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Liquid discharge apparatus

Abstract

A liquid discharge apparatus includes a liquid discharge head configured to discharge liquid. The liquid discharge apparatus includes a reservoir configured to store liquid to be supplied to the liquid discharge head. The reservoir is provided at a position lower than the liquid discharge head. The liquid discharge apparatus includes a supply flow path configured to communicate with the liquid discharge head and the reservoir. The supply flow path is provided with a joint detachable from the liquid discharge head. The liquid discharge apparatus includes a retainer configured to retain the joint detached from the liquid discharge head. The joint has a coupler to be coupled to the liquid discharge head. The retainer is configured to retain the joint with the coupler facing up.

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Background/Summary

(1) The present application is based on, and claims priority from JP Application Serial Number 2022-028221, filed Feb. 25, 2022, the disclosure of which is hereby incorporated by reference herein in its entirety.

BACKGROUND

1. Technical Field

(2) The present disclosure relates to a liquid discharge apparatus including a liquid discharge head that discharges liquid supplied from a reservoir in which liquid is stored.

2. Related Art

(3) JP-A-2016-175279 discloses an ink jet printer as an example of a liquid discharge apparatus including a liquid discharge head that discharges liquid such as ink. This kind of liquid discharge apparatus includes a reservoir to store liquid. The reservoir and the liquid discharge head are coupled via a supply flow path. The liquid discharge head performs printing on a medium by discharging the liquid supplied from the reservoir through the supply flow path.

(4) In the liquid discharge apparatus described in JP-A-2016-175279, the liquid discharge head is replaceable. The liquid discharge apparatus includes a joint at the leading end of the supply flow path extending from the reservoir. A coupler of the joint is detachably coupled to a female coupler provided in the liquid discharge head. When the liquid discharge head is replaced, the joint is

detached from the liquid discharge head.
(5) However, in the liquid discharge apparatus described in JP-A-2016-175279, the supply flow path is retained by a retainer with the coupler of the joint detached from the liquid discharge head facing in a horizontal direction. For this reason, liquid such as ink may drip from the coupler of the joint. The dripping of liquid may contaminate the components in the body of the liquid discharge apparatus and located below the joint. Note that when the liquid in the reservoir is emptied once, the dripping of liquid from the joint may be prevented, but extra work of emptying the reservoir is necessary.
SUMMARY
(6) A liquid discharge apparatus to solve the above-mentioned problem includes: a liquid discharge head configured to discharge liquid; a reservoir provided at a position lower than the liquid discharge head, and configured to store liquid to be supplied to the liquid discharge head; a supply flow path provided with a joint detachable from the liquid discharge head, and configured to communicate with the liquid discharge head and the reservoir; and a retainer configured to retain the joint detached from the liquid discharge head. The joint has a coupler to be coupled to the liquid discharge head, and the retainer is configured to retain the joint with the coupler facing up.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a perspective view illustrating a liquid discharge apparatus in a first embodiment.
(2) FIG. **2** is a schematic front cross-sectional view illustrating the internal configuration of the liquid discharge apparatus.
(3) FIG. **3** is a schematic front cross-sectional view for explaining a moving mechanism of the liquid discharge head.
(4) FIG. **4** is a schematic front view for explaining a configuration related to replacement work of the liquid discharge head.
(5) FIG. **5** is a schematic front view illustrating a state where a joint is placed on a retainer.
(6) FIG. **6** is a schematic view of a liquid supply unit.
(7) FIG. **7** is a schematic cross-sectional view illustrating a variable capacity mechanism in an initial state.
(8) FIG. **8** is a schematic cross-sectional view illustrating the variable capacity mechanism in a state where liquid is sucked.
(9) FIG. **9** is a flowchart illustrating a liquid dripping prevention control routine.
(10) FIG. **10** is a flowchart illustrating a liquid dripping prevention control routine in a second embodiment.
DESCRIPTION OF EXEMPLARY EMBODIMENTS
First Embodiment
(11) Hereinafter a first embodiment of a liquid discharge apparatus will be described with reference to the drawings. The liquid discharge apparatus is, for example, an ink jet printer that performs printing by discharging ink, which is an example liquid, on a medium such as a sheet of paper.
(12) In the drawings, a liquid discharge apparatus **11** is assumed to be placed on a horizontal surface, and the direction of gravity is indicated by the Z-axis, and the direction along the horizontal surface is indicated by the X-axis and the Y-axis. The X-axis, the Y-axis, and the Z-axis are perpendicular to each other. The X-axis indicates the depth direction of the liquid discharge apparatus **11**, and the Y-axis indicates the width direction of the liquid discharge apparatus **11**. The direction parallel to the X-axis is also the width direction of a medium M, thus may be referred to as the width direction X.
(13) Entire Configuration of Liquid Discharge Apparatus

(14) As illustrated in FIG. **1**, the liquid discharge apparatus **11** is, for example, a multifunction printer. The liquid discharge apparatus **11** includes an apparatus body **12** in a cuboid shape. The apparatus body **12** forms an ink jet printer. In this example in which the liquid discharge apparatus **11** is a multifunction printer, an image reader **13** is provided above the apparatus body **12**.
(15) The image reader **13** includes a reader **13**A that reads a document D, and an automatic document feeder **13**B that feeds the document D. The automatic document feeder **13**B feeds a document D placed on a document tray **13**C to the reader **13**A, and discharges the document D read by the reader **13**A to a discharge tray **13**D. In addition, the image reader **13** also has a flatbed reading function of the reader **13**A of reading a document D set on a platen which is exposed when the automatic document feeder **13**B also serving as a platen cover is opened.
(16) The liquid discharge apparatus **11** may include a media storage **14** that can store a plurality of media M. The media storage **14** is, for example, a cassette. In this situation, the media storage **14** is provided as one drawer or several drawers (for example, four drawers in FIG. **1**). When the media storage **14** is a cassette, it is inserted below the apparatus body **12** by sliding in the X direction in a state where the media storage **14** is detachable. In a plurality of media storages **14**, for example, media M having different sizes or types are stored. Note that in addition to or in replacement of the media storage **14**, as a media supply unit, the liquid discharge apparatus **11** may include a media placement unit **14**A, such as a paper feed tray, on which media M can be placed.
(17) As illustrated in FIG. **1**, the apparatus body **12** has a liquid discharge head **20** that can discharge liquid. The liquid discharge head **20** prints an image on a medium M by discharging ink as an example of liquid to the medium M fed from the media storage **14**. In the apparatus body **12**, liquid storages **82** (see FIG. **2**) are housed, which store ink as an example of liquid. The liquid discharge head **20** performs printing on the medium M using the liquid such as ink supplied from the liquid storages **82**. The liquid discharge apparatus **11** of this embodiment allows replacement of the liquid discharge head **20**. The details of replacement work of the liquid discharge head **20** will be described later.
(18) The liquid discharge apparatus **11** includes a stacker **18** that receives media M after printing. The liquid discharge apparatus **11** has a depressed section **12**A between the apparatus body **12** and the image reader **13**. The stacker **18** is comprised of the depressed section **12**A, and a discharge tray **18**A mounted on the bottom of the depressed section **12**A. The discharge tray **18**A is a member in a rectangular plate shape. In this embodiment, the discharge tray **18**A is mounted in a state where it is detachable from the apparatus body **12**. A medium M after printing discharged from the apparatus body **12** into the depressed section **12**A is placed on the upper surface (placement surface) of the discharge tray **18**A. The discharge tray **18**A is inclined by a predetermined angle in a direction in which a downstream position in a discharge direction in which a printed medium M is discharged is higher than an upstream position.
(19) The liquid discharge apparatus **11** may have a display unit **19** in the apparatus body **12**. The display unit **19** is comprised of, for example, a touch panel. A touch operation function of the display unit **19** may serve as an operation section **19**A. A user can give instructions to the liquid discharge apparatus **11** by operating the operation section **19**A. In addition, the liquid discharge apparatus **11** includes a power button **19**B which is operated to turn on/off a power supply. Note that the operation section **19**A may be an operation button provided separately from the display unit **19**.
(20) The liquid discharge apparatus **11** includes a controller **100** that is responsible for the control of the entire apparatus. The controller **100** performs a plurality of types of control including print control to control a printing mechanism including the liquid discharge head **20**, read control to control the image reader **13**, and display control to control the display unit **19**. The controller **100** includes a computer which is not illustrated. The computer is configured to include a central processing unit (CPU), and a memory which are not illustrated. The CPU is an arithmetic processing unit. The memory is a storage device that ensures an area to store the program of the

CPU or a work area, and has a memory device and a storage, such as a random access memory (RAM), and an electrically erasable programmable read-only memory (EEPROM). The CPU controls the operation of the components of the liquid discharge apparatus **11** in accordance with the program stored in the memory.

(21) In the liquid discharge apparatus **11** of this embodiment, the liquid discharge head **20** can be replaced by an operator such as a serviceman or a user. An operator selects a service mode by operating the operation section **19**A on a menu screen displayed on the display unit **19**, and further selects head replacement.

(22) When receiving input of a signal indicating the service mode, the controller **100** shifts from the print mode to the service mode. When receiving head replacement instructions in the service mode, the controller **100** causes the liquid discharge head **20** to move from the current position (for example, a cap position) to a replacement position PH**2** (see FIG. **3**) below the discharge tray **18**A. The liquid discharge head **20** can be detached from the apparatus body **12** by an operator detaching the discharge tray **18**A. After the liquid discharge head **20** is moved to the replacement position PH**2**, an operator may operate the power button **19**B to achieve a power OFF state, and may perform head replacement work in the power OFF state. In addition, an operator may detach the liquid discharge head **20** from the apparatus body **12** for the purpose of maintenance or investigation of a cause of a failure.

(23) Internal Configuration of Liquid Discharge Apparatus **11**

(24) Next, the internal configuration of the liquid discharge apparatus **11** will be described with reference to FIG. **2**. As illustrated in FIG. **2**, the media storage **14** can store a plurality of media M in a stacked state. The liquid discharge apparatus **11** includes a feeder **15** that feeds a medium M from the media storage **14**, and a transporter **17** that transports a medium M along a transport path **16** indicated by a dashed-dotted line in FIG. **2**. The transport path **16** is a path connecting the media storage **14** and the stacker **18**.

(25) The feeder **15** may include a feed roller **23** that feeds a medium M stored in the media storage **14**, and a separator **24** that separates the media M sheet by sheet. The feeder **15** delivers a medium M stored in the media storage **14** to the transport path **16**.

(26) The transporter **17** may include transport rollers **26**, an endless-shaped transport belt **27**, and a pair of rollers **28** around which the transport belt **27** is wound. The transporter **17** may include a plurality of transport rollers **26**. The transport rollers **26** rotate with a medium M held therebetween, thereby transporting the medium M.

(27) The transport belt **27** has a transport surface **27***a* for transporting the medium M. The transport surface **27***a* is a planar part of the outer peripheral surface of the transport belt **27** for supporting the medium M, for example, by electrostatic adsorption. The transport belt **27** may be provided so that the transport surface **27***a* is inclined to a horizontal plane. In this embodiment, the direction which is along the transport surface **27***a*, and in which the medium M is transported is referred to as a transport direction Dc. The transport belt **27** circumferentially rotates with the medium M supported by the transport surface **27***a*, thereby transporting the medium M in the transport direction Dc.

(28) The liquid discharge head **20** has a nozzle surface **21**A in which nozzles **21**N for discharging liquid are opened. The liquid discharge head **20** discharges liquid through the nozzles **21**N, thereby performing printing on the medium M supported by the transport surface **27***a* of the transport belt **27**. The liquid discharge head **20** of this embodiment is a line type that can discharge liquid in the width direction X of the medium M. The liquid discharge head **20** is mounted so that the longitudinal direction of the liquid discharge head **20** matches the width direction X of the medium M.

