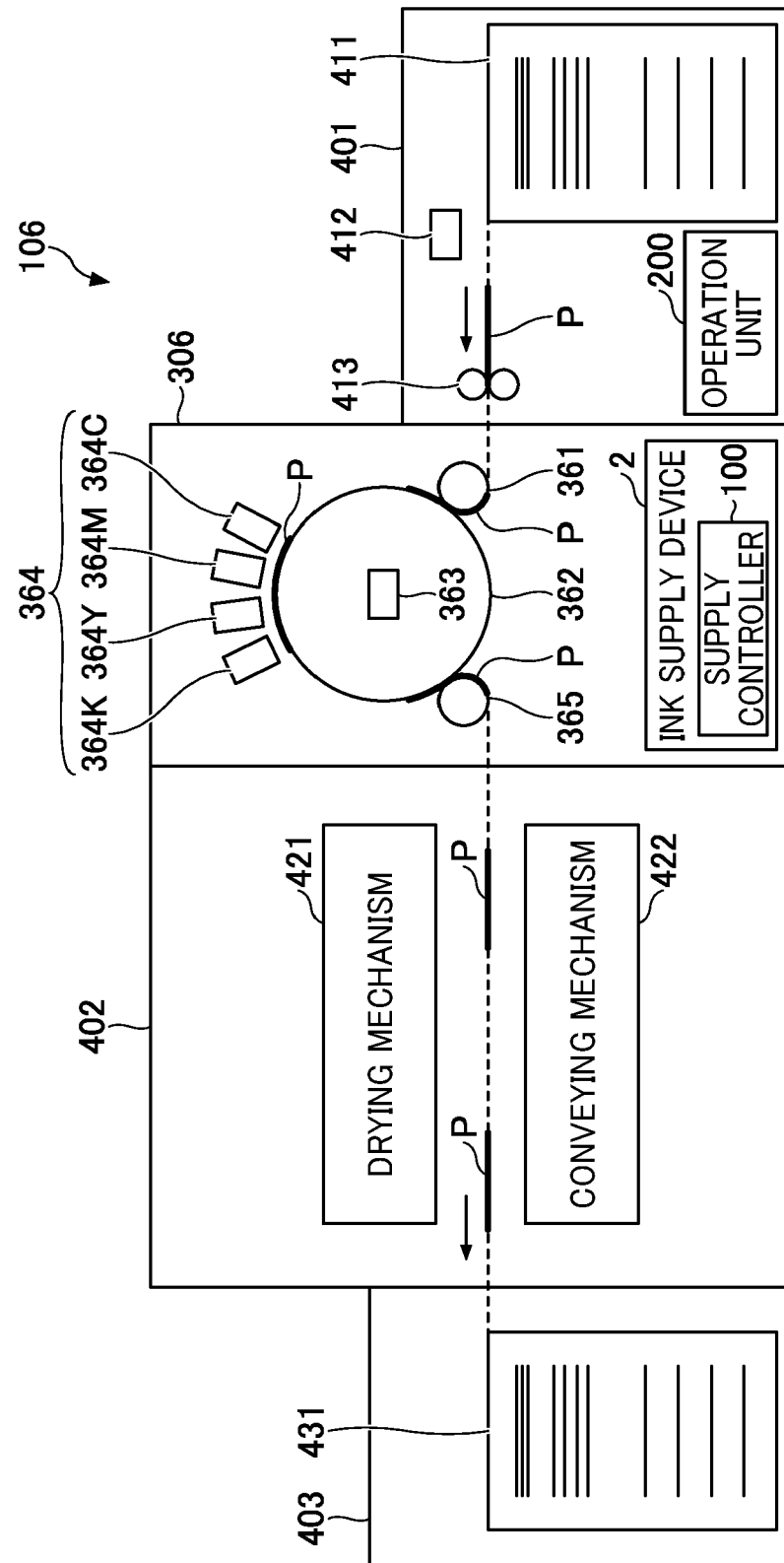


FIG. 2

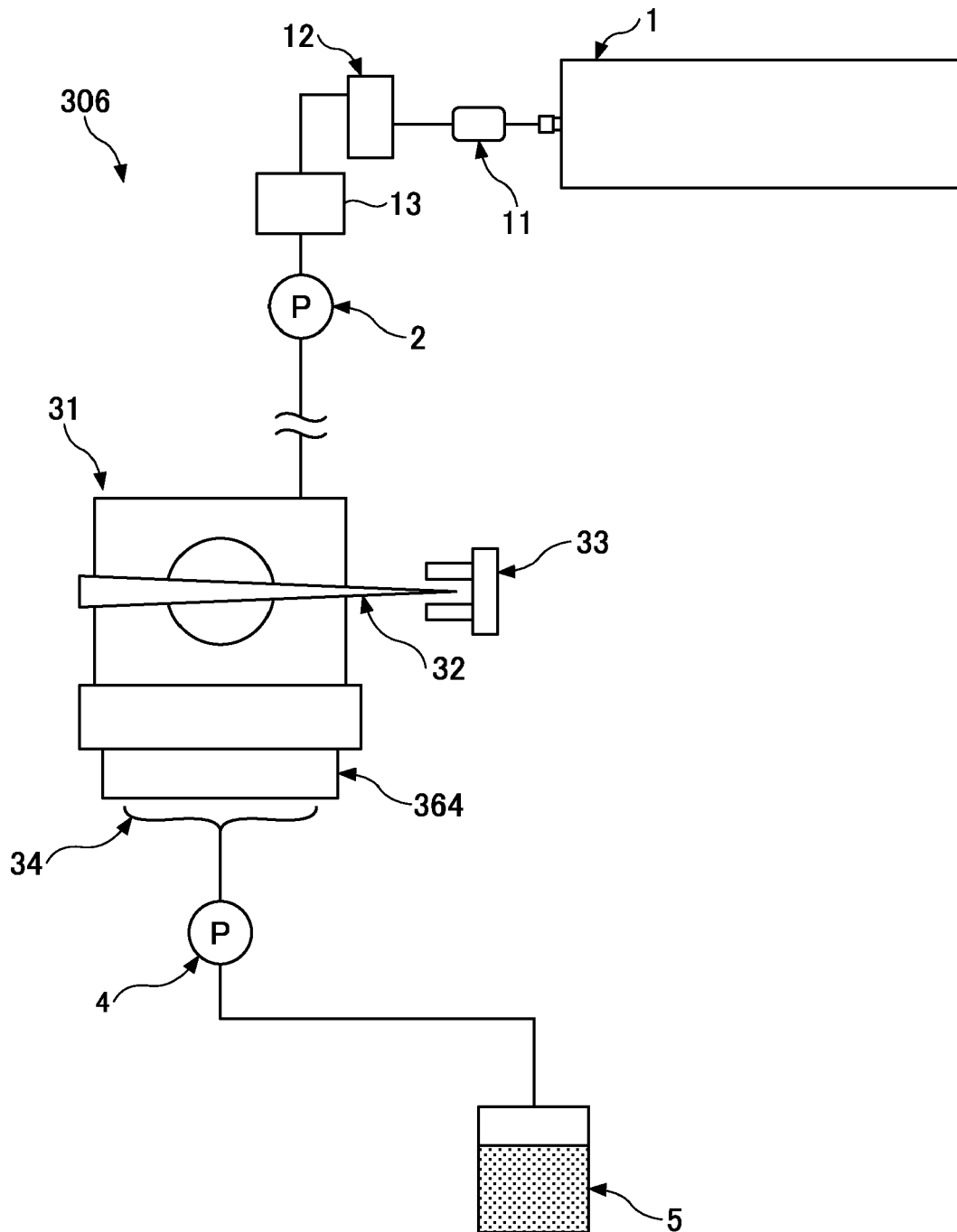


FIG. 3

