(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 263 343 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
03.01.2018 Bulletin 2018/01

(21) Application number: **16755083.9**

(22) Date of filing: **19.01.2016**

(51) Int Cl.:
B41J 2/175 *(2006.01)*

(86) International application number:
PCT/JP2016/051446

(87) International publication number:
WO 2016/136333 (01.09.2016 Gazette 2016/35)

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

(30) Priority: **26.02.2015 JP 2015036294**
30.10.2015 JP 2015213928

(71) Applicant: **Seiko Epson Corporation**
Tokyo 160-8801 (JP)

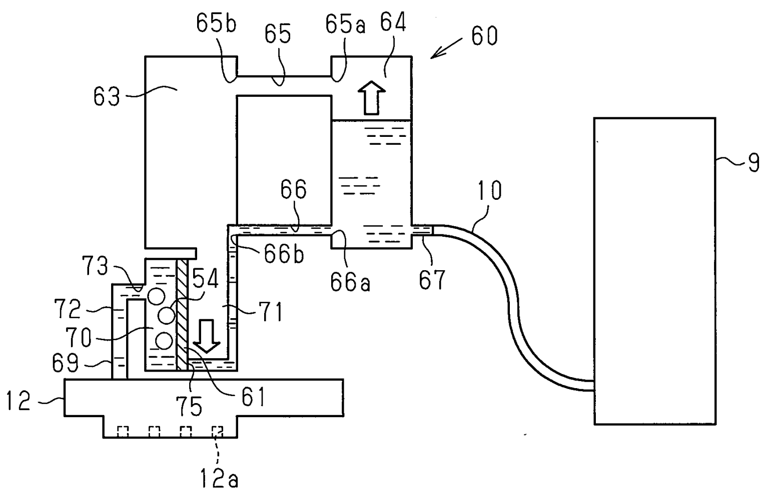
(72) Inventor: **KOASE, Takashi**
Suwa-shi
Nagano 392-8502 (JP)

(74) Representative: **Miller Sturt Kenyon**
9 John Street
London WC1N 2ES (GB)

(54) LIQUID DISCHARGE DEVICE AND INTERMEDIATE RETAINING BODY

(57) In the present invention, a liquid discharge device is provided with a discharge head that discharges a liquid, a liquid supply path that supplies the liquid to the discharge head, and an intermediate retaining body disposed in the liquid supply path. The intermediate retaining body comprises a first retaining chamber, a second retaining chamber disposed upstream of the first retaining chamber, an upper communication path that communicates between the first retaining chamber and the second retaining chamber, and a lower communication path that communicates between the first retaining chamber and the second retaining chamber below the upper communication path. The lower communication path has a lower communication opening that opens into the second retaining chamber, the upper communication path has an upper communication opening that opens into the second retaining chamber, and the lower communication opening is smaller than the upper communication opening.

Fig.19



Printed by Jouve, 75001 PARIS (FR)

Description

TECHNICAL FIELD

[0001] The present invention relates to a liquid ejection device for an inkjet printer or the like and an intermediate reservoir for a liquid ejection device.

BACKGROUND ART

[0002] An inkjet printer that ejects ink (liquid) from a nozzle opening of an ejection head onto a medium to perform printing is widely known as one type of a typical liquid ejection device. Such a printer may include a liquid intake passage member (for example, refer to patent document 1) that draws ink into a head body (ejection head).

[0003] The liquid intake passage member includes an ink intake passage that supplies ink to the nozzle opening. The ink intake passage includes a filter chamber, a pressure chamber located at the upstream side of the filter compartment, a first communication passage, and a second communication passage. The first communication passage includes a bubble chamber that extends vertically upward from the pressure chamber. Ink flows from the pressure chamber through a first communication passage inlet of the pressure chamber into the first communication passage and enters the filter chamber. Further, ink flows from the pressure chamber through a second communication passage inlet, which is separate from the first communication passage inlet and located downward from the first communication passage inlet, into the second communication passage and enters the filter chamber.