(29) As illustrated in FIG. **2**, the liquid discharge apparatus **11** includes a liquid supply unit **80** that can supply liquid to the liquid discharge head **20**. The liquid discharge apparatus **11** includes a frame **12**C that stores the liquid discharge head **20** and the liquid supply unit **80**. In the frame **12**C,

an opening HL is formed, which allows the liquid supply unit **80** to pass in the depth direction X.
(30) The liquid supply unit **80** includes a liquid supply member **81**, a supply flow path **87**, and a joint **88** provided at the leading end of the supply flow path **87**. The joint **88** is coupled to a female coupler **22** provided in the liquid discharge head **20**.
(31) The liquid supply member **81** includes a mounting section **83** on which the liquid storages **82** storing liquid are detachably mounted. The mounting section **83** has needle sections **84**. Each liquid storage **82** mounted on the mounting section **83** can supply liquid by being inserted in a corresponding needle section **84**. The liquid supply member **81** includes a supply mechanism **85** that can store the liquid supplied from the liquid storages **82** through the mounting section **83**, and can supply the stored liquid to the liquid discharge head **20** through the supply flow path **87**.
(32) The liquid discharge apparatus **11** includes reservoirs **86** configured to store the liquid to be supplied to the liquid discharge head **20**. The reservoirs **86** of this embodiment are provided in the supply mechanism **85**, and store the liquid supplied from the liquid storages **82** through the mounting section **83**. In this respect, the liquid storages **82** in this example stores the liquid to be supplied to the reservoirs **86**.
(33) Each reservoir **86** is provided at a position lower than the liquid discharge head **20**. The liquid discharge head **20** in this example is configured to be movable along a movement path through a print position PH**1** and a replacement position PH**2** (see FIG. **3**) which are different in height position in the vertical direction Z. In a state where the liquid discharge head **20** is at the print position PH**1** which is the lowest position illustrated in FIG. **2** on the movement path, the position of the liquid level of the liquid in the reservoir **86** is lower than the position of the nozzle surface **21**A of the liquid discharge head **20**.
(34) The liquid discharge apparatus **11** includes the supply flow path **87** configured to communicate with the liquid discharge head **20** and the reservoirs **86**. The supply flow path **87** is provided with the joint **88** which is detachable from the liquid discharge head **20**.
(35) The supply flow path **87** is coupled to the supply mechanism **85** at one end, and is coupled to the joint **88** at the other end. The one end of the supply flow path **87** is coupled to the reservoirs **86** included in the supply mechanism **85**. The reservoirs **86** are provided as many as the number of types of liquid discharged by the liquid discharge head **20**.
(36) The plurality of liquid storages **82** may store liquid which are different types from each other. The plurality of liquid storages **82** may store, for example, ink of different colors. For example, the plurality of liquid storages **82** store ink in cyan, magenta, yellow, black. The plurality of liquid storages **82** may have different amounts of stored liquid. For example, the liquid storage **82** that stores black ink may have a greater amount of stored liquid than any liquid storage **82** that stores ink of another color.
(37) The liquid stored in the plurality of liquid storages **82** is individually supplied to the plurality of corresponding reservoirs **86** through the mounting section **83**. Different types of liquid are stored in the plurality of reservoirs **86**. The supply flow path **87** is provided for each of the types of liquid supplied from the plurality of reservoirs **86** to the liquid discharge head **20**.
(38) The supply flow path **87** is configured to have a variable section **87**A which is deformable for a predetermined length from the joint **88**. The supply flow path **87** may have a fixed section **87**B in part of the extension from the reservoir **86** to the variable section **87**A, the fixed section **87**B being retained in a state unlikely to be deformed. The fixed section **87**B of the supply flow path **87** is a communicating hole formed as a flow path in a flow path member made of a synthetic resin, or is comprised of a tube held by a guide member. The variable section **87**A of the supply flow path **87** is formed of a material having flexibility, and is a flow path composed of, for example, a synthetic resin or rubber having elasticity. The variable section **87**A of the supply flow path **87** is comprised of a tube, for example. Note that at least part of the supply flow path **87** may be a deformable variable section **87**A, or the entirety thereof may be the variable section **87**A. The variable section **87**A is not limited to a tube having flexibility, and may be bellows or the like.

(39) The female coupler **22**, to which the joint **88** is detachably coupled, is fixed to the liquid discharge head **20**. The joint **88** is coupled to the female coupler **22**, thus the reservoir **86** and the liquid discharge head **20** are coupled to each other through the supply flow path **87**.
(40) Regarding the joint **88**, a plurality of supply flow paths **87** may be collectively coupled to the liquid discharge head **20** by one joint **88**. Alternatively, the joints **88** may be provided as many as the number of the supply flow paths **87**. In the following, a description will be given using an example of a configuration in which one joint **88** collectively couples the plurality of supply flow paths **87** to the liquid discharge head **20**.
(41) As illustrated in FIG. **2**, the liquid discharge apparatus **11** includes a retainer **90** that can retain the joint **88** detached from the liquid discharge head **20**. The retainer **90** is located on the lower side of the discharge tray **18**A. The retainer **90** is disposed at a position such that when the discharge tray **18**A is detached for head replacement, the retainer **90** is exposed through an opening **12**D. In the example illustrated in FIG. **2**, the retainer **90** is fixed to the upper surface of a frame unit **12**F having a horizontal surface disposed above an area in which the plurality of liquid storages **82** are disposed in the frame **12**C. The configuration including the retainer **90** provided in the liquid discharge apparatus **11** for head replacement will be described later.
(42) In the liquid supply member **81**, part of the mounting section **83** and the supply flow path **87** is located rearward of the opening HL in the depth direction X. Thus, when viewing the opening HL from a position forward of the frame **12**C, an operator can get a view of part of the reservoir **86** through the opening HL. The reservoir **86** has a window made of a transparent synthetic resin at the front in FIG. **2**, and a user can visually check the remaining amount of liquid in the reservoir **86** through the window.
(43) The liquid discharge apparatus **11** includes a maintenance unit **95** that performs maintenance of the liquid discharge head **20**. In addition, the liquid discharge apparatus **11** includes a waste liquid storage **97** that stores, as waste liquid, the liquid discharged from the liquid discharge head **20** due to maintenance. The maintenance unit **95** is coupled to the waste liquid storage **97** through unillustrated pump and waste liquid flow path to deliver, as waste liquid, the liquid discharged from the liquid discharge head **20** due to maintenance. Both ends of the waste liquid flow path are coupled to the maintenance unit **95** and a needle section **98** of the waste liquid storage **97**. The liquid discharge apparatus **11** includes a tray **99** on which the supply mechanism **85** and the waste liquid storage **97** are placed. The tray **99** houses a liquid absorbing member (not illustrated) that can absorb liquid.
(44) Moving Mechanism of Liquid Discharge Head **20**
(45) Next, referring to FIG. **3**, the moving mechanism of the liquid discharge head **20** will be described. As illustrated in FIG. **3**, the liquid discharge head **20** is movable in B direction which is a direction opposed to the transport surface **27***a*. The B direction may be inclined to a horizontal plane by a predetermined angle. The liquid discharge apparatus **11** includes a guide rail **101** that movably guides the liquid discharge head **20** in the B direction. The liquid discharge head **20** includes guide rollers **20**R engaged with the guide rail **101**. A plurality of guide rollers **20**R are guided to the guide rail **101**, thus the liquid discharge head **20** is moved in the B direction.
(46) As illustrated in FIG. **3**, the liquid discharge apparatus **11** includes a moving mechanism **110** that causes the liquid discharge head **20** to move in the B direction. The moving mechanism **110** is, for example, a rack and pinion mechanism. The moving mechanism **110** is configured to include a rack **111** and a drive gear **112**, for example. The drive gear **112** is driven by the power of a motor **113** that is a drive source of the moving mechanism **110**. When motor **113** is driven in a normal direction, the liquid discharge head **20** is moved in +B direction. In contrast, when the motor **113** is driven in a reverse direction, the liquid discharge head **20** is moved in −B direction. The liquid discharge head **20** is moved in a movement direction (±B direction), and placed at the print position PH**1** (FIG. **2**) and the replacement position PH**2**.
(47) The print position PH**1** is the position of the liquid discharge head **20** when printing is

performed on the medium M. The replacement position PH**2** is the position when the liquid discharge head **20** is replaced. As illustrated in FIG. **3**, the liquid discharge apparatus **11** includes guide rails **102**,**103** for replacement to detach or attach the liquid discharge head **20** from or to the apparatus body **12** at the replacement position PH**2**. Note that as other stop positions of the liquid discharge head **20**, there are a cap position and a retreat position on the movement path between the print position PH**1** and the replacement position PH**2**.
(48) The maintenance unit **95** illustrated in FIG. **3** includes a cap unit **115** having a cap **116**. The cap **116** is capable of capping to cover the nozzles **21**N by coming into contact with the nozzle surface **21**A of a head **21**.
(49) As illustrated in FIG. **3**, the liquid discharge apparatus **11** includes a moving mechanism **120** that causes the cap unit **115** to move in A direction crossing (for example, perpendicular to) the B direction that is the movement direction of the liquid discharge head **20**. The moving mechanism **120** is, for example, a rack and pinion mechanism, and includes a rack **121**, a drive gear **122**, and a motor **123**. When the motor **123** is driven in a normal direction, the cap unit **115** is moved in +A direction, and when the motor **123** is driven in a reverse direction, the cap unit **115** is moved in −A direction. When the liquid discharge head **20** is moved in +B direction from the retreat position with the cap **116** of the cap unit **115** located at the capping position opposed to the head **21**, illustrated in FIG. **3**, capping is performed on the liquid discharge head **20**. In a capping state, a substantially closed space communicating with the nozzles **21**N is formed between the nozzle surface **21**A and the cap **116**, thus the liquid in the nozzles **21**N is prevented from being dried. In addition, in the capping state, the nozzles **21**N are cleaned by forcibly discharging liquid such as ink into the cap **116** through the nozzles **21**N of the head **21**. The liquid in the nozzles **21**N is forcibly discharged along with the thickened ink and air bubbles by the cleaning, thus poor discharge of the liquid discharge head **20** is prevented or eliminated.
(50) As illustrated in FIG. **3**, at the time of head replacement, the liquid discharge head **20** is moved along the guide rail **101**, for example, from the cap position to the replacement position PH**2**. When the liquid discharge head **20** is at the replacement position PH**2**, it can be detached or attached from or to the apparatus body **12** by the guide rollers **20**R moving along two guide rails **102**,**103** in the vertical direction Z. At the replacement position PH**2**, the liquid discharge head **20** is detached from the apparatus body **12** by an operator lifting the liquid discharge head **20** upward along the guide rails **102**,**103**.
(51) When replacing the liquid discharge head **20**, an operator uses the operation section **19**A to perform an operation to instruct head replacement, then the controller **100** drives the motor **113** in a reverse direction to cause the liquid discharge head **20** to move to the replacement position PH**2**. With the discharge tray **18**A detached, an operator detaches the joint **88** from the liquid discharge head **20** through the opening **12**D. Next, the liquid discharge head **20** is detached from the apparatus body **12** as shown by a double-dotted line in FIG. **3**.
(52) During printing, valves **38**, **40** (see FIG. **6**) capable of opening and closing the supply flow path **87** coupling the reservoir **86** and the liquid discharge head **20** are in an open state, and the liquid supplied from the reservoir **86** is discharged from the liquid discharge head **20**. While printing is not performed, the valves **38**, **40** are in a closed state. Since the valves **38**,**40** are closed like this while printing is not performed, when the disturbances as mentioned below occur at the time of head replacement, liquid may drip from the joint **88** detached from the liquid discharge head **20**. Examples of disturbances (causes) of dripping of liquid from the joint **88** include the following. (a) The tube of the supply flow path **87** is pressed by an operator during head replacement work. (b) Acceleration or impact is applied when the joint **88** is detached from the liquid discharge head **20**. (c) Air bubbles are present within the tube of the supply flow path **87**. Note that in (c), the air bubbles reduce a holding pressure that is a negative pressure applied in a direction to prevent liquid from dripping from the joint **88**.
(53) In this embodiment, contamination in the apparatus body **12** by the liquid dripped from the