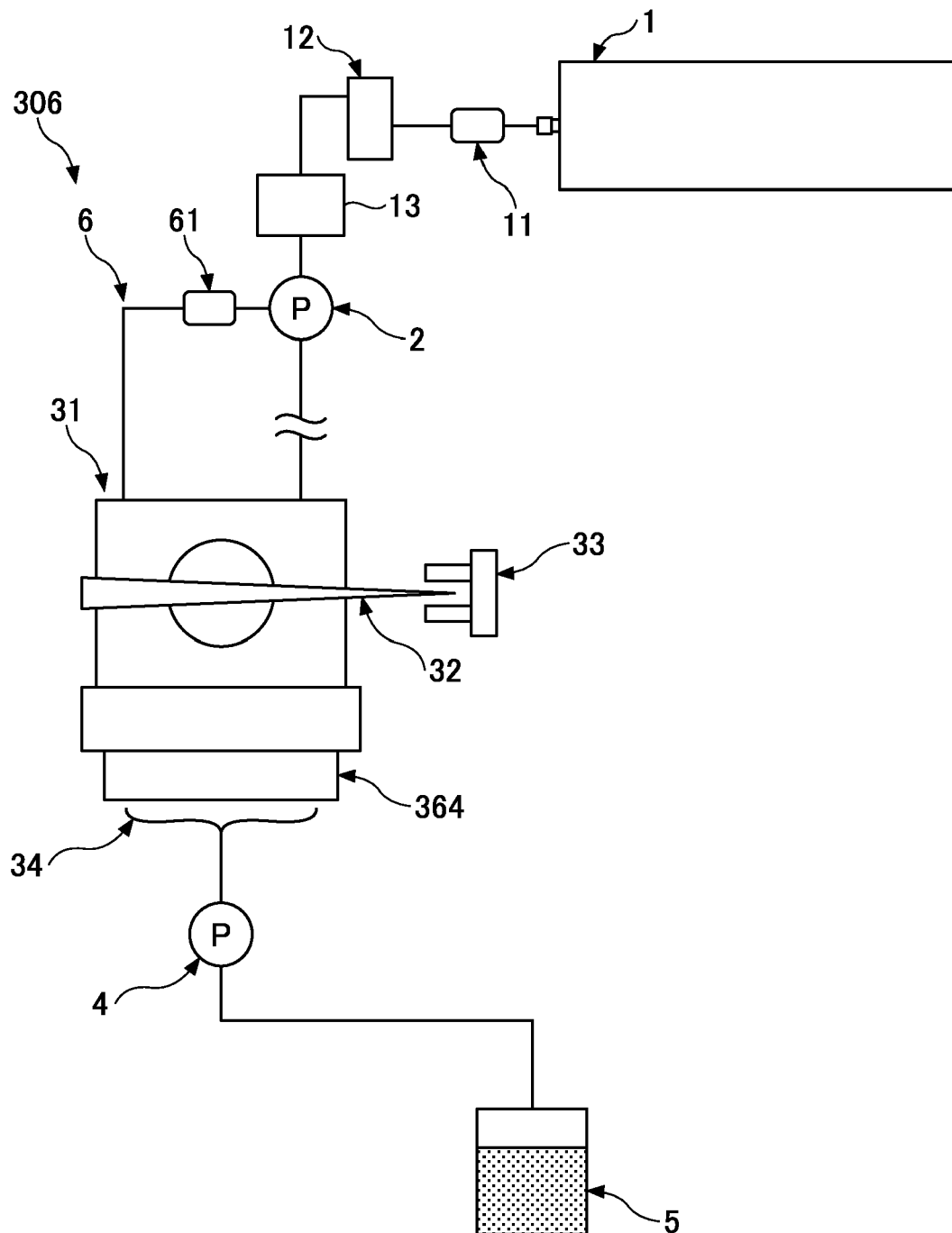


FIG. 4A

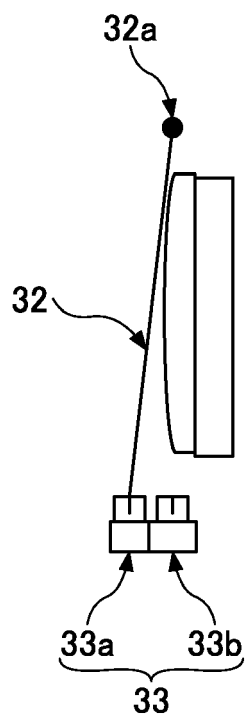
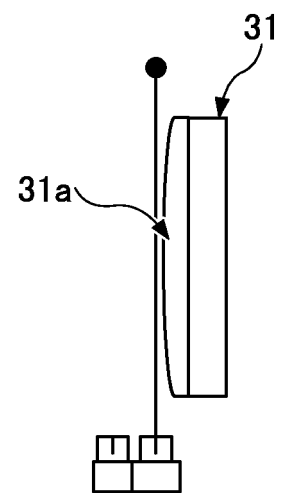