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0004] Patent Document 1: JP-A-2010-52210

SUMMARY OF THE INVENTION

PROBLEMS THAT ARE TO BE SOLVED BY THE INVENTION

[0005] In the printer of patent document 1, the second communication passage inlet is located below the first communication passage inlet. When the ink from the pressure chamber contains bubbles, the bubbles may enter the second communication passage through the second communication passage inlet and reach the filter chamber together with the ink. As a result, the bubbles may enter the head body.

[0006] Such a problem is not limited to an inkjet printer that ejects ink from the nozzle opening of the ejection head and also occurs in a liquid ejection device that ejects liquid from a nozzle opening of an ejection head.

[0007] It is an object of the present invention to provide a liquid ejection device and an intermediate reservoir that restricts the entrance of bubbles into an ejection head.

MEANS FOR SOLVING THE PROBLEM

[0008] A liquid ejection device according to one embodiment of the present disclosure includes an ejection head that ejects liquid from a nozzle onto a medium, a liquid supply passage that supplies the ejection head with the liquid that is held in a liquid supply source, and an intermediate reservoir arranged in the liquid supply passage and capable of storing the liquid. The intermediate reservoir includes a first storage chamber capable of storing the liquid, a second storage chamber capable of storing the liquid and located at an upstream side of the first storage chamber, an upper communication passage that connects the first storage chamber and the second storage chamber, and a lower communication passage that connects the first storage chamber and the second storage chamber at a location lower than the upper communication passage. The lower communication passage includes a lower communication port that opens in the second storage chamber. The upper communication passage includes an upper communication port that opens in the second storage chamber. The lower communication port is smaller than the upper communication port.

[0009] With this structure, the lower communication port is smaller than the upper communication port. This restricts the entrance of bubbles into the lower communication passage from the lower communication port. Accordingly, the entrance of bubbles into the ejection head is restricted.

[0010] Preferably, in the liquid ejection device, the lower communication port opens upward.

[0011] With this structure, bubbles easily float upward in the liquid. This effectively restricts the entrance of bubbles into the lower communication passage from the lower communication port.

[0012] Preferably, in the liquid ejection device, the lower communication passage includes an upstream path that extends from the lower communication port to a location lower than the lower communication port and a downstream path that extends upward from a downstream side of the upstream path.

[0013] With this structure, even when bubbles enter the lower communication passage from the lower communication port, the upstream path extends from the lower communication port at a lower location than the lower communication port. Thus, the buoyance of the bubbles entering the lower communication passage returns the bubbles to the second storage chamber. In addition, the lower communication passage includes the upstream path and the downstream path. This allows a high flow passage resistance to be set for the lower communication passage without increasing the distance between the first storage chamber and the second storage chamber.

[0014] Preferably, the liquid ejection device further includes a filter arranged in the first storage chamber. The filter partitions the first storage chamber into a downstream cavity that is connected to the ejection head and an upstream cavity that is connected to the second storage chamber. The filter includes a pore that allows for the passage of the liquid. The lower communication port is located upward from the filter.

[0015] This structure restricts the passage of bubbles through the filter and entrance of the bubbles into the ejection head even when bubbles enter the lower communication passage from the lower communication port.

[0016] Preferably, in the liquid ejection device, the liquid supply passage includes an inlet that opens in the second storage chamber. The liquid supplied from the liquid supply source enters the second storage chamber through the inlet. The lower communication port is located downward from the inlet and opens in a direction that differs from an opening direction of the inlet.

[0017] This structure restricts the entrance of bubbles, which are suspended in the liquid entering the second storage chamber from the inlet, into the lower communication passage from the lower communication port.