joint **88** due to the cause of one of the above-mentioned (a)˜(c) is prevented or reduced from the following two points of view.
(54) Point of View 1: Even when Liquid Drips, No Contamination Occurs in the Apparatus Body.
(55) Point of View 2: Dripping of liquid is prevented or reduced.
(56) Even when work of detachment of the liquid discharge head **20** from the apparatus body **12** is performed with the joint **88** coupled to the liquid discharge head **20**, in a case in which the above-mentioned disturbances occur, liquid may drip through the nozzles **21**N of the liquid discharge head **20**. In this respect, with the joint **88** coupled to the liquid discharge head **20**, the points of view 1, 2 are also for reducing dripping of liquid through the nozzles **21**N of the liquid discharge head **20**.
(57) First, referring to FIG. **2**, FIG. **4** and FIG. **5**, the configuration to be adopted from the point of view 1 will be described. As illustrated in FIG. **4**, the joint **88** has couplers **89** to be coupled to the liquid discharge head **20**. The liquid discharge head **20** has the female coupler **22** configured to be coupled to the couplers **89** of the joint **88**. With the couplers **89** of the joint **88** coupled to the female coupler **22**, at least part of the supply flow path **87** passes above the mounting section **83**, and is coupled to the liquid discharge head **20**.
(58) The couplers **89** includes the same number of pipes **89**A as the number of supply flow paths **87**. Each supply flow path **87** constitutes part of a circulation flow path for circulating liquid between the reservoir **86** and the inside of the liquid discharge head **20**. Thus, the supply flow path **87** includes a delivery flow path **37** to deliver liquid from the reservoir **86** to the liquid discharge head **20**, and a return flow path **39** (see FIG. **6** for each flow path) to return liquid from the liquid discharge head **20** to the reservoir **86**. For each of reservoirs **86** that store different types of liquid, the supply flow path **87** has the delivery flow path **37** and the return flow path **39**. Thus, let N be the number of liquid storages **82** and reservoirs **86**, the N being a natural number, then the supply flow paths **87** are composed of 2N flow paths. The variable sections **87**A of the supply flow paths **87** are composed of, for example, 2N tubes. The couplers **89** of the joint **88** have 2N pipes **89**A. For example, when the liquid discharge apparatus **11** is configured to perform printing using ink of four colors, the supply flow paths **87** are composed of four delivery flow paths **37** and four return flow paths **39**.
(59) As illustrated in FIG. **4**, the liquid discharge apparatus **11** includes the retainer **90** that can retain the joint **88** detached from the liquid discharge head **20**. The retainer **90** is formed in a bottomed box shape with an opening upward. As illustrated in FIG. **4**, the retainer **90** may have a dish shape having an opening **90**A upward. The bottomed box shape with an opening upward refers to the shape including a bottom having a placement surface **90**B on which the joint **88** is placeable, and an annular outer peripheral section that is higher in height than the placement surface **90**B, and surrounds the placement surface **90**B. The shape in a plan view of the retainer **90** as seen in the vertical direction Z is not limited to a rectangle, and may be a circle, an oval, or a polygon other than quadrilaterals. The dish shape refers to a shape in which the height dimension is smaller than the smallest dimension in a direction parallel to the placement surface **90**B of the retainer **90**. The retainer **90** may have a dish shape having a bottom and a side, or a dish shape in which the outer peripheral section of the bottom is bent or curved upward.
(60) The retainer **90** is horizontally disposed on the upper surface of the frame unit **12**F with the opening **90**A facing up. The frame unit **12**F may be part of the frame **12**C in which the liquid discharge head **20** is housed, or may be provided separately from the frame **12**C. The frame unit **12**F may be part (for example, an upper part) of a housing frame in which the liquid storage **82** is housed. When the mounting section **83** has, as its part, the housing frame in which the liquid storage **82** is housed as illustrated in FIG. **4**, the retainer **90** may be disposed on the upper surface of the mounting section **83**.
(61) As illustrated in FIG. **4**, FIG. **5**, the inner peripheral section of the retainer **90** is provided with a latch **91**. The latch **91** may be provided at a position closer to the outer periphery than a central

section of the placement surface **90**B of the retainer **90**. In the examples illustrated in FIG. **4**, FIG. **5**, the latch **91** is provided in the bottom, but may be provided in the outer peripheral section (for example, the lateral section). The latch **91** may have an L shape as illustrated in a front view of FIG. **4**, FIG. **5**, for example. The latch **91** is latched in the joint **88** placed on the retainer **90**, and is provided to retain the joint **88** in a posture with the couplers **89** facing up. In this respect, the shape and mechanism of the latch **91** may be selected as appropriate as long as the joint **88** is retainable in a posture with the couplers **89** facing up.
(62) As illustrated in FIG. **4**, the liquid discharge apparatus **11** may include a cap **92** detachably provided in the retainer **90**. The cap **92** is configured to be attachable to and detachable from the couplers **89** of the joint **88** detached from the liquid discharge head **20**. The cap **92** can cover the couplers **89** of the detached joint **88**. The cap **92** may be retained by the retainer **90** with latched by the latch **91**. In this situation, the cap **92** may have a female latch **92**A that is engageable with the latch **91**. The cap **92** may be retained on the placement surface **90**B of the retainer **90** by engagement between the latch **91** and the female latch **92**A with the opening side of the cover facing down.
(63) As illustrated in FIG. **4**, the liquid discharge head **20** is disposed at the replacement position PH**2** at the time of head replacement. The joint **88** is coupled to the female coupler **22** positioned at an upper section of the liquid discharge head **20** in a posture with the couplers **89** facing down. With the couplers **89** of the joint **88** coupled to the female coupler **22**, at least part of the supply flow path **87** passes above the mounting section **83**, and is coupled to the liquid discharge head **20**.
(64) When detaching the joint **88** from the female coupler **22**, an operator lifts the joint **88** upward. Thus, the joint **88** can be detached from the female coupler **22** of the liquid discharge head **20**. Herein, the direction of detachment of the joint **88** is not limited to −Z direction (upper direction), and may be a diagonally upward direction which forms an acute angle with −Z direction. The female coupler **22** may be provided at the lateral section of the liquid discharge head **20** in the depth direction X, instead of at the upper section thereof, and the joint **88** may be configured to be attachable to and detachable from the female coupler **22** in the depth direction X or a diagonally upward direction which forms an acute angle with the depth direction X.
(65) As illustrated in FIG. **5**, the retainer **90** is configured to retain the joint **88** with the couplers **89** facing up. The joint **88** detached from the liquid discharge head **20** is placed on the placement surface **90**B of the retainer **90** by an operator. The retainer **90** is provided at a position closer to a base end of the supply flow path **87** than the female coupler **22** of the liquid discharge head **20**, the base end being one end of the supply flow path **87** and near the reservoir **86**. The position for disposing the retainer **90** is set so that the retainer **90** is placed at a position closer to the base end of the supply flow path **87** extending from the reservoir **86** than the position at which the joint **88** is coupled to the female coupler **22** of the liquid discharge head **20** illustrated in FIG. **4**.
(66) Particularly, when the supply flow path **87** has a variable section **87**A and a fixed section **87**B, as illustrated in FIG. **5**, a base end **87**E which is an end, closer to the fixed section **87**B, of the variable section **87**A of the supply flow path **87** is assumed to be at the position illustrated in FIG. **5**, for example. In this situation, the retainer **90** is provided at a position closer to the base end **87**E which is one end, closer to the fixed section **87**B, of the variable section **87**A of the supply flow path **87** than the female coupler **22** of the liquid discharge head **20**.
(67) Thus, as illustrated in FIG. **5**, the joint **88** is easily retained by the retainer **90** in an orientation with the couplers **89** facing up. Specifically, even when the couplers **89** are placed on the retainer **90** in an orientation with the couplers **89** facing up, which is the opposite orientation to the orientation with the couplers **89** facing down when coupled to the female coupler **22** of the liquid discharge head **20**, an unnatural force is not applied to the supply flow path **87**. As illustrated in FIG. **5**, the supply flow path **87** extending from the joint **88** is held in the form of a circular arc path. Specifically, with the joint **88** placed on the retainer **90** in an orientation with the couplers **89** facing up, the supply flow path **87** is held in the form of a circular arc path, which is unlikely to be

subjected to a load due to tension, fracture, or torsion.
(68) The joint **88** has a female latch **88**A at a position corresponding to the latch **91**. With the latch **91** engaged with the female latch **88**A, the joint **88** is retained by the retainer **90** in a posture with the couplers **89** facing up. In the joint **88**, the posture of the couplers **89** facing up is likely to be lost due to an elastic reaction force received from a curved supply flow path **87**. However, the joint **88** is latched by the retainer **90** due to the engagement between the latch **91** and the female latch **88**A, thus even if an elastic reaction force is received from the supply flow path **87**, or if an operator performing head replacement work accidentally touches a coupler **89**, the posture of the coupler **89** facing up is maintained. Therefore, liquid is unlikely to drip from the couplers **89** of the joint **88**, and even if liquid drips, the liquid dripped is collected in the retainer **90**. Thus, contamination in the apparatus body **12** by the liquid dripped from the joint **88** is prevented.
(69) Next, before a configuration to adopt the point of view 2 is explained, the configuration of the liquid supply unit **80** used to implement a configuration which can prevent or reduce dripping of liquid in the liquid discharge apparatus **11** will be described with reference to FIG. **6**. FIG. **6** illustrates part of supply of liquid from the reservoir **86** of the liquid supply unit **80**, which stores one type of liquid, to the liquid discharge head **20**.
(70) As illustrated in FIG. **6**, the liquid supply unit **80** includes the above-described liquid supply member **81**. The liquid supply member **81** is comprised of the supply mechanism **85** including: the mounting section **83** to which the liquid storage **82** is detachably attached, and the reservoir **86** coupled to the liquid storage **82** via the mounting section **83**. The supply mechanism **85** supplies the liquid stored in the reservoir **86** to the liquid discharge head **20**. The reservoir **86** includes a first reservoir **33** and a second reservoir **35**.
(71) The liquid discharge apparatus **11** may include a plurality of supply mechanisms **85**. The plurality of supply mechanisms **85** may supply different types of liquid to the liquid discharge head **20**. For example, the liquid discharge apparatus **11** may perform color printing by discharging ink of multiple colors supplied by the plurality of supply mechanisms **85**.
(72) As illustrated in FIG. **6**, the liquid supply unit **80** includes a drive mechanism **57** that drives the supply mechanism **85**. When a plurality of supply mechanisms **85** are provided according to types of liquid, the liquid discharge apparatus **11** may include a plurality of drive mechanisms **57** that drive the plurality of supply mechanisms **85** individually. Alternatively, the liquid discharge apparatus **11** may include one drive mechanism **57** that collectively drives the plurality of supply mechanisms **85**.
(73) The liquid storage **82** may include: a storage chamber **29** that stores liquid; an outlet section **30** to deliver the liquid stored in the storage chamber **29**; and an outlet valve **31** provided in the outlet section **30**. The storage chamber **29** of this embodiment is a sealed space not communicating with the atmosphere. The liquid storage **82** before mounted on the mounting section **83** may store an amount of liquid greater than the amount of liquid retainable by the supply mechanism **85**.
(74) The supply mechanism **85** includes the first reservoir **33** and the second reservoir **35** as the reservoir **86** that stores the liquid supplied from the liquid storage **82**. The first reservoir **33** and the second reservoir **35** are coupled to each other via a communication path **34**. The supply mechanism **85** includes a one-way valve **36** that can open and close the communication path **34**.
(75) The supply flow path **87** includes the delivery flow path **37** that couples the second reservoir **35** and the liquid discharge head **20**, and the return flow path **39** that couples the liquid discharge head **20** and the first reservoir **33**. The delivery flow path **37** is a flow path to supply liquid from the second reservoir **35** to the liquid discharge head **20**. The return flow path **39** is a flow path to return liquid from the liquid discharge head **20** to the first reservoir **33**.
(76) The return flow path **39** may include a liquid chamber **41** in part. Part of the liquid chamber **41** is a flexible section **42**, and deformation of the flexible section **42** changes the volume of the liquid chamber **41**.
(77) The supply mechanism **85** includes a first valve **38** that can open and close the delivery flow