FIG. 4B



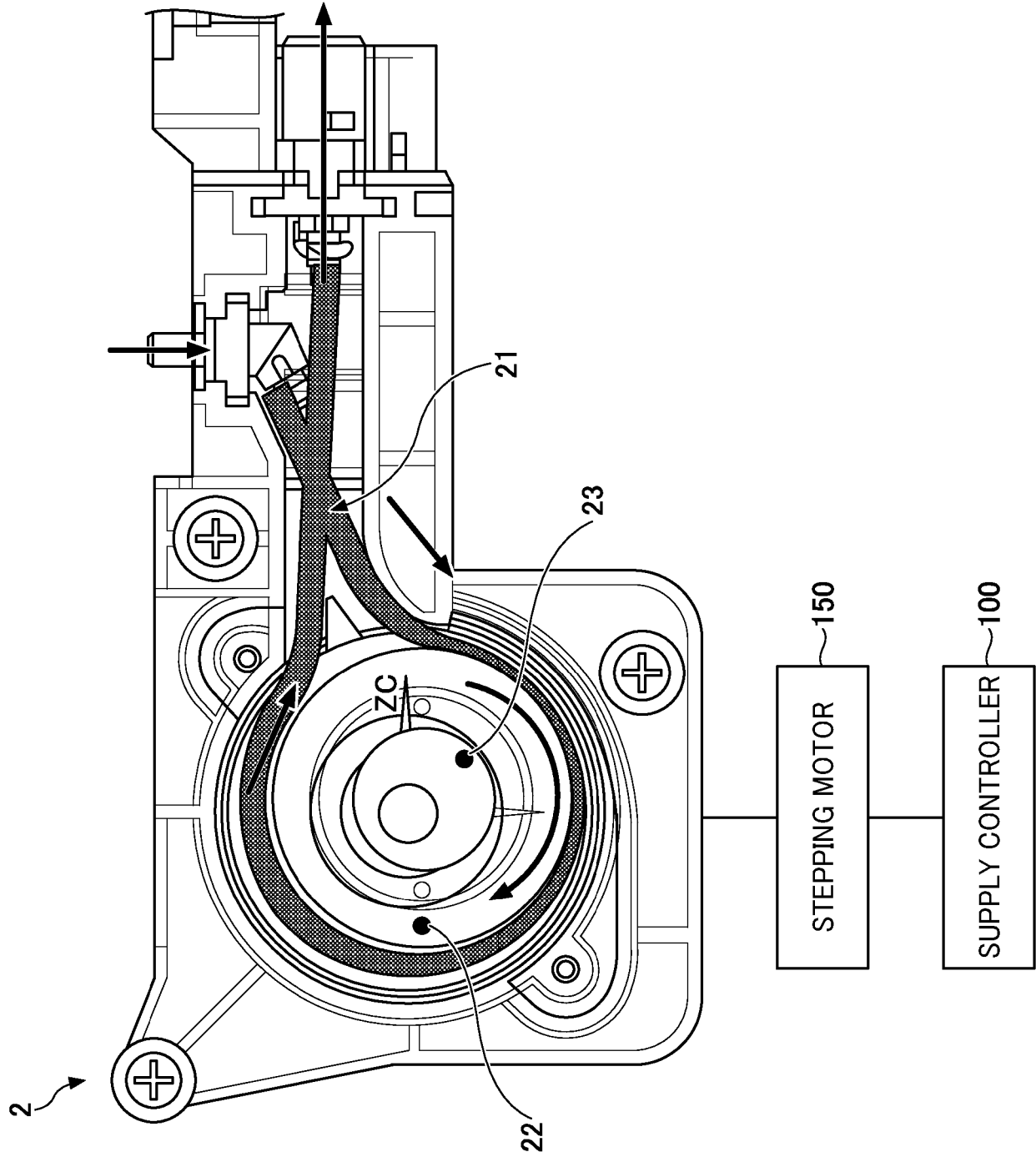


FIG. 5

FIG. 6

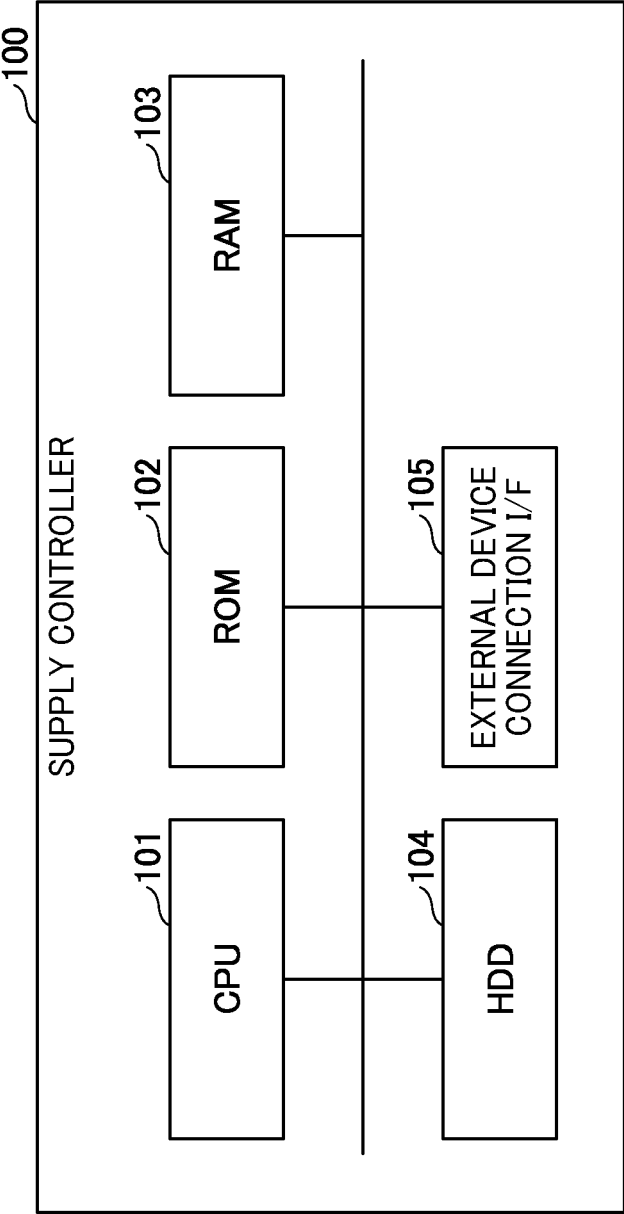