[0018] Preferably, in the liquid ejection device, the upper communication port is an upper second communication port, and the upper communication passage further includes an upper first communication port that opens in the first storage chamber. The lower communication port is a lower second communication port, and the lower communication passage further includes a lower first communication port that opens in the first storage chamber. The lower communication passage has a flow passage resistance and the upper communication passage has a flow passage resistance that are set so that when the liquid is ejected onto the medium from the ejection head in a normal state in which a liquid surface of the liquid in the intermediate reservoir is located upward from the lower first communication port and the lower second communication port and downward from the upper first communication port and the upper second communication port, the liquid surface of the first storage chamber does not contact the filter.

[0019] With this structure, when the ejection head ejects liquid, the liquid surface (air-liquid interface) of the liquid does not contact the filter. This limits decreases in the capacity for supplying liquid to the ejection head and restricts the passage of bubbles through the ejection head and the entrance of the bubbles into ejection head.

[0020] Preferably, the liquid ejection device further includes a discharge unit configured to perform a discharge operation that discharges the liquid ink from the nozzle. The discharge unit is configured to perform a special discharge operation in which the liquid surface of the first storage chamber comes into contact with the filter by discharging the liquid from the nozzle in the normal state. The pore of the filter is configured so that a pressure difference between the downstream cavity and the upstream cavity produced as the liquid flows through the liquid supply passage when the special discharge operation is performed breaks a meniscus of the liquid formed at the pore of the filter.

[0021] With this structure, residual bubbles can be discharged from the second storage chamber by performing a special discharge operation.

[0022] An intermediate reservoir according to one aspect of the present disclosure is arranged in a liquid supply passage that supplies liquid held in a liquid supply source to an ejection head that ejects the liquid from a nozzle onto a medium, and is capable of storing the liquid. The intermediate reservoir includes a first storage chamber capable of storing the liquid, a second storage chamber capable of storing the liquid and located at an upstream side of the first storage chamber, an upper communication passage that connects the first storage chamber and the second storage chamber, and a lower communication passage that connects the first storage chamber and the second storage chamber at a location lower than the upper communication passage. The lower communication passage includes a lower communication port that opens in the second storage chamber. The upper communication passage includes an upper communication port that is in communication with the second storage chamber. The lower communication port is smaller than the upper communication port.

[0023] With this structure, the lower communication port is smaller than the upper communication port. This restricts the entrance of bubbles into the lower communication passage from the lower communication port. Accordingly, the entrance of bubbles into the ejection head is restricted.

[0024] A liquid ejection device according to a further aspect of the present disclosure includes an ejection head that ejects liquid, a liquid supply passage that supplies the ejection head with the liquid from a liquid holder that holds the liquid, and a filter unit located in the liquid supply passage and including a filtering member that removes foreign matter from the liquid. The filter unit includes a filter chamber that accommodates the filtering member and an ink storage chamber that stores the liquid. The filter chamber includes an upstream filter chamber and a downstream filter chamber that are partitioned by the filtering member. The ink storage chamber and the upstream filter chamber are in communication through a first communication pipe, a second communication pipe, and an airflow pipe. The first communication pipe is located downward in a gravitational direction from the second communication pipe and the airflow pipe, and the first communication pipe is configured so that pressure loss caused by the first communication pipe produces a hydraulic head difference between the ink storage chamber and the upstream filter chamber that is greater than or equal to a length of the upstream filter chamber in the gravitational direction.

[0025] With this structure, the ink supplied to the ink storage chamber is sent through the first communication pipe to the upstream filter chamber. The ink then passes through the filter member, enters the downstream filter chamber, and is then discharged toward the ejection head. In this state, air exists in the upper part of the ink storage chamber and the airflow pipe. The airflow pipe allows air to flow between chambers. Thus, the liquid level of each chamber changes in accordance with the hydraulic head difference between the chambers.