path **37**, and a second valve **40** that can open and close the return flow path **39**. The valves **38**, **40** are provided in the middle of the supply flow path **87**. Specifically, the first valve **38** is provided in the middle of the delivery flow path **37**. In addition, the second valve **40** is provided in the middle of the return flow path **39**. The second valve **40** is provided at a position between the liquid chamber **41** and the first reservoir **33** on the return flow path **39**.
(78) The valves **38**, **40** are, for example, electromagnetic valves, and controlled by the controller **100**. In this manner, the liquid discharge apparatus **11** includes the valves **38**, **40** that can open and close the supply flow path **87**, and the controller **100** that can control the opening and closing of the valves **38**, **40**.
(79) The valves **38**, **40** are each a normally closed valve that automatically closes the supply flow path **87** when power supply is OFF. Specifically, the first valve **38** is a normally closed valve, and automatically closes the delivery flow path **37** when power supply is OFF. Also, the second valve **40** is a normally closed valve, and automatically closes the return flow path **39** when power supply is OFF.
(80) The valves **38**, **40** of this embodiment are configured to be manually openable and closable when power supply is OFF. When performing head replacement work in a power OFF state, an operator can manually switch the first valve **38** and the second valve **40** from a closed state to an open state.
(81) The liquid discharge head **20** includes a first flow path **44** which is caused to communicate with the delivery flow path **37** by coupling between the joint **88** and the female coupler **22**, and a second flow path **45** which is caused to communicate with the return flow path **39** by coupling between the joint **88** and the female coupler **22**. The first flow path **44** and the second flow path **45** are both coupled to a head flow path **201**. Specifically, the downstream end of the first flow path **44**, the upstream end of the second flow path **45**, and the upstream end of the head flow path communicate with each other through a liquid chamber (not illustrated). The head flow path **201** is coupled to a common flow path **202**. The common flow path **202** communicates with the nozzles **21**N through a pressure chamber (not illustrated). The wall in part of the pressure chamber is provided with a piezoelectric element, and change in the volume of the pressure chamber due to driving of the piezoelectric element causes liquid to be discharged through the nozzles **21**N communicating with the pressure chamber.
(82) A filter **46** is provided in the middle of the head flow path **201**. Liquid with foreign materials and air bubbles removed by the filter **46** is supplied to the common flow path **202** and the nozzles **21**N. Therefore, poor discharge caused by foreign materials and air bubbles in the nozzles **21**N is prevented. The filter **46** has a mesh structure or a porous structure.
(83) When the liquid discharge head **20** movable by the moving mechanism **110** in the B direction is at the print position PH**1** which is the lowest position in the vertical direction Z on a movement path, the liquid surface of the reservoir **86** is at a position lower than the opening height position of any nozzle **21**N. The first reservoir **33** and the second reservoir **35** are coupled via the communication path **34** provided with the one-way valve **36** that is openable and closable by a differential pressure. For this reason, a first liquid surface **66** that is the liquid surface of the first reservoir **33** and a second liquid surface **70** that is the liquid surface of the second reservoir **35** are approximately at the same height in many cases. Even if one of the first liquid surface and the second liquid surface fluctuates to a maximum height higher than a standard height position, the opening height position of any nozzle **21**N is set to be higher than the liquid surface at the maximum height.
(84) Therefore, the liquid within the nozzles **21**N, a negative pressure is generated due to a water head difference between the first liquid surface **66** of the first reservoir **33** and the second liquid surface **70** of the second reservoir **35**, and the liquid surface of meniscus formed in the openings of the nozzles **21**N. Due to the negative pressure, liquid does not drip from the nozzles **21**N. In addition, due to the negative pressure, a meniscus is formed on the liquid in the nozzles **21**N.

(85) The drive mechanism **57** includes a pump **47** that adjusts the pressure of a gas phase section within the second reservoir **35**. The drive mechanism **57** may include a switching mechanism **48** coupled to the pump **47**, and a pressure sensor **49** that detects a pressure. The drive mechanism **57** may include an atmosphere open path **50** coupled to the first reservoir **33**, a pressurization flow path **51** coupled to the second reservoir **35**, and a coupling flow path **52** that couples the atmosphere open path **50** and the pressurization flow path **51** to the pump **47**.
(86) The pump **47** is, for example, a tube pump that sends air by a roller rotating while flattening a tube. In the tube, which is not illustrated, of the pump **47**, one end is coupled to an air flow path **55**, and the other end is coupled to the coupling flow path **52**. The pump **47** is driven in a normal direction, thereby sending the air taken from the air flow path **55** to the coupling flow path **52**. The pump **47** is driven in a reverse direction, thereby sending the air taken from the coupling flow path **52** to the air flow path **55**.
(87) The air flow path **55** is coupled to a variable capacity mechanism **58**. The variable capacity mechanism **58** is a mechanism that changes the volume of the liquid chamber **41**. The variable capacity mechanism **58** includes the flexible section **42**, an air chamber **53** separated from the liquid chamber **41** with the flexible section **42** interposed between the chambers, and a spring **54** provided in the air chamber **53**. The air flow path **55** communicates with the air chamber **53**. The spring **54** presses the flexible section **42**, thereby reducing the pressure variation of the liquid in the return flow path **39** and the liquid discharge head **20** by changing the volume of the liquid chamber **41**. The variable capacity mechanism **58** changes the volume of the liquid chamber **41** by causing the air chamber **53** to be pressurized or depressurized through the air flow path **55**, the liquid chamber **41** being separated from the air chamber **53** with the flexible section **42** interposed between the chambers. In short, the variable capacity mechanism **58** changes the volume of the liquid chamber **41** by pneumatic drive. The variable capacity mechanism **58** is provided in the return flow path **39** between the liquid discharge head **20** and the second valve **40**, and is driven to pressurize the liquid in the return flow path **39**, for example.
(88) Configuration of First Reservoir **33**
(89) Next, the first reservoir **33** will be described. The first reservoir **33** has an inlet section **60** that can introduce the liquid stored in the liquid storage **82** mounted on the mounting section **83**. The first reservoir **33** may have an inlet valve **61** provided in the inlet section **60**, a first reservoir chamber **62** that stores liquid, a liquid amount sensor **63** that detects an amount of liquid stored in the first reservoir chamber **62**, and a first gas-liquid separation film **64** that separates the first reservoir chamber **62** from the atmosphere open path **50**. The first gas-liquid separation film **64** is a film having properties such that the film allows gas to pass therethrough, whereas the film allows no liquid to pass therethrough.
(90) The outlet valve **31** and the inlet valve **61** are opened by the liquid storage **82** being mounted on the mounting section **83**, and as long as the liquid storage **82** is mounted on the mounting section **83**, an open valve state is maintained. When the liquid storage **82** is mounted on the mounting section **83**, the inlet valve **61** is configured to be opened before the outlet valve **31** is opened, thus the possibility of leakage of liquid from the liquid storage **82** can be reduced.
(91) The inlet section **60** is provided above the first reservoir **33**. The inlet section **60** in this embodiment is provided to penetrate a top plate **65** of the first reservoir chamber **62**. The lower end of the inlet section **60** is located at a predetermined height of the first reservoir chamber **62**. The inlet section **60** is coupled to the outlet section **30** included in the liquid storage **82** by the liquid storage **82** being mounted on the mounting section **83**.
(92) The lower end of the inlet section **60** is located below the nozzle surface **21**A. Thus, the first liquid surface **66** of the liquid stored in the first reservoir **33** varies in a range lower than the nozzle surface **21**A. Specifically, the liquid in the liquid storage **82** is supplied to the first reservoir **33** by a water head through the outlet section **30** and the inlet section **60**. Air is introduced from the first reservoir **33** to the liquid storage **82** in an amount corresponding to the liquid supplied to the first

reservoir **33** through the inlet section **60** and the outlet section **30**. The first liquid surface **66** is raised by a level corresponding to the supplied liquid. When the first liquid surface **66** reaches the lower end of the inlet section **60**, inflow of air from the first reservoir **33** to the liquid storage **82** is restricted. Since the storage chamber **29** is sealed, when inflow of air is restricted, the pressure in the storage chamber **29** decreases by a level corresponding to the supplied liquid. When the negative pressure in the storage chamber **29** becomes higher than the water head of the liquid in the storage chamber **29**, supply of liquid from the liquid storage **82** to the first reservoir **33** is restricted.
(93) The first liquid surface **66** is lowered when liquid is supplied from the first reservoir **33** to the second reservoir **35**. When the first liquid surface **66** is lowered, and air flows into the storage chamber **29** through the inlet section **60** and the outlet section **30**, the negative pressure in the storage chamber **29** decreases. When the negative pressure in the storage chamber **29** becomes smaller than the water head of the liquid in the storage chamber **29**, liquid is supplied from the liquid storage **82** to the first reservoir **33**. Therefore, while liquid is stored in the liquid storage **82**, the first liquid surface **66** is maintained at a standard position which is near the lower end of the inlet section **60**. When no liquid is stored in the liquid storage **82**, the first liquid surface **66** is located below the standard position.
(94) The liquid amount sensor **63** may detect that the first liquid surface **66** is located at the standard position, the first liquid surface **66** is located lower than the standard position, or the first liquid surface **66** is located at a full position higher than the standard position. When the first liquid surface **66** is located at a full position, the first reservoir **33** stores a maximum amount of liquid. When the liquid amount sensor **63** detects that the first liquid surface **66** is located lower than the standard position, the controller **100** determines that the liquid storage **82** is empty, and may instruct a user to replace the liquid storage **82**.
(95) In the first reservoir chamber **62**, the standard position of this embodiment is located higher than the position to which the downstream end of the return flow path **39** is coupled. Therefore, when the first liquid surface **66** is at the standard position, the liquid in the first reservoir **33** can be supplied to the liquid discharge head **20** through the return flow path **39**.
(96) Configuration of Second Reservoir **35**
(97) Next, the second reservoir **35** will be described. The second reservoir **35** may have a second reservoir chamber **68** that stores liquid, and a second gas-liquid separation film **69** that separates the second reservoir chamber **68** from the pressurization flow path **51**. As with the first gas-liquid separation film **64**, the second gas-liquid separation film **69** is a film having properties such that the film allows gas to pass therethrough, whereas the film allows no liquid to pass therethrough.
(98) The second reservoir **35** receives supply of liquid from the first reservoir **33** due to a water head difference. The one-way valve **36** allows the flow of liquid from the first reservoir **33** to the second reservoir **35**, and restricts the flow of liquid from the second reservoir **35** to the first reservoir **33**. The one-way valve **36** is a differential pressure valve, for example. The one-way valve **36** which is a differential pressure valve is opened and closed due to a differential pressure based on the water head difference between the liquid in the first reservoir **33** and the liquid in the second reservoir **35**. The one-way valve **36** may also be configured to have a check valve. When the pressure in the first reservoir chamber **62** and the second reservoir chamber **68** is the atmospheric pressure, the second liquid surface **70** of the liquid in the second reservoir **35** is at the same height as the first liquid surface **66**. In other words, the second liquid surface **70** is maintained at the standard position which is approximately at the same height as the lower end of the inlet section **60**, and varies in a range lower than the nozzle surface **21**A. The liquid in the liquid discharge head **20** is maintained at a negative pressure by the water head difference between the liquid in the first reservoir **33** and the liquid in the second reservoir **35**. When liquid is consumed in the liquid discharge head **20**, the liquid stored in the second reservoir **35** is supplied to the liquid discharge head **20**.
(99) When the pressure in the second reservoir **35** is higher than the pressure in the first reservoir