FIG. 7

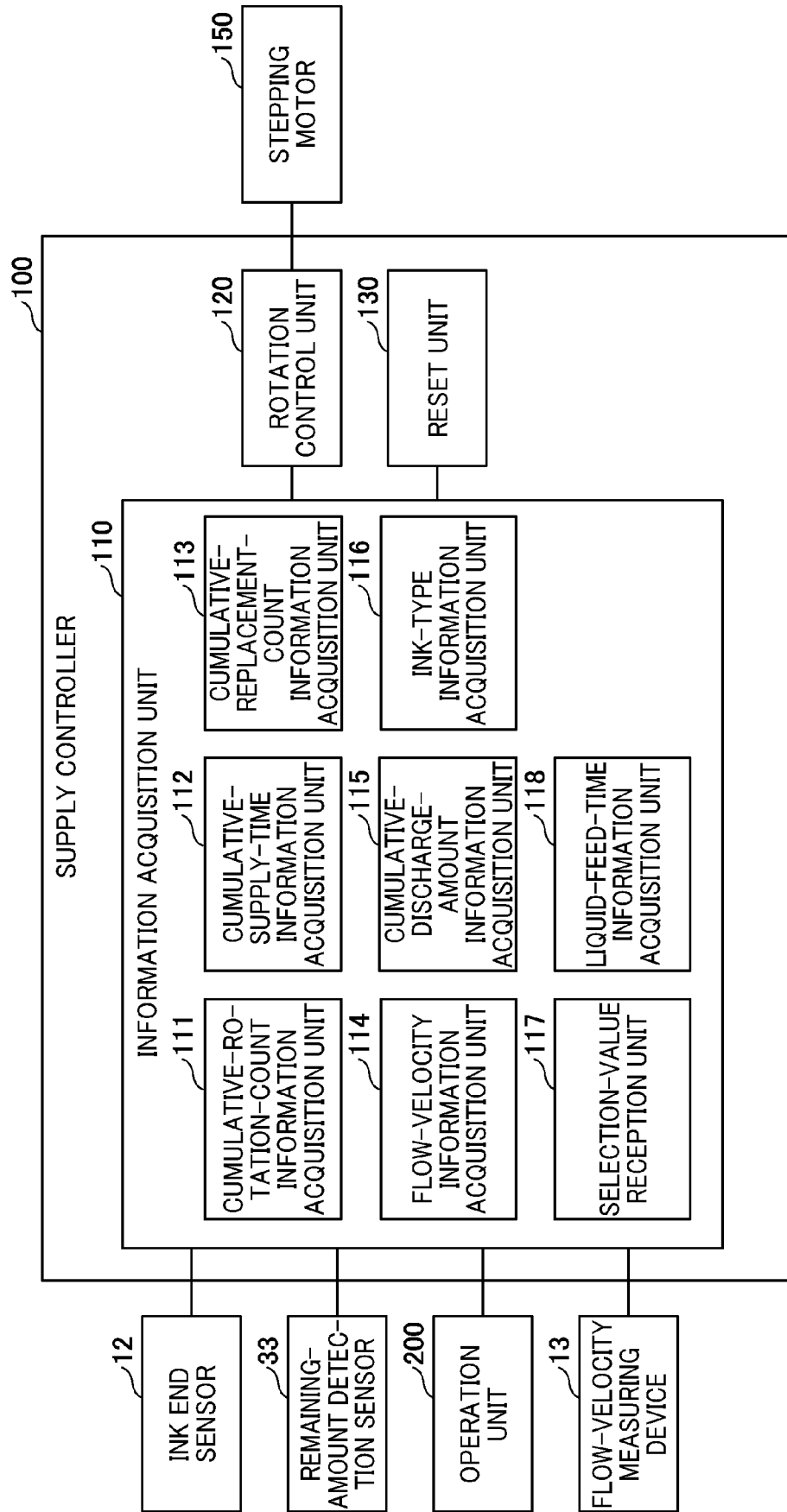


FIG. 8

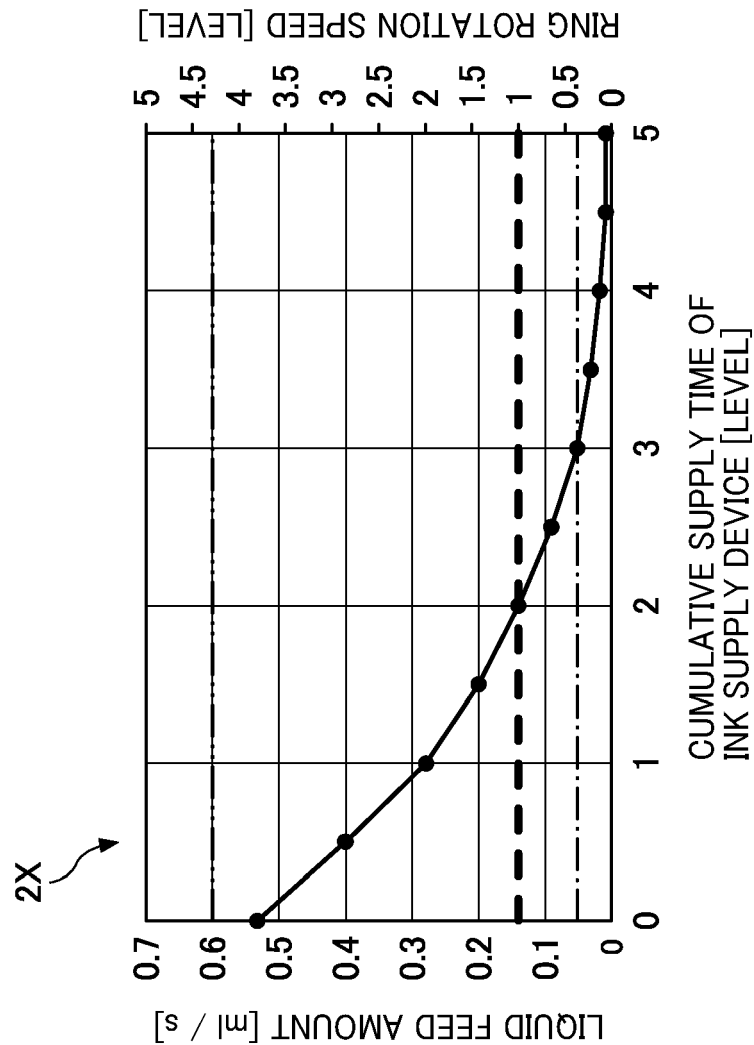


FIG. 9