[0026] If the ejection head performs ink suction when the liquid surface of the ink storage chamber is lower than the portion connected with the second communication pipe and the portion connected with the airflow pipe, the pressure loss of the first communication pipe produces a hydraulic head difference between the ink storage chamber and the upstream filter chamber that is greater than or equal to the length in the gravitational direction of the upstream filter chamber. Thus, the liquid level of the upstream filter chamber falls and covers most of the surface of the filtering member with air. The flow of ink concentrates at the portion of the filtering member that is not covered by air. This locally raises the flow speed and increases the pressure loss of the filter unit. As a result, pressure that is greater than or equal to the bubble point is applied to the filter unit, and air is discharged from the filter chamber toward the downstream side. Accordingly, a liquid ejection device that is capable of discharging bubbles accumulated in the filter unit is obtained with a simple and low-cost structure.

[0027] Preferably, in the liquid ejection device, the second communication pipe is shaped to project upward in the gravitational direction, and the second communication pipe includes an uppermost portion that is located downward in the gravitational direction from the uppermost portion of the ink storage chamber.

[0028] With this structure, the second communication pipe shaped to project upward in the gravitational direction raises the liquid level of the ink storage chamber to the uppermost portion of the second communication pipe when discharging bubbles through ink suction. Then, the liquid level falls as bubbles enter from the upstream side. However, the siphon principle results in a continuous flow of ink between the ink storage chamber and the filter chamber. In this state, even when ink suction is performed, most of the ink flows through the second communication pipe. Thus, the pressure loss of the first communication pipe does not lower the liquid level of the filter chamber. That is, the discharge of bubbles is restricted.

[0029] The flow of ink in the second communication pipe is maintained until the liquid level of the ink storage chamber becomes lower than or equal to the portion connected to the second communication pipe. Thus, bubbles are not discharged until a certain amount of bubbles enter the ink storage chamber. Accordingly, this structure is advantageous in that the frequency in which bubbles enter the ejection head during ink suction is reduced, and defective ejections seldom occur.

[0030] Preferably, in the liquid ejection device, an upper surface of the ink storage chamber is located upward in the gravitational direction from an upper surface of the upstream filter chamber.

[0031] With this structure, the ink storage chamber is higher than the filter chamber. Thus, residual air mainly accumulates in the ink storage chamber. This decreases the area of the filtering member covered by air and increases the area of the filtering member that allows the passage of ink.

Accordingly, this structure is advantageous in that the usage efficiency of the filtering member is increased.

[0032] Preferably, in the liquid ejection device, the first communication pipe has a larger flow passage resistance than the second communication pipe.

[0033] With this structure, the first communication pipe has a larger flow passage resistance than the second communication pipe. When ink flows through the second communication pipe, the hydraulic head difference between the ink storage chamber and the filter chamber is smaller. Thus, if ink suction is performed when ink is flowing through the second communication pipe, the liquid level of the upstream filter chamber does not easily fall. This restricts the discharge of bubbles. Bubble discharge does not occur even when ink suction is performed unless new bubbles are accumulated. Accordingly, this structure is advantageous in that the frequency in which bubbles enter the ejection head during ink suction is reduced, and in that defective ejections seldom occur.

[0034] Preferably, in the liquid ejection device, the airflow pipe is coupled to the ink storage chamber at a position located upward in the gravitational direction from where the second communication pipe is coupled to the ink storage chamber.

[0035] With this structure, the airflow pipe is coupled to the ink storage chamber at a position located upward in the gravitational direction from where the second communication pipe is coupled to the ink storage chamber. Thus, the air in the ink storage chamber above the portion connected to the second communication pipe can be discharged through the airflow pipe during ink suction. Further, when the liquid level of the ink storage chamber rises to above the position connected to the second communication pipe, even when new bubbles enter the ink storage chamber, the liquid level does not immediately become lower than the portion connected to the second communication pipe. Bubble discharge is restricted until air flows into the second communication pipe. Thus, once bubbles are discharged, bubble discharge does not occur even when a certain amount of bubbles is entered. Accordingly, this structure is advantageous in that the frequency in which bubbles enter the ejection head during ink suction is reduced, and in that defective ejections seldom occur.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036]

Fig. 1 is a schematic perspective view showing the structure of an inkjet printer in a first embodiment.