33, the one-way valve **36** closes the communication path **34**. Thus, at the time of pressurization in the second reservoir **35** by the pump **47**, the one-way valve **36** closes the communication path **34**.
(100) The opening and closing of the first valve **38** and the second valve **40** are controlled by the controller **100**. The first valve **38** is provided so that the delivery flow path **37** is openable and closable at the time of pressurization by the pump **47**. The second valve **40** is provided so that the return flow path **39** is openable and closable.
(101) Configuration of Switching Mechanism **48**
(102) Next, the switching mechanism **48** will be described. The switching mechanism **48** includes a narrow tube **72** provided in the coupling flow path **52**, and a first selection valve **73***a* to 11th selection valve **73***k* which can open and close a flow path. The narrow tube **72** is meandering and narrow to an extent that flow of liquid is significantly restricted relative to flow of air.
(103) The first selection valve **73***a* is opened to cause the air flow path **55** to communicate with the atmosphere. The second selection valve **73***b* is opened to cause the air flow path **55** and the pressure sensor **49** to communicate with each other. The third selection valve **73***c* is opened to open the air flow path **55**, and causes the pump **75** and the air chamber **53** to communicate with each other.
(104) The fourth selection valve **73***d* is opened to cause the coupling flow path **52** between the pump **47** and the eighth selection valve **73***h* to communicate with the atmosphere. The fifth selection valve **73***e* is opened to cause the coupling flow path **52** and the pressure sensor **49** to communicate with each other. The sixth selection valve **73***f* and the seventh selection valve **73***g* are opened to cause the coupling flow path **52** to communicate with the atmosphere. The eighth selection valve **73***h* is opened to open the coupling flow path **52**. The ninth selection valve **73***i* is opened to cause the narrow tube **72** to communicate with the atmosphere. The 10th selection valve **73***j* is opened to open the atmosphere open path **50**, and causes the first reservoir **33** and the coupling flow path **52** to communicate with each other. The 11th selection valve **73***k* is opened to open the pressurization flow path **51**, and causes the second reservoir **35** and the coupling flow path **52** to communicate with each other.
(105) When the pressure in the air chamber **53** is changed, the switching mechanism **48** opens the second selection valve **73***b* and the third selection valve **73***c*, and closes other selection valves. When the pump **75** is driven in a normal direction in this state, the air in the air chamber **53** is discharged through the air flow path **55**, and the pressure in the air chamber **53** decreases. When the pump **75** is driven in a reverse direction in this state, air is sent into the air chamber **53** through the air flow path **55**, and the pressure in the air chamber **53** increases. At this point, the pressure sensor **49** may detect the pressure in the air flow path **55** and the air chamber **53**. The controller **100** may control the driving of the pump **47** based on the result of detection of the pressure sensor **49**.
(106) In this embodiment, a drive unit **59** is comprised of the pump **75**, the air flow path **55**, the air chamber **53**, and the spring **54**. In this respect, the liquid discharge apparatus **11** includes the drive unit **59**. The supply flow path **87** has the flexible section **42** having flexibility in at least part of the supply flow path **87**. The drive unit **59** may be configured to displace the flexible section **42** in a direction in which the volume of the supply flow path **87** increases, and to maintain the state of the displaced flexible section **42**. Specifically, the pump **75** is driven in a reverse direction with the third selection valve **73***c* open, thus the drive unit **59** displaces the flexible section **42** in a direction in which the volume of the supply flow path **87** increases. When the third selection valve **73***c* is closed in this state, the state of the displaced flexible section **42** can be maintained.
(107) The drive unit **59** may be configured to be controlled by the controller **100**, and configured to be manually operable. In this situation, the pump **75** may be configured to be controlled by the controller **100**, and may include an operation section **75**A that is manually operable.
(108) The switching mechanism **48** may be configured to be controlled by the controller **100**, and configured to be manually operable. In this situation, the switching mechanism **48** may include a cam mechanism (not illustrated) configured to allow opening and closing of the selection valves

73*a* to **73***k* to be selectable. The controller **100** is configured to allow opening and closing of the selection valves **73***a* to **73***k* to be selectable by driving the cam mechanism. The switching mechanism **48** may include an operation section **74** by which the cam mechanism is manually operable. In this respect, the third selection valve **73***c* included in the drive unit **59** of the switching mechanism **48** is configured to be controlled by the controller **100**, and configured to be manually operable by the operation section **74**.
(109) Note that the variable capacity mechanism **58** may be used to slightly pressurize the liquid in the liquid discharge head **20** by changing the flexible section **42**. To slightly pressurize refers to pressurization to an extent that breaks the meniscus of each nozzle **21**N. With the first valve **38** and the second valve **40** open, the controller **100** pulls liquid into the liquid chamber **41** by depressurizing the air chamber **53** for a predetermined depressurization time, then closes the first valve **38** and the second valve **40**. In this state, the controller **100** extrudes the liquid in the liquid chamber **41** by pressurizing the air chamber **53** for a slight pressurization time, thereby slightly pressurizing the liquid in the liquid discharge head **20**. The slight pressurization time refers to a time greater than or equal to the time necessary for the pressure at the time of extrusion of liquid in the liquid chamber **41** to propagate to the liquid in the nozzles **21**N. When finishing the slight pressurization, the controller **100** opens the air chamber **53** to the atmosphere.
(110) When the first reservoir **33** is opened to the atmosphere, the switching mechanism **48** opens the sixth selection valve **73***f* and the 10th selection valve **73***j*. The first reservoir chamber **62** communicates with the atmosphere through the atmosphere open path **50** and the coupling flow path **52**.
(111) When the second reservoir **35** is opened to the atmosphere, the switching mechanism **48** opens the seventh selection valve **73***g* and the 11th selection valve **73***k*. The second reservoir chamber **68** communicates with the atmosphere through the pressurization flow path **51** and the coupling flow path **52**.
(112) When the inside of the second reservoir **35** is pressurized, the switching mechanism **48** opens the first selection valve **73***a*, the fifth selection valve **73***e*, the eighth selection valve **73***h*, and the 11th selection valve **73***k*, and closes other selection valves. When the pump **47** is driven in a normal direction in this state, air flows into the second reservoir chamber **68** through the air flow path **55**, the coupling flow path **52**, and the pressurization flow path **51**, and the pressure in the second reservoir chamber **68** increases. At this point, the pressure sensor **49** may detect the pressure in the coupling flow path **52**, the pressurization flow path **51**, and the second reservoir chamber **68**. The controller **100** may control the driving of the pump **47** based on the result of detection of the pressure sensor **49**. The controller **100** pressurizes the inside of the second reservoir **35** with the first valve **38** open and the second valve **40** closed, thereby performing cleaning to discharge liquid through the nozzles **21**N of the liquid discharge head **20**.
(113) When the inside of the first reservoir **33** is depressurized, the switching mechanism **48** opens the first selection valve **73***a*, the fifth selection valve **73***e*, the eighth selection valve **73***h*, and the 10th selection valve **73***j*, and closes other selection valves. When the pump **47** is driven in a reverse direction in this state, the air in the first reservoir chamber **62** is discharged through the air flow path **55**, the coupling flow path **52**, and the atmosphere open path **50**, then the pressure in the first reservoir chamber **62** decreases. At this point, the pressure sensor **49** may detect the pressure in the coupling flow path **52**, the atmosphere open path **50**, and the first reservoir chamber **62**. The controller **100** may control the driving of the pump **47** based on the result of detection of the pressure sensor **49**.
(114) When the inside of the second reservoir **35** is depressurized, the switching mechanism **48** opens the first selection valve **73***a*, the fifth selection valve **73***e*, the eighth selection valve **73***h*, and the 11th selection valve **73***k*, and closes other selection valves. When the pump **47** is driven in a reverse direction in this state, the air in the second reservoir chamber **68** is discharged through the air flow path **55**, the coupling flow path **52**, and the pressurization flow path **51**, then the pressure

in the second reservoir chamber **68** decreases. At this point, the pressure sensor **49** may detect the pressure in the coupling flow path **52**, the pressurization flow path **51**, and the second reservoir chamber **68**. The controller **100** may control the driving of the pump **47** based on the result of detection of the pressure sensor **49**.

(115) In this embodiment, a depressurizer **76** is comprised of the pump **47**, the coupling flow path **52**, the atmosphere open path **50**, the pressurization flow path **51**, the first selection valve **73***a*, the fifth selection valve **73***e*, the eighth selection valve **73***h*, the 10th selection valve **73***j*, and the 11th selection valve **73***k*. In this respect, the liquid discharge apparatus **11** includes the depressurizer **76** that can depressurize the space in the reservoirs **33**, **35**.

(116) In this embodiment, a depressurization maintainer **77** is composed of the 10th selection valve **73***j* and the 11th selection valve **73***k*. In this respect, the liquid discharge apparatus **11** includes the depressurization maintainer **77** that can maintain the space depressurized by the depressurizer **76**. The depressurizer **76** and the depressurization maintainer **77** may be configured to be controlled by the controller **100**, and configured to be manually operable. In this situation, the pump **47** may be configured to be controlled by the controller **100**, and may include an operation section **47**A that is manually operable. The first selection valve **73***a*, the fifth selection valve **73***e*, the eighth selection valve **73***h*, the 10th selection valve **73***j*, and the 11th selection valve **73***k* included in the depressurizer **76** are configured to be controlled by the controller **100**, and configured to be manually operable by the above-mentioned operation section **74**. The 10th selection valve **73***j* and the 11th selection valve **73***k* included in the depressurization maintainer **77** are configured to be controlled by the controller **100**, and configured to be manually operable by the above-mentioned operation section **74**.

Operation of First Embodiment

(117) Next, the operation of this embodiment will be described.

(118) An operator operates the operation section **19**A to select a service mode on a menu screen displayed on the display unit **19**, and further selects the item “head replacement”. When receiving instructions for head replacement, the controller **100** moves the liquid discharge head **20** in −B direction to the replacement position PH**2** by driving the motor **113** in a reverse direction. Upon detection of movement of the liquid discharge head **20** to the replacement position PH**2** based on a signal detected by a sensor which is not illustrated, the controller **100** stops the motor **113**. Before the movement, during the movement, or immediately after the movement of the liquid discharge head **20**, the controller **100** causes a computer to execute the liquid dripping prevention control routine illustrated in FIG. **9**. Note that head replacement work is performed while printing is not performed, thus the first valve **38** and the second valve **40** are in a closed state.

(119) In step S**11**, the controller **100** draws the liquid in the liquid discharge head **20** upstream. The controller **100** causes the variable capacity mechanism **58** to execute a drawing operation. Specifically, the controller **100** opens the second selection valve **73***b* and the third selection valve **73***c*, and closes other selection valves by controlling the switching mechanism **48**. In this state, the controller **100** drives the pump **75** in a normal direction. In the initial state illustrated in FIG. **7**, the air in the air chamber **53** is discharged through the air flow path **55**, and the pressure in the air chamber **53** decreases. As illustrated in FIG. **8**, the flexible section **42** is raised toward the air chamber **53** by depressurization in the air chamber **53** against the urging force of the spring **54**, and accordingly, the volume of the liquid chamber **41** is increased. When the volume of the liquid chamber **41** is increased, in the supply flow path **87**, the liquid in the flow path portion downstream of the first valve **38** and upstream of the liquid chamber **41** is drawn to the liquid chamber **41**. Specifically, as illustrated by the white arrow in FIG. **8**, liquid is drawn into the liquid chamber **41** from the liquid discharge head **20** upstream of the liquid chamber **41**. Thus, in the liquid discharge head **20**, the liquid downstream (the nozzles **21**N) of the filter **46** is drawn upstream in an amount corresponding to the volume of the liquid chamber **41**. A gas-liquid interface formed by the meniscus in each nozzle **21**N is moved toward the filter **46**. In other words, air is taken through the