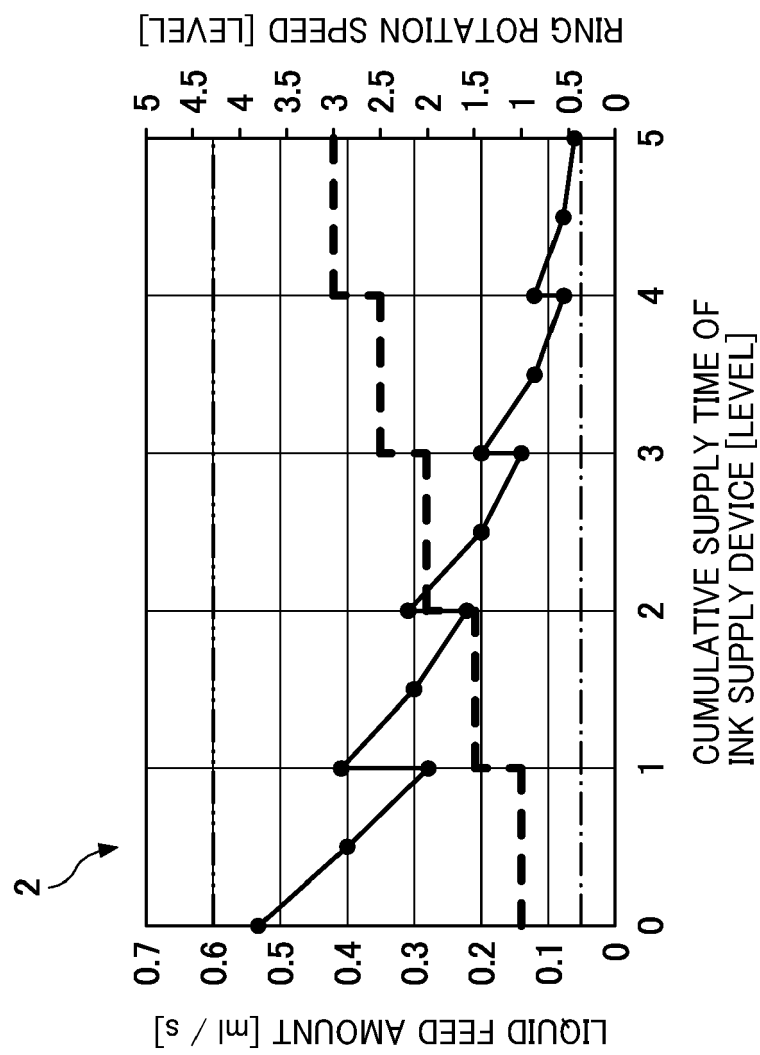


FIG. 10

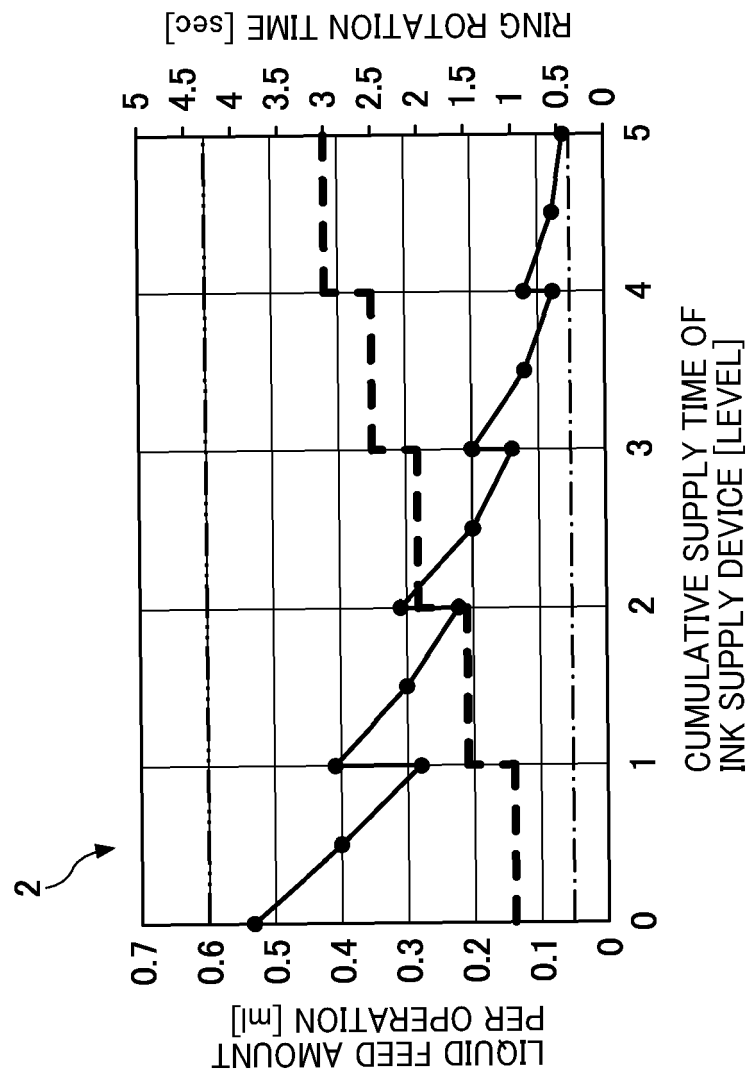


FIG. 11