Fig. 2 is a schematic cross-sectional view showing the inner structure of the printer of Fig. 1.

Fig. 3 is a schematic cross-sectional view of an ink supply passage in the printer of Fig. 1.

Fig. 4 is a schematic cross-sectional view showing the structure of an intermediate reservoir in the ink supply passage of Fig. 3.

Fig. 5 is a schematic cross-sectional view illustrating the operation (initial full state) of the intermediate reservoir of Fig. 4.

Fig. 6 is a schematic cross-sectional view illustrating the operation (after long term use) of the intermediate reservoir of Fig. 4.

Fig. 7 is a schematic cross-sectional view illustrating the operation (first air discharge operation) of the intermediate reservoir of Fig. 4.

Fig. 8 is a schematic cross-sectional view illustrating the operation (second air discharge operation) of the intermediate reservoir of Fig. 4.

Fig. 9 is a schematic cross-sectional view illustrating the operation (third air discharge operation) of the intermediate reservoir of Fig. 4.

Fig. 10 is a schematic cross-sectional view illustrating the operation (fourth air discharge operation) of the intermediate reservoir of Fig. 4.

Fig. 11 is a schematic cross-sectional view illustrating the operation (printing state) of the intermediate reservoir of Fig. 4.

Fig. 12 is a schematic cross-sectional view showing the structure of an intermediate reservoir (air discharging state) in a second embodiment.

Fig. 13 is a side view showing an intermediate reservoir in a third embodiment.

Fig. 14 is a perspective view showing the intermediate reservoir of Fig. 13.

Fig. 15 is a cross-sectional view taken along line 15-15 in Fig. 14.

Fig. 16 is a schematic cross-sectional view illustrating the operation (initial full state) of the intermediate reservoir of Fig. 13.

Fig. 17 is a schematic cross-sectional view illustrating the operation (after long term non-use) of the intermediate reservoir of Fig. 13.

Fig. 18 is a schematic cross-sectional view illustrating the operation (first special discharge operation) of the intermediate reservoir of Fig. 13.

Fig. 19 is a schematic cross-sectional view illustrating the operation (second special discharge operation) of the intermediate reservoir of Fig. 13.

Fig. 20 is a schematic diagram illustrating pressure that breaks a meniscus formed in a filter pore of the intermediate reservoir of Fig. 14.

Fig. 21 is a schematic cross-sectional view illustrating the operation (third special discharge operation) of the intermediate reservoir of Fig. 13.

Fig. 22 is a schematic cross-sectional view illustrating the operation (discharge operation) of the intermediate reservoir of Fig. 13.

Fig. 23 is a schematic cross-sectional view illustrating the operation (printing state) of the intermediate reservoir of Fig. 13.

Fig. 24 is a schematic cross-sectional view showing an inkjet printer in a fourth embodiment.

Fig. 25 is a schematic cross-sectional view showing a main part of an inkjet printer in a modified example.

Fig. 26 is a schematic cross-sectional view showing a main part of an inkjet printer in a further modified example.

EMBODIMENTS OF THE INVENTION

First Embodiment

[0037] A first embodiment of a liquid ejection device embodied in an inkjet printer will now be described with reference to the drawings.

[0038] As shown in Fig. 1, an inkjet printer 1, which is one example of a liquid ejection device, has the form of a rectangular box. In the description hereafter, when the inkjet printer 1 is set, among the two surface that are orthogonal to the gravitational direction, the upper one is referred to as the upper surface and the lower one is referred to as the bottom surface. Among the two surfaces contacting the long sides of the upper surface and the bottom surface, one surface is referred to as the front surface and the surface opposite to the front surface is referred to as the rear surface. The two surfaces contacting the short sides of the upper surface and the bottom surface are referred to as the side surfaces.