nozzles **21**N, and an air area is moved in a depth direction (upstream) of the nozzles **21**N.
(120) In next step S**12**, the controller **100** determines whether liquid drawing number of times has reached a set number of times N. When the set number of times N is not reached, the flow proceeds to step S**13**, and when the set number of times N is reached, the routine is completed.
(121) In next step S**13**, the controller **100** opens the valves **38**, **40**. Specifically, the controller **100** switches the first valve **38** and the second valve **40** from a closed valve state to an open valve state.
(122) In next step S**14**, the controller **100** delivers the drawn liquid to the reservoir **33**. The controller **100** delivers the liquid drawn into the liquid chamber **41** to the reservoir **33**. The controller **100** opens the air chamber **53** to the atmosphere, or drives the pump **75** in a reverse direction. In the former case, the volume of the liquid chamber **41** is reduced by the flexible section **42** being pressed down by the urging force of the spring **54**. In the latter case, the flexible section **42** is pressed down by the air introduced into the air chamber **53** and the urging force of the spring **54**. Consequently, the volume of the liquid chamber **41** is decreased. At this point, liquid is extruded from the liquid chamber **41**, and the extruded liquid flows into the first reservoir chamber **62** because of a relationship of water head difference between the liquid discharge head **20** and the first reservoir **33**.
(123) In step S**15**, the controller **100** closes the valves **38**, **40**. Specifically, the controller **100** switches the first valve **38** and the second valve **40** from an open valve state to a closed valve state.
(124) After the controller **100** completes the process in step S**15**, the flow returns to step S**11**. In step S**12**, the controller **100** repeats the processes in step S**11**, S**13**, S**14**, S**15** until the liquid drawing number of times reaches the set number of times N. In this manner, each time a drawing operation is performed to draw liquid into the liquid chamber **41**, the controller **100** determines whether the set number of times N is reached, and when not reached, delivers the liquid drawn into the liquid chamber **41** to the first reservoir chamber **62**. When the liquid drawing number of times reaches the set number of times N, the routine is completed.
(125) When the controller **100** completes the liquid dripping prevention control, the first valve **38** and the second valve **40** are in a closed state, and the flexible section **42** of the variable capacity mechanism **58** is in a state of being displaced in a direction in which the volume of the liquid chamber **41** is increased. For this reason, when liquid is drawn into the liquid chamber **41** last, a negative pressure generated in the supply flow path **87** is maintained.
(126) In this manner, the controller **100** performs a liquid drawing operation for the set number of times N, and a liquid delivery operation for (N−1) times by the processes in step S**11** to step S**15**. The controller **100** completes the routine with liquid drawn into the liquid chamber **41**.
(127) The variable capacity mechanism **58** performs a liquid drawing operation for the set number of times N, and N is a predetermined number of times from **2** to **5**, for example. Thus, part of the liquid in the liquid discharge head **20** is drawn toward the supply flow path **87**.
(128) The set number of times N may be determined based on a relationship between drawn liquid amount Q per drive of the variable capacity mechanism **58**, and flow path volume Vh from the filter **46** in the liquid discharge head **20** to the openings of the nozzles **21**N. Specifically, the set number of times N may be set to the number of times until the gas-liquid interface (interface of the meniscus) of the liquid in the liquid discharge head **20** reaches the filter **46**. For example, the set number of times N may be set to Nmin that is a minimum natural number N satisfying $N \geq Vh/Q$ or (Nmin+1) obtained by adding “1” to the minimum value Nmin.
(129) The filter **46** has a mesh structure or a porous structure including a large number of micropores. When the gas-liquid interface of liquid reaches the filter **46**, a meniscus (hereinafter also referred to as a “micro meniscus”) of the liquid is formed in the large number of micropores. The value of bubble point Bp of the micro meniscus is a predetermined value in a range of 5 to 10 kPa, for example. The bubble point prevents the gas-liquid interface of the liquid from moving upstream of the filter **46**. Thus, air can be taken into the flow path area from the nozzles **21**N to the filter **46** in the liquid discharge head **20**. In addition, a relatively high negative pressure (however, a

negative pressure is lower than the bubble point pressure) due to the micro meniscus can be generated in the liquid of the flow path portion upstream of the filter **46**.

(130) When completing the liquid dripping prevention control, the controller **100** causes the display unit **19** to display information indicating that preparation for head replacement is ready. An operator detaches the discharge tray **18**A from the apparatus body **12**. For example, an operator loosens a screw (not illustrated) to detach the joint **88** from the liquid discharge head **20** at the replacement position PH**2**.

(131) When detaching the joint **88** from the liquid discharge head **20**, the operator may press the tube of the supply flow path **87** or apply excessive impact to the joint **88** unintentionally. At this point, the gas-liquid interface in the liquid discharge head **20** is located further in the depth direction of the nozzles **21**N, as compared to when printing is performed. Therefore, even when the gas-liquid interface in the liquid discharge head **20** is displaced somewhat toward the nozzles **21**N, liquid does not drip from the nozzles **21**N.

(132) At this point, the gas-liquid interface in the liquid discharge head **20** has reached the filter **46**, thus the liquid is prevented from moving toward the nozzles **21**N as long as a pressure exceeding the bubble point pressure is not applied to the liquid in the liquid discharge head **20**. Even if a pressure exceeding the bubble point pressure is applied to the liquid in the liquid discharge head **20**, and the gas-liquid interface is displaced somewhat toward the nozzles **21**N, liquid does not drip from the nozzles **21**N.

(133) Until the joint **88** is detached from the liquid discharge head **20**, a relatively high negative pressure (negative pressure close to the bubble point pressure) is applied to the liquid in the supply flow path **87**. Therefore, when the joint **88** is detached from the liquid discharge head **20**, the meniscus of the liquid in the couplers **89** moves in the depth direction. Thus, after the joint **88** is detached, even if causes of the above-mentioned disturbances (a) to (c) occur due to accidental pressing of the tube of the supply flow path **87** or applying acceleration or an impact to the joint **88** by an operator, dripping of liquid from the couplers **89** of the joint **88** is prevented.

(134) An operator places the detached joint **88** on the inner bottom surface of the retainer **90** with the couplers **89** facing up. At this point, the latch **91** is latched to the female latch **88**A. This latch maintains the couplers **89** in an upward posture even if the joint **88** receives an elastic reaction force from the tube of the supply flow path **87**. Since the couplers **89** face up, dripping of liquid from the couplers **89** is prevented. In addition, even if a slight amount of liquid dripped from the couplers **89** streams down the lateral surface of the joint **88** during a period until the joint **88** is placed on the retainer **90**, the streamed-down liquid is received by the retainer **90** in a dish shape. Therefore, even if liquid drips from the couplers **89**, contamination in the apparatus body **12** is prevented.

(135) As illustrated in FIG. **5**, an operator mounts the cap **92** on the joint **88** so as to cover the couplers **89**. Even if the joint **88** is detached from the retainer **90** or the joint **88** is turned down or inclined because of a fault of an operator or an elastic reaction force of the tube, no liquid leaks from the couplers **89** covered with the cap **92**, thus contamination of the retainer **90** and its periphery caused by the liquid from the joint **88** is prevented. In addition, the cap **92** mounted on the joint **88** prevents the liquid such as ink in the couplers **89** from being thickened or dried.

(136) An operator then detaches the liquid discharge head **20** from the apparatus body **12**. An operator pulls up the liquid discharge head **20** at the replacement position PH**2** in −Z direction along two guide rails **102**, **103**. The liquid discharge head **20** is taken out through the opening **12**D as shown by a double-dotted line in FIG. **3**.

(137) Next, a new liquid discharge head **20** is attached to the apparatus body **12**. An operator inserts the liquid discharge head **20** through the opening **12**D by setting the guide rollers **20**R of the liquid discharge head **20** along the guide rails **102**, **103**. The liquid discharge head **20** inserted along the guide rails **102**, **103** in the vertical direction Z is disposed at the replacement position PH**2** shown by a solid line in FIG. **3**. Subsequently, an operator detaches the cap **92** from the joint **88**

retained by the retainer **90**, and couples the joint **88** to the female coupler **22** of the liquid discharge head **20**. For example, an operator tightens a screw to fix the joint **88** coupled to the female coupler **22** to the liquid discharge head **20**. An operator sets the cap **92** to be retained by the retainer **90**. At this point, an operator sets the cap **92** to be retained by the retainer **90** with the latch **91** and the female latch **92**A latched together. Finally, the discharge tray **18**A is attached to the apparatus body **12** so as to close the opening **12**D. In this manner, the liquid discharge head **20** is replaced.
(138) Liquid Dripping Prevention When Power Is OFF
(139) Next, the head replacement work performed in a power OFF state of the liquid discharge apparatus **11** will be described. For some reasons such as a failure of a power supply circuit of the liquid discharge apparatus **11** or blackout, an operator may have no choice but to perform a head replacement work in a power OFF state.
(140) An operator drives the pump **47** and the switching mechanism **48** by a manual operation with the same content as that of the liquid dripping prevention control. Since the first valve **38** and the second valve **40** are normally closed valves, the supply flow path **87** is in a closed state when power supply is OFF.
(141) An operator operates the operation section **74** to manually switch a cam for selection, thereby selecting a switching position to open the second selection valve **73***b* and the third selection valve **73***c*, and close other selection valves.
(142) Next, an operator operates the operation section **47**A to manually drive the pump **47** in a normal direction. Starting with the initial state illustrated in FIG. **7**, the air in the air chamber **53** is discharged through the air flow path **55**, thus the pressure in the air chamber **53** decreases. The decrease of the pressure causes the flexible section **42** to be raised toward the air chamber **53** against the urging force of the spring **54** as illustrated in FIG. **8**. Consequently, liquid is drawn into the liquid chamber **41**.
(143) Next, an operator operates an operation section **38**A to switch the first valve **38** from a closed valve state to an open valve state. In addition, an operator operates an operation section **40**A to switch the second valve **40** from a closed valve state to an open valve state. Furthermore, an operator delivers the liquid in the liquid chamber **41** to the first reservoir chamber **62** by a manual operation. Specifically, an operator operates the operation section **74** to perform a cam switching operation to select a switching position to open the first selection valve **73***a* to the third selection valve **73***c*, and close other selection valves. Thus, the inside of the air chamber **53** is opened to the atmosphere. Then the flexible section **42** is pressed down by the urging force of the spring **54**, and the volume of the liquid chamber **41** is decreased. At this point, the liquid extruded from the liquid chamber **41** flows into the first reservoir chamber **62**. In this manner, one-time drive for pumping is executed to deliver, to the first reservoir chamber **62**, a predetermined volume of liquid drawn from the liquid discharge head **20** through the supply flow path **87**.
(144) This liquid delivery operation can be performed by another method. After manually setting the first valve **38** and the second valve **40** in an open state, an operator performs the following operations. An operator operates the operation section **74** to perform a cam switching operation to select a switching position to open the second selection valve **73***b* and the third selection valve **73***c*, and close other selection valves. Next, an operator operates the operation section **75**A to drive the pump **75** in a reverse direction. Then air is introduced into the air chamber **53**. The introduced air and the urging force of the spring **54** cause the flexible section **42** to be pressed down. Decrease of the volume of the liquid chamber **41** causes the liquid extruded from the liquid chamber **41** to flow into the first reservoir chamber **62**. In this manner, one-time drive for pumping is executed to deliver, to the first reservoir chamber **62**, a predetermined volume of liquid drawn from the liquid discharge head **20** through the supply flow path **87**.
(145) An operator executes drive for pumping, for example, for the set number of times N by a manual operation. Note that when drive for pumping is executed on the variable capacity mechanism **58** by a manual operation at the time of power OFF, the number of times of execution

may be smaller than the set number of times N at the time of automatic control, or may be arbitrarily selected by an operator from a range less than or equal to an upper limit number of times.

Effects of First Embodiment

(146) The effects of the first embodiment will be described.

(147) (1) The liquid discharge apparatus **11** includes the liquid discharge head **20** that can discharge liquid. The liquid discharge apparatus **11** includes the reservoir **86** configured to store liquid to be supplied to the liquid discharge head **20**. The reservoir **86** is provided at a position lower than the liquid discharge head **20**. The liquid discharge apparatus **11** includes the supply flow path **87** configured to communicate with the liquid discharge head **20** and the reservoir **86**. The supply flow path **87** is provided with the joint **88** detachable from the liquid discharge head **20**. The liquid discharge apparatus **11** includes the retainer **90** configured to retain the joint **88** detached from the liquid discharge head **20**. The joint **88** has the couplers **89** to be coupled to the liquid discharge head **20**. The retainer **90** is configured to retain the joint **88** with the couplers **89** facing up. With this configuration, even when the joint **88** of the supply flow path **87** is detached from the liquid discharge head **20**, dripping of liquid from the couplers **89** of the joint **88** can be prevented.

(148) (2) The liquid discharge apparatus **11** is detachably provided in the retainer **90**, and further includes the cap **92** detachably provided in the retainer **90**, and attachable to and detachable from the couplers **89** of the joint **88** detached from the liquid discharge head **20**. With this configuration, dripping of liquid from the couplers **89** can be further prevented.

(149) (3) The retainer **90** is formed in a bottomed box shape with an opening upward. With this configuration, even when liquid drips from the couplers **89**, adhesion of liquid to other portions can be prevented.

(150) (4) The valves **38**, **40** are normally closed valves that automatically close the supply flow path **87** when power supply is OFF. With this configuration, continuous dripping of liquid from the nozzles due to an unexpected situation at the time of power OFF can be prevented.