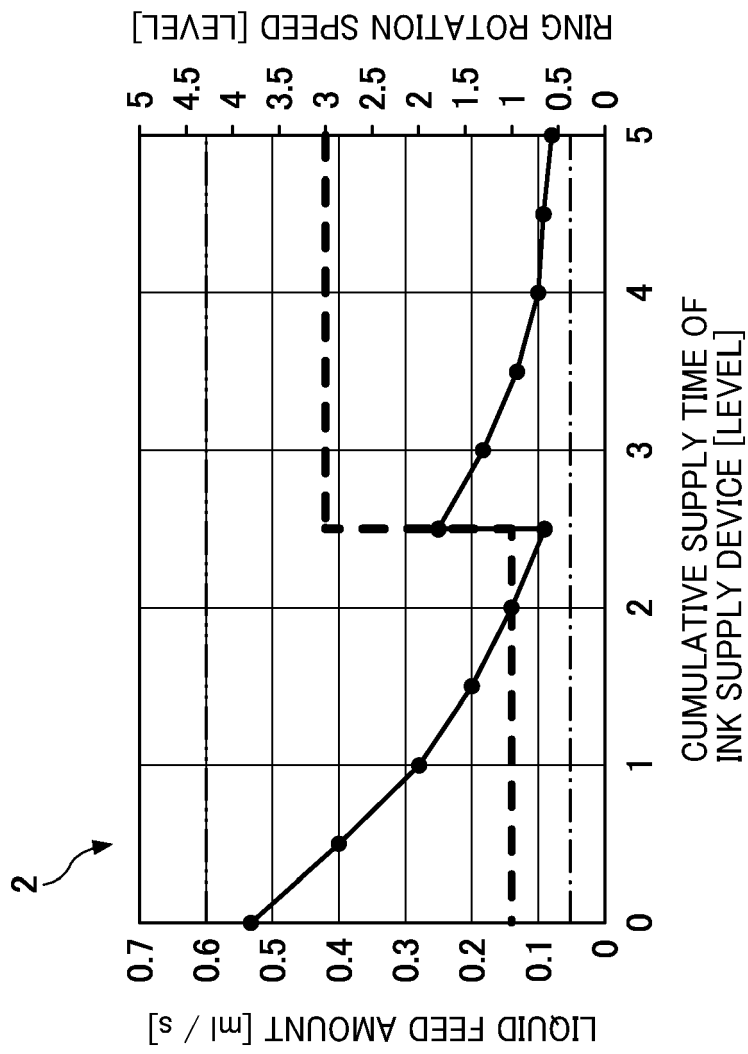


FIG. 12

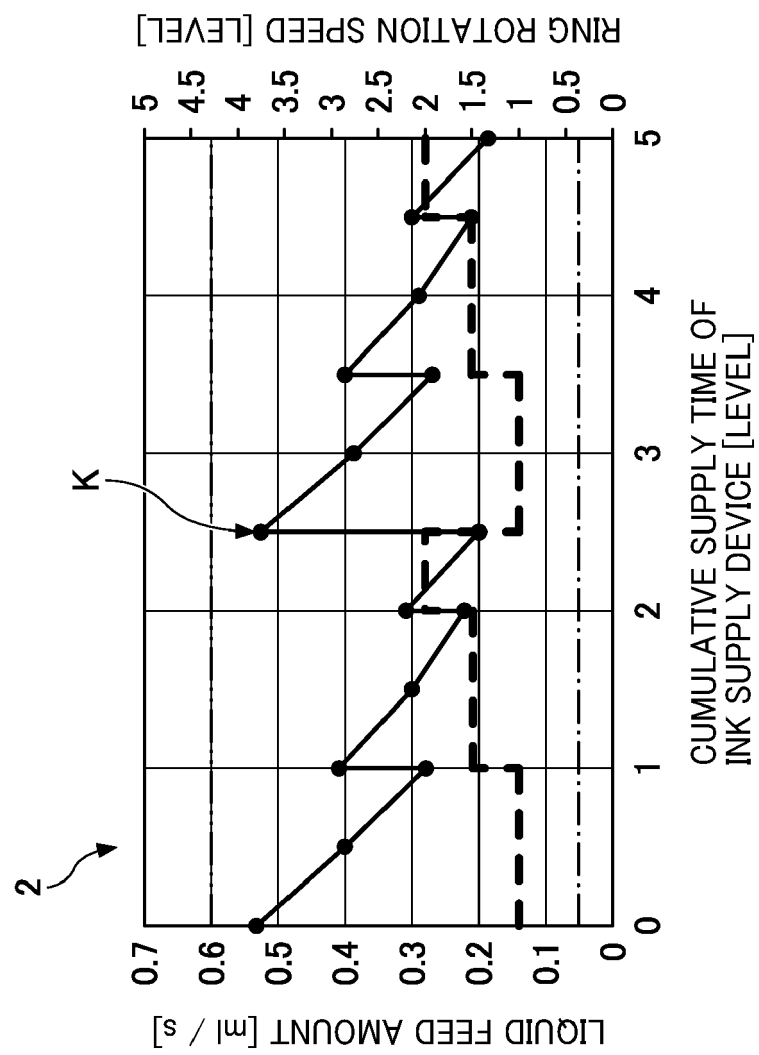


FIG. 13

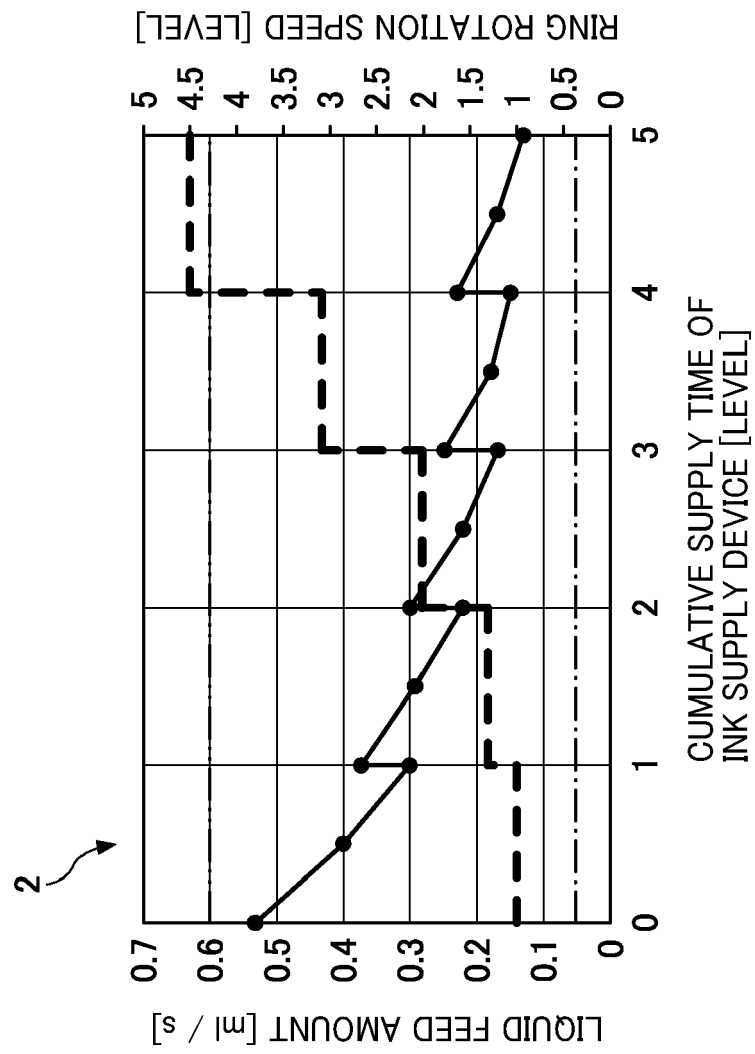