[0039] As shown in Fig. 1, the front surface of the inkjet printer 1 includes a front cover 2 and operation buttons 4. The front cover 2 includes a lower end that is pivotally supported and an upper end that is pulled and pivoted to horizontally arrange the front cover 2 and open an elongated paper discharge port 3. Printing paper 20, which is one example of a medium, is discharged from the paper discharge port 3.

[0040] The rear side of the inkjet printer 1 includes a paper feed tray (not shown). The printing paper 20 is set on the paper feed tray. Operation of the operation buttons 4 moves the printing paper 20 fed from the paper feed tray in predetermined amounts, prints an image or the like on the surface of the printing paper 20 inside the inkjet printer 1, and then discharges the printing paper 20 out of the paper discharge port 3.

[0041] The upper side of the inkjet printer 1 includes an upper cover 6. The rear side of the upper cover 6 is pivotally supported. The front side of the upper cover 6 is lifted and pivoted to open the upper cover 6 and check the inside of the inkjet printer 1 or repair the inkjet printer 1.

[0042] The side surface of the inkjet printer 1 includes a seat 5. A tank case 7, which has the form of a rectangular box, is arranged on the seat 5. Four ink tanks 9, which are examples of liquid supply sources, are arranged in the tank case 7. Each tank 9 holds ink, which serves as liquid. The ink is supplied to the inkjet printer 1 and used for printing. In the present embodiment, the inkjet printer 1 prints color images using four types of ink, namely, cyan ink, magenta ink, yellow ink, and black ink. Each type of ink is held in one of the ink tanks 9.

[0043] Aside surface of the tank case 7 (surface at side that is far from inkjet printer 1) includes a check window 8 that allows the four ink tanks 9 in the tank case 7 to be visually checked. The ink tanks 9 are formed from transparent or translucent material. This allows the remaining amount of ink in each ink tank 9 to be visually checked from the outside.

[0044] The inner structure of the inkjet printer 1 will now be described.

[0045] As shown in Fig. 2, the inkjet printer 1 includes a carriage 11 that travels back and forth above the printing paper 20, an ejection head 12 attached to the bottom side (side where printing paper 20 is located) of the carriage 11, and intermediate reservoirs 30 mounted on the carriage 11. The intermediate reservoirs 30 are connected by connection tubes 10 to the ink tanks 9 and connected by head connection tubes 52 (refer to Fig. 3) to the ejection head 12.

[0046] The intermediate reservoirs 30 temporarily store the ink supplied from the ink tanks 9 through the connection tubes 10, remove foreign matter from the ink, and then supply the ink through the head connection tubes 52 (refer to Fig. 3) to the ejection head 12. In the present embodiment, the connection tubes 10, the intermediate reservoirs 30, and the head connection tubes 52 are the elements forming liquid supply passages that supply the ejection head 12 with the ink held in the ink tanks 9. Each intermediate reservoir 30 is located at an intermediate position in the corresponding liquid supply passage.

[0047] The ejection head 12 ejects the ink supplied from the ink tanks 9 as ink droplets from nozzles 12a onto the printing paper 20. In the present embodiment, the inkjet printer 1 uses four types of ink, namely, cyan ink, magenta ink, yellow ink, and black ink. Thus, the ejection head 12 mounted on the carriage 11 includes a nozzle 12a for each type (color) of ink.

[0048] The carriage 11 is driven by a driving mechanism (not shown) and guided by a guide rail 13 to repetitively travel back and forth above the printing paper 20. The inkjet printer 1 also includes a paper feed mechanism (not shown) that transfers the printing paper 20 little by little in accordance with the reciprocating movement of the carriage 11. Ink is ejected from the nozzles 12a of the ejection head 12 in accordance with the reciprocating movement of the carriage 11 and the transferring movement of the printing paper 20 to print an image on the printing paper 20.