(151) (5) The liquid discharge apparatus **11** includes the drive unit **59**. The supply flow path **87** has the flexible section **42** having flexibility in at least part of the supply flow path **87**. The drive unit **59** can displace the flexible section **42** in a direction in which the volume of the supply flow path **87** increases, and can maintain the state of the displaced flexible section **42**. The drive unit **59** is configured to be controlled by the controller **100**, and configured to be manually operable. With this configuration, when the supply flow path **87** is detached from the liquid discharge head **20**, a negative pressure can be applied to the couplers **89** of the joint **88**.

(152) (6) The drive unit **59** displaces the flexible section **42** in a direction in which the volume of the supply flow path **87** increases, and delivers liquid to the reservoir **86** by displacing the flexible section **42** in a direction in which the volume of the supply flow path **87** increases as well as in a direction in which the volume of the supply flow path **87** decreases before the state of displaced flexible section **42** is maintained. With this configuration, when the joint **88** is detached from the liquid discharge head **20**, dripping of liquid through the nozzles **21**N of the liquid discharge head **20** can be prevented.

(153) (7) The liquid discharge apparatus **11** further includes the mounting section **83** detachably provided with the liquid storage **82** that stores liquid to be supplied to the reservoir **86**. The liquid discharge head **20** has the female coupler **22** configured to be coupled to the couplers **89** of the joint **88**. The retainer **90** is provided at a position closer to a base end of the supply flow path **87** than the female coupler **22** of the liquid discharge head **20**, the base end being one end of the supply flow path **87** and near the reservoir **86**. With this configuration, the joint **88** detached from the liquid discharge head **20** is easily retained by the retainer **90**. For example, when an operator places the detached joint **88** on the retainer **90**, a load due to tension, fracture, or torsion is unlikely to be applied to the supply flow path **87**. Specifically, with the joint **88** placed on the retainer **90** in an orientation with the couplers **89** facing up, the supply flow path **87** is held in the form of a

circular arc path, which is unlikely to be subjected to a load due to tension, fracture, or torsion.

Second Embodiment

(154) Next, a second embodiment will be described. The second embodiment is different from the first embodiment in the content of liquid dripping prevention control. The configuration of the liquid discharge apparatus **11** and its liquid supply unit is the same as that of the first embodiment.

(155) When receiving instructions for head replacement, the controller **100** moves the liquid discharge head **20** to the replacement position. The controller **100** causes a computer to execute the liquid dripping prevention control routine illustrated in FIG. **10**.

(156) In step S**21**, the controller **100** opens the valves **38**, **40**. Specifically, the controller **100** switches the first valve **38** and the second valve **40** from a closed valve state to an open valve state. A negative pressure according to the water head difference between the liquid in the first reservoir chamber **62** and the second reservoir chamber **68**, and the liquid at the nozzle surface **21**A of the liquid discharge head **20** is applied to the meniscus of each nozzle **21**N. At this point, the liquid discharge head **20** is moved from the cap position to the replacement position, thus the height position of the nozzle surface **21**A of the liquid discharge head **20** is displaced in −Z direction by a predetermined distance. In other words, because of the movement of the liquid discharge head **20** to the replacement position, the water head difference between the liquid at the standard position of the liquid surface of the first reservoir chamber **62** and the second reservoir chamber **68**, and the meniscus of the liquid at the nozzle surface **21**A of the liquid discharge head **20** is further increased, thus a negative pressure applied to the meniscus in each nozzle **21**N is increased according to the water head difference. The meniscus of the liquid in the liquid discharge head **20** is moved in a depth direction (upstream direction) of the nozzles **21**N.

(157) In step S**22**, the controller **100** depressurizes the reservoirs **33**, **35**. Specifically, the controller **100** depressurizes the first reservoir chamber **62** and the second reservoir chamber **68**. Specifically, the controller **100** performs switching control on the switching mechanism **48**, thereby opening the first selection valve **73***a*, the fifth selection valve **73***e*, the eighth selection valve **73***h*, the 10th selection valve **73***j* and the 11th selection valve **73***k*, and closing other selection valves. In this state, the controller **100** drives the pump **47** in a reverse direction. Thus, the air in the first reservoir chamber **62** is discharged through the air flow path **55**, the coupling flow path **52** and the atmosphere open path **50**, and the pressure in the first reservoir chamber **62** decreases. At the same time, the air in the second reservoir chamber **68** is discharged through the air flow path **55**, the coupling flow path **52**, and the pressurization flow path **51**, and the pressure in the second reservoir chamber **68** decreases.

(158) Because the first reservoir chamber **62** and the second reservoir chamber **68** are depressurized, the negative pressure applied to the liquid at the position of the meniscus of the liquid further increases by the amount of depressurization in the liquid discharge head **20** communicating with these reservoir chambers **62**, **68** through the supply flow path **87**. Therefore, the meniscus of the liquid in the liquid discharge head **20** is moved further upstream. Due to the movement of the meniscus, an air area is generated in a portion including the nozzles **21**N in the liquid discharge head **20**.

(159) The meniscus of the liquid in the liquid discharge head **20** reaches the filter **46** depending on the water head difference based on the distance difference in the vertical direction Z between the liquid surface height in the reservoir chambers **62**, **68**, and the meniscus height of the liquid in the liquid discharge head **20**, as well as the value of depressurization of the reservoir chambers **62**, **68**. In this situation, as in the first embodiment, areas including the nozzles **21**N downstream of the filter **46** are all air areas. A micro meniscus is formed in the filter **46**.

(160) In step S**23**, the controller **100** maintains the depressurized state of the reservoirs. Specifically, the controller **100** opens the first selection valve **73***a*, the fifth selection valve **73***e*, the eighth selection valve **73***h*, the 10th selection valve **73***j* and the 11th selection valve **73***k*. When the reservoir chambers **62**, **68** are in a state of communicating with the stopped pump **47**, air gradually

leaks into the reservoir chambers **62**, **68** through the pump **47**, thus the reduced pressure in the reservoir chambers **62**, **68** gradually approaches the atmospheric pressure. Thus, the controller **100** maintains the depressurized state in the first reservoir chamber **62** and the second reservoir chamber **68** by opening the 10th selection valve **73***j* and the 11th selection valve **73***k*.

(161) When completing the liquid dripping prevention control in this way, the controller **100** causes the display unit **19** to display information indicating that head replacement is ready. After detaching the discharge tray **18**A from the apparatus body **12**, an operator detaches the joint **88** from the liquid discharge head **20**.

(162) When an operator detaches the joint **88** from the liquid discharge head **20**, the operator may press the tube of the supply flow path **87** or apply an excessive acceleration or impact to the joint **88** unintentionally. At this point, the gas-liquid interface of the liquid in the liquid discharge head **20** is located further in the depth direction of the nozzles **21**N, as compared to when printing is performed, thus even when the gas-liquid interface of the liquid is displaced somewhat toward the nozzles **21**N, liquid does not drip from the nozzles **21**N.

(163) Liquid Dripping Prevention When Power Supply Is Off

(164) Next, the head replacement work performed in a power OFF state of the liquid discharge apparatus **11** in the second embodiment will be described.

(165) When power supply is OFF, an operator performs an operation having the same content as that of the liquid dripping prevention control by a manual operation. An operator drives the pump **47**, the first valve **38**, the second valve **40** and the switching mechanism **48** by a manual operation. The first valve **38** and the second valve **40** are normally closed valves, thus are in a closed state when power supply is OFF. Thus, the supply flow path **87** is closed. An operator operates the operation sections **38**A, **40**A to switch the first valve **38** and the second valve **40** from a closed valve state to an open valve state.

(166) Because of the movement of the liquid discharge head **20** to the replacement position PH**2**, the water head difference between the liquid at the standard position of the liquid surface of the first reservoir chamber **62** and the second reservoir chamber **68**, and the meniscus of the liquid located at the nozzle surface **21**A of the liquid discharge head **20** is further increased. A negative pressure applied to the liquid in the nozzles **21**N is increased according to the increase of the water head difference. As a result, the meniscus of the liquid in the liquid discharge head **20** is moved in a depth direction (upstream direction) of the nozzles **21**N.

(167) Next, an operator depressurizes the first reservoir chamber **62** and the second reservoir chamber **68** by a manual operation. First, an operator uses the operation section **74** to perform a switching operation on the cam of the switching mechanism **48**. An operator performs a cam switching operation to select a switching position to open the first selection valve **73***a*, the fifth selection valve **73***e*, the eighth selection valve **73***h*, the 10th selection valve **73***j* and the 11th selection valve **73***k*, and close other selection valves. In this state, an operator operates the operation section **47**A to drive the pump **47** in a reverse direction. Thus, the air in the first reservoir chamber **62** is discharged through the coupling flow path **52** and the atmosphere open path **50**, and the pressure in the first reservoir chamber **62** decreases. At the same time, the air in the second reservoir chamber **68** is discharged through the coupling flow path **52**, and the pressurization flow path **51**, and the pressure in the second reservoir chamber **68** decreases.

(168) Because the first reservoir chamber **62** and the second reservoir chamber **68** are depressurized, the negative pressure applied to the liquid at the position of the meniscus of the liquid further increases by the amount of depressurization in the liquid discharge head **20**. Therefore, the meniscus of the liquid in the liquid discharge head **20** is moved further upstream. An air area is generated in a portion including the nozzles **21**N in the liquid discharge head **20**. After driving the pump **47** in a reverse direction for a necessary number of rotations, an operator stops the operation using the operation section **47**A. In this manner, the reservoirs **33**, **35** are depressurized.

(169) Furthermore, an operator uses the operation section **74** to perform a switching operation on the cam of the switching mechanism **48**. An operator performs a cam switching operation to select a switching position to open the first selection valve **73***a*, the fifth selection valve **73***e*, the eighth selection valve **73***h*, the 10th selection valve **73***j* and the 11th selection valve **73***k*. Therefore, the depressurized state of the reservoirs **33**, **35** is maintained.

Effects of Second Embodiment

(170) According to the second embodiment, the effects of the above-mentioned (1) to (4) in the first embodiment are obtained in the same manner, and additionally the following effects are obtained.

(171) (8) The liquid discharge apparatus **11** is provided in the middle of the supply flow path **87**, and includes the valves **38**, **40** that can open and close the supply flow path **87**, and the controller **100** that can control the opening and closing of the valves **38**, **40**. The valves **38**, **40** are configured to be manually opened and closed when power supply is OFF. With this configuration, even when the supply flow path **87** is detached from the liquid discharge head **20** in a power OFF state, a negative pressure can be applied to the couplers **89** of the joint **88** by manually opening the valves **38**, **40**. Thus, when the supply flow path **87** is detached from the liquid discharge head **20**, liquid dripping can be prevented.

(172) (9) The liquid discharge apparatus **11** further includes the depressurizer **76** configured to depressurize the space in the reservoir **86**, and the depressurization maintainer **77** configured to maintain a depressurized state of the space depressurized by the depressurizer **76**. The depressurizer **76** and the depressurization maintainer **77** are configured to be controlled by the controller **100**, and configured to be manually operable. With this configuration, when the supply flow path **87** is detached from the liquid discharge head **20**, a negative pressure can be applied to the couplers **89** of the joint **88**.