FIG. 14A

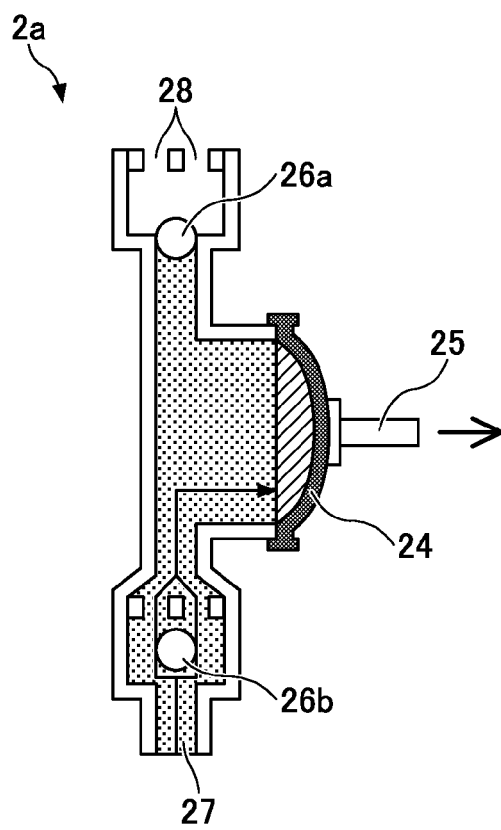


FIG. 14B

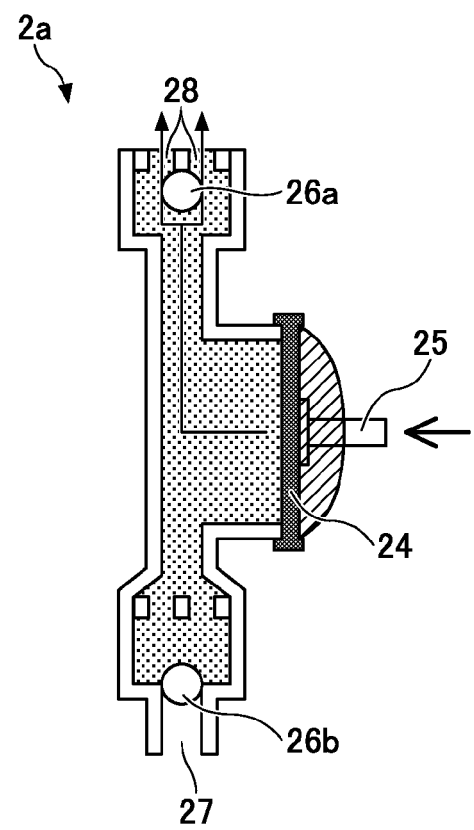