[0049] The four types of ink (cyan ink, magenta ink, yellow ink, and black ink) ejected from the nozzles 12a of the ejection head 12 are respectively held in the four ink tanks 9 of the tank case 7. The ink in each ink tank 9 is supplied to the ejection head 12 of the carriage 11 through the corresponding connection tube 10, the corresponding intermediate reservoir 30, and the corresponding head connection tube 52 (refer to Fig. 3). Each intermediate reservoir 30 has a pressure damping function and absorbs the pressure fluctuation of the ink that occurs when the carriage 11 moves.

[0050] A region referred to as a home position is defined in the inkjet printer 1 at the outer side of the printing paper 20 to where the carriage 11 is moved along the guide rail 13. A cap 14, which is box-shaped and includes a closed bottom, is arranged at the home position. A lifting mechanism (not shown) vertically moves the cap 14.

[0051] When the inkjet printer 1 is not printing an image or the like, the carriage 11 is moved to the home position and the cap 14 is lifted to press the cap 14 against the bottom surface (surface in which nozzles 12a open). This forms a closed space and covers the nozzles 12a. Thus, drying of the ink in the nozzles 12a (in ejection head 12) is limited.

[0052] The cap 14 is connected by a suction tube 15 to the suction pump 16. In a state in which the cap 14 is pressed against the bottom side of the ejection head 12, the suction pump 16 is activated to draw air from the interior of the cap 14 (closed space). This allows for initial filling of the ejection head 12 with ink and normal cleaning (maintenance) of the ejection head 12 that draws out deteriorated ink (dry or thickened ink). In the present embodiment, the cap 14, the suction tube 15, and the suction pump 16 are elements forming a discharge unit 18 capable of performing a discharge operation (normal cleaning) that draws and discharges ink from the nozzles 12a.

[0053] A controller 17 is arranged in the inkjet printer 1 to control the operation of the entire inkjet printer 1. The controller 17 controls the operation that moves the carriage 11 back and forth, the operation that transfers the printing paper 20, the operation that ejects ink from the nozzles 12a, and the discharge operation (normal cleaning) that draws and discharges the ink from the nozzles 12a to maintain normal printing.

[0054] As shown in Figs. 3 and 5, each ink tank 9 is connected to the corresponding intermediate reservoir 30 by the corresponding connection tube 10, and each intermediate reservoir 30 is connected to the ejection head 12 by the corresponding head connection tube 52. The intermediate reservoir 30, which serves as one example of a filter unit, includes an ink storage chamber 32, which serves as one example of an ink storage chamber or a second storage chamber. Ink is held together with a certain amount of air in the ink storage chamber 32. The air acts to absorb and damp pressure fluctuations in the ink.

[0055] When performing printing on the printing paper 20, acceleration and deceleration of the carriage 11 produces a water hammer effect that fluctuates the pressure of the ink in each connection tube 10. The arrangement of the intermediate reservoir 30 limits sudden pressure fluctuation in the ink supplied to the ejection head 12. This allows for stable ejection of ink from the ejection head 12.

[0056] A filter 42, which is one example of a filtering member that removes foreign matter, is arranged in each intermediate reservoir 30. The filter 42 obstructs the passage of foreign matter suspended in the ink supplied from the corresponding ink tank 9. This limits the foreign matter that enters the ejection head 12 and reduces clogging of the ejection head 12 and defective ejection of ink from the ejection head 12.

[0057] In addition to foreign matter, the filter 42 obstructs the passage of fine bubbles 54 (refer to Fig. 6). Thus, the bubbles 54 accumulate at the upstream side of the filter 42. The accumulated bubbles 54 form a large mass of air that closes the filter 42 and cause defective ejection of ink from the ejection head 12. Thus, the bubbles 54 need to be periodically discharged. In the present embodiment, the ejection head 12 performs ink suction to discharge the bubbles 54.

[0058] The structure of the intermediate reservoir 30 will now be described in detail.