(173) This embodiment can be modified and implemented in the following manner. This embodiment and the following modifications can be combined in a technically consistent range and implemented. In the first embodiment, the controller **100** may cause the variable capacity mechanism **58** to drive in a direction in which the volume of the liquid chamber **41** increases so that the number of times of drawing liquid into the liquid chamber **41** may be one. In other words, only the process of step S**11** may be performed. In the first embodiment, a flow path valve that opens and closes the supply flow path **87** may be provided at a position between the liquid chamber **41** of the variable capacity mechanism **58** and the joint **88**. When the liquid in the liquid discharge head **20** is drawn upstream (toward the joint **88**) by increasing the volume of the liquid chamber **41**, the flow path valve may be opened, and when the liquid drawn into the liquid chamber **41** is delivered to the first reservoir chamber **62**, the flow path valve may be closed. In the first embodiment, when the joint **88** is detached from the female coupler **22** of the liquid discharge head **20**, the first valve **38** and the second valve **40** may be in an open state. In the first embodiment, as in the second embodiment, the first reservoir chamber **62** and the second reservoir chamber **68** may be depressurized at the time of head replacement. With this configuration, when the joint **88** is detached from the liquid discharge head **20**, dripping of liquid from the couplers **89** can be further prevented. In the second embodiment and the above-described modifications, only one of the first reservoir chamber **62** and the second reservoir chamber **68** may be depressurized at the time of head replacement. In the second embodiment, only one of the first valve **38** and the second valve **40** may be in an open state at the time of head replacement. In the second embodiment, each of the first reservoir chamber **62** and the second reservoir chamber **68** may not be depressurized at the time of head replacement. The replacement position PH**2** of the liquid discharge head **20** may be same as the cap position at which the head **21** is capped by the cap **116**. In addition, the liquid discharge head **20** may not be a liftable head that is designed to be moved to a height position at the time of replacement, which is different from the position during printing or in print standby. The pumps **47**, **75** are not limited to tube pumps, and may be other pumps. For example, the pumps **47**,

75 may be diaphragm pumps or gear pumps. The liquid supply member **81** is not limited to the one which is disposed in the apparatus body **12** of the liquid discharge apparatus **11**, and may be an external one which is coupled to the apparatus body **12** via a tube or the like. The latch **91** and the female latch **88**A are not necessarily a projecting section and a depressed section, respectively, and may be reversed. Also, for the latch **91** and the female latch **92**A, a projecting section and a depressed section may be reversed. In the retainer **90**, the latch **91** to be latched to the joint **88** and the latch **91** to be latched to the cap **92** may be separately provided. The latch **91** may also be a snap-fit latch. The joint **88** may not include the female latch **88**A. The latch **91** may be configured to have a regulation surface which comes into contact with the lateral surface of the joint **88** to regulate the joint **88** at a retained position. The first reservoir **33** or the second reservoir **35** may have a window through which a user can visually recognize an amount of liquid. The reservoir **86** may be one reservoir without being divided into the first reservoir **33** and the second reservoir **35**. The reservoir **86** may be the liquid storage **82**. In other words, the first reservoir **33** and the second reservoir **35** may not be provided in the embodiment. The liquid storage **82** attached to the mounting section **83** may be configured to be coupled to the supply flow path **87** as a reservoir. At the time of circulation of liquid, liquid from the liquid discharge head **20** may be returned to the second reservoir chamber **68** through the return flow path **39**. The supply flow path **87** is not limited to a liquid circulation flow path including the delivery flow path **37** and the return flow path **39**, and may be a supply flow path **87** including only one flow path for each color corresponding to the delivery flow path **37**. The liquid storage **82** is not limited to a cartridge such as an ink cartridge, and may be a tank configured to be attachable to and detachable from the mounting section **83**. The reservoir **86** may be a tank which is attachable to and detachable from the apparatus body **12**, and which is to be filled with liquid by a user. The opening **12**D through which the liquid discharge head **20** is taken out for replacement may be formed in the lateral section of the apparatus body. For example, the liquid discharge head **20** may be replaced through an opening in the rear surface of the apparatus body **12**. The arrangement position of the retainer **90** is not limited to an upper position of the mounting section **83**, and may be a lateral position of the mounting section **83**. The liquid discharge apparatus **11** may be a serial printer. In this situation, the serial liquid discharge head **20** has the head **21**, and a carriage provided with the head **21** and movable in the width direction X. The joint **88** coupled to one end of the supply flow path **87** is coupled to the female coupler **22** provided in the carriage. The liquid discharge apparatus may be an ink jet textile printing apparatus. The textile printing apparatus may include the retainer **90** on which the joint **88** is placed, and may additionally include the cap **92**. Furthermore, the textile printing apparatus may perform the liquid dripping prevention control. The liquid discharge apparatus **11** is not limited to a multifunction printer. The liquid discharge apparatus **11** may not include the image reader **13** The liquid discharge apparatus **11** may be a liquid discharge apparatus that discharges liquid other than ink. Examples of the liquid include pre-treatment liquid and post-treatment liquid for printing. The state of liquid discharged from the liquid discharge apparatus as a tiny amount of droplets also includes a granular state, a tear-shaped state, and a thread-like state. The liquid referred to herein may be a material which can be discharged from the liquid discharge apparatus. For example, the liquid may be in a state where a substance is in a liquid phase, and includes a high or low viscosity fluid, a sol, gel water, and other fluids such as an inorganic solvent, an organic solvent, a solution, a liquid resin, liquid metal, and metal melt. The liquid includes not only liquid as a state of substance, but also solutions obtained by dissolving, dispersing or mixing particles of functional material in a solvent, the particles being comprised of solid substances such as pigments and metal particles.

(174) In the following, the technical idea and its operational effects derived from the embodiment and its modifications will be described.

(175) (A) A liquid discharge apparatus includes: a liquid discharge head configured to discharge liquid; a reservoir provided at a position lower than the liquid discharge head, and configured to

store liquid to be supplied to the liquid discharge head; a supply flow path provided with a joint detachable from the liquid discharge head, and configured to communicate with the liquid discharge head and the reservoir; and a retainer configured to retain the joint detached from the liquid discharge head. The joint has a coupler to be coupled to the liquid discharge head, and the retainer is configured to retain the joint with the coupler facing up.

(176) With this configuration, even when the joint of the supply flow path is detached from the liquid discharge head, dripping of liquid from the coupler of the joint can be prevented.

(177) (B) The liquid discharge apparatus may further include a cap detachably provided in the retainer, and configured to be attachable to and detachable from the coupler of the joint detached from the liquid discharge head.

(178) With this configuration, dripping of liquid from the coupler can be further prevented.

(179) (C) In the liquid discharge apparatus, the retainer may be formed in a bottomed box shape with an opening upward.

(180) With this configuration, even when liquid drips from the coupler, adhesion of liquid to other portions can be prevented.

(181) (D) The liquid discharge apparatus may further include a valve provided in a middle of the supply flow path, and configured to open and close the supply flow path; and a controller configured to control opening and closing of the valve. The valve may be configured to be manually opened and closed when power supply is off.

(182) With this configuration, even when the supply flow path is detached from the liquid discharge head in a power OFF state, a negative pressure can be applied to the coupler of the joint by manually opening the valve. Thus, when the supply flow path is detached from the liquid discharge head, liquid dripping can be prevented.

(183) (E) In the liquid discharge apparatus, the valve may be a normally closed valve that automatically closes the supply flow path when power supply is off.

(184) With this configuration, continuous dripping of liquid from the nozzles due to an unexpected situation at the time of power OFF can be prevented.

(185) (F) The liquid discharge apparatus may further include a depressurizer configured to depressurize space in the reservoir; and a depressurization maintainer configured to maintain a depressurized state of the space depressurized by the depressurizer. The depressurizer and the depressurization maintainer may be configured to be controlled by the controller, and to be manually operable.

(186) With this configuration, when the supply flow path is detached from the liquid discharge head, a negative pressure can be applied to the coupler of the joint.

(187) (G) The liquid discharge apparatus may further include a drive unit. The supply flow path may include a flexible section having flexibility in at least part of the supply flow path, the drive unit may be configured to displace the flexible section in a direction in which a capacity of the supply flow path increases, and to maintain a state of the displaced flexible section, and the drive unit may be configured to be controlled by the controller, and to be manually operable.

(188) With this configuration, when the supply flow path is detached from the liquid discharge head, a negative pressure can be further applied to the coupler of the joint.

(189) (H) The liquid discharge apparatus may further include a mounting section detachably provided with a liquid storage that stores liquid to be supplied to the reservoir. The liquid discharge head may have a female coupler configured to be coupled to the coupler of the joint, and the retainer may be provided at a position closer to a base end of the supply flow path than the female coupler of the liquid discharge head, the base end being one end of the supply flow path and near the reservoir.

(190) With this configuration, the joint detached from the liquid discharge head is easily retained by the retainer. For example, when an operator places the detached joint on the retainer, a load due to tension, fracture, or torsion is unlikely to be applied to the supply flow path.

Claims

1. A liquid discharge apparatus comprising: a liquid discharge head configured to discharge liquid; a reservoir provided at a position lower than the liquid discharge head, and configured to store liquid to be supplied to the liquid discharge head; a supply flow path provided with a joint detachable from the liquid discharge head, and configured to communicate with the liquid discharge head and the reservoir; and a retainer configured to retain the joint detached from the liquid discharge head, wherein the joint has a coupler to be coupled to the liquid discharge head, the retainer is configured to retain the joint with the coupler facing up, and a cap is detachably provided in the retainer, and configured to be attachable to and detachable from the coupler of the joint detached from the liquid discharge head.
2. The liquid discharge apparatus according to claim 1, wherein the retainer is formed in a bottomed box shape with an opening upward.
3. The liquid discharge apparatus according to claim 1, further comprising: a valve provided in a middle of the supply flow path, and configured to open and close the supply flow path; and a controller configured to control opening and closing of the valve, wherein the valve is configured to be manually opened and closed when power supply is off.
4. The liquid discharge apparatus according to claim 3, wherein the valve is a normally closed valve that automatically closes the supply flow path when power supply is off.
5. The liquid discharge apparatus according to claim 3, further comprising: a depressurizer configured to depressurize space in the reservoir; and a depressurization maintainer configured to maintain a depressurized state of the space depressurized by the depressurizer, wherein the depressurizer and the depressurization maintainer are configured to be controlled by the controller, and to be manually operable.
6. The liquid discharge apparatus according to claim 3, further comprising a drive unit, wherein the supply flow path includes a flexible section having flexibility in at least part of the supply flow path, the drive unit is configured to displace the flexible section in a direction in which a capacity of the supply flow path increases, and to maintain a state of the displaced flexible section, and the drive unit is configured to be controlled by the controller, and to be manually operable.
7. The liquid discharge apparatus according to claim 1, further comprising a mounting section detachably provided with a liquid storage that stores liquid to be supplied to the reservoir, wherein the liquid discharge head has a female coupler configured to be coupled to the coupler of the joint, and the retainer is provided at a position closer to a base end of the supply flow path than the female coupler of the liquid discharge head, the base end being one end of the supply flow path and near the reservoir.
8. A liquid discharge apparatus comprising: a liquid discharge head configured to discharge liquid; a reservoir provided at a position lower than the liquid discharge head, and configured to store liquid to be supplied to the liquid discharge head; a supply flow path provided with a joint detachable from the liquid discharge head, and configured to communicate with the liquid discharge head and the reservoir; a retainer configured to retain the joint detached from the liquid discharge head; a valve provided in a middle of the supply flow path, and configured to open and close the supply flow path; and a controller configured to control opening and closing of the valve, wherein the joint has a coupler to be coupled to the liquid discharge head, the retainer is configured to retain the joint with the coupler facing up, and the valve is configured to be manually opened and closed when power supply is off.
9. The liquid discharge apparatus according to claim 8, wherein the valve is a normally closed valve that automatically closes the supply flow path when power supply is off.
10. The liquid discharge apparatus according to claim 8, further comprising: a depressurizer configured to depressurize space in the reservoir; and a depressurization maintainer configured to

maintain a depressurized state of the space depressurized by the depressurizer, wherein the depressurizer and the depressurization maintainer are configured to be controlled by the controller, and to be manually operable.

11. The liquid discharge apparatus according to claim 8, further comprising a drive unit, wherein the supply flow path includes a flexible section having flexibility in at least part of the supply flow path, the drive unit is configured to displace the flexible section in a direction in which a capacity of the supply flow path increases, and to maintain a state of the displaced flexible section, and the drive unit is configured to be controlled by the controller, and to be manually operable.

12. A liquid discharge apparatus comprising: a liquid discharge head configured to discharge liquid; a reservoir provided at a position lower than the liquid discharge head, and configured to store liquid to be supplied to the liquid discharge head; a supply flow path provided with a joint detachable from the liquid discharge head, and configured to communicate with the liquid discharge head and the reservoir; a retainer configured to retain the joint detached from the liquid discharge head; and a mounting section detachably provided with a liquid storage that stores liquid to be supplied to the reservoir, wherein the joint has a coupler to be coupled to the liquid discharge head, the retainer is configured to retain the joint with the coupler facing up, the liquid discharge head has a female coupler configured to be coupled to the coupler of the joint, and the retainer is provided at a position closer to a base end of the supply flow path than the female coupler of the liquid discharge head, the base end being one end of the supply flow path and near the reservoir.