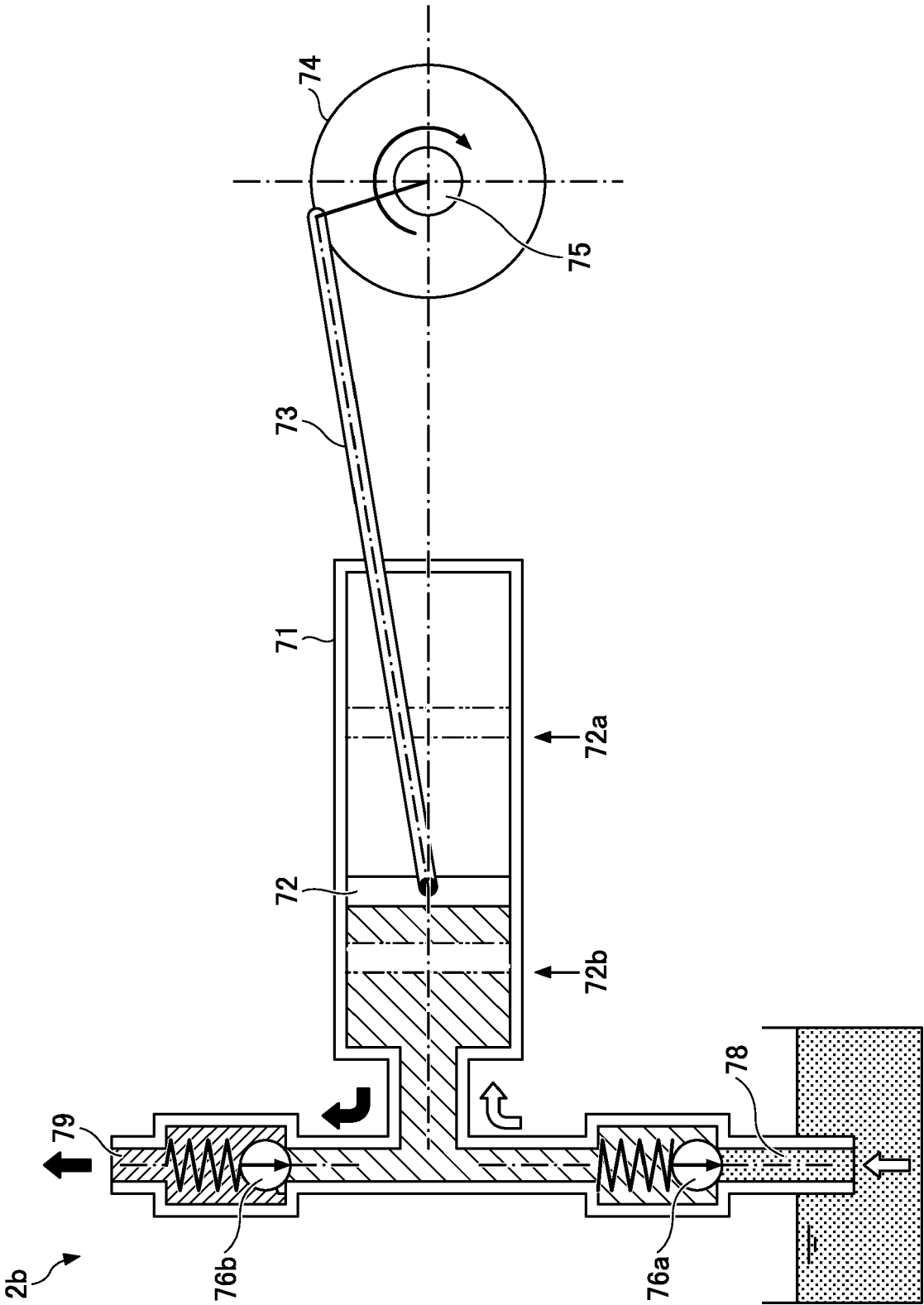


FIG. 15





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