[0059] As shown in Figs. 3 and 4, the intermediate reservoir 30 includes a filter chamber 34, which is one example of a first storage chamber that is capable of storing ink, and the ink storage chamber 32, which is cable of storing ink. The filter 42 is arranged in the filter chamber 34. In the present embodiment, the filter 42 partitions the filter chamber 34 in the vertical direction into an upstream filter chamber 44, which defines an upstream cavity, and a downstream filter chamber 46, which defines a downstream cavity. The downstream filter chamber 46 includes an ink outlet 50. The ink outlet 50 is connected to the ejection head 12 through the head connection tube 52.

[0060] The upstream filter chamber 44 is connected to the ink storage chamber 32 through a first communication pipe 36 and a second communication pipe 38, which form a lower communication passage, and an airflow pipe 40, which forms an upper communication passage. The ink storage chamber 32 includes an ink inlet 48. The ink inlet 48 is connected to the ink tank 9 through the connection tube 10. The upper surface of the ink storage chamber 32 is located upward in the gravitational direction from the upper surface of the upstream filter chamber 44.

[0061] The first communication pipe 36 is located downward in the gravitational direction from the second communication pipe 38 and the airflow pipe 40. A constant flow of ink is maintained in the first communication pipe 36. The first communication pipe 36 is formed by a fine pipe and functions as an orifice. Thus, a large pressure loss occurs at the first communication pipe 36 when the ejection head 12 performs ink suction. The pressure loss is designed to produce a hydraulic head difference between the ink storage chamber 32 and the upstream filter chamber 44 that is greater than the length in the gravitational direction of the upstream filter chamber 44. The flow passage resistance of the first communication pipe 36 is designed to be greater than the flow passage resistance of the second communication pipe 38.

[0062] The second communication pipe 38 is connected to a side surface of the ink storage chamber 32 and bent to project upward in the gravitational direction. The uppermost portion of the second communication pipe 38 is located downward in the gravitational direction from the uppermost portion of the ink storage chamber 32. The second communication pipe 38 functions as a siphon. Thus, even if the liquid level of the ink storage chamber 32 is lower than the uppermost portion of the second communication pipe 38, once ink starts to flow, the ink continues to flow through the second communication pipe 38. The airflow pipe 40 and the ink storage chamber 32 are coupled at a position located upward in the vertical position from where the second communication pipe 38 and the ink storage chamber 32 are coupled. The uppermost position of the airflow pipe 40 is located upward in the gravitational direction from the uppermost position of the second communication pipe 38.

[0063] The operation of the intermediate reservoir 30 will now be described.

Initial Full State

[0064] As shown in Fig. 5, in a state immediately after the ejection head 12 performs ink suction and fills the intermediate reservoir 30 with ink, the filter chamber 34, the first communication pipe 36, and the second communication pipe 38 are fully filled with ink. However, air remains in the upper portion of the ink storage chamber 32 and the upper portion of the airflow pipe 40. The air produces a damping effect that reduces pressure fluctuation in the ink.

After Long Term Use

[0065] As shown in Fig. 6, the use of the inkjet printer 1 over a long term may form the bubbles 54 in each connection tube 10. When printing is performed, the bubbles 54 are suspended in the flowing ink and enter the ink storage chamber 32 from the ink inlet 48. The entering bubbles 54 are accumulated and integrated with the air in the upper portion of the ink storage chamber 32. As the amount of the bubbles 54 entering the ink storage chamber 32 increases, the liquid level of the upstream filter chamber 44 falls.

[0066] When the liquid level of the upstream filter chamber 44 falls to a certain value or less, the filter 42 closes and causes defective ejection. Thus, there is a need to discharge the air before the liquid level of the upstream filter chamber 44 falls to the certain level or lower. Ink suction is performed to discharge the air.

First Air Discharge Operation

[0067] As shown in Fig. 7, in a state in which the liquid level of the upstream filter chamber 44 is low, the ejection head 12 performs ink suction and ink flows from the ink storage chamber 32 to the upstream filter chamber 44 only through the first communication pipe 36. Under this situation, a pressure loss occurs in the first communication pipe 36. The pressure loss produces a hydraulic head difference H between the ink in the ink storage chamber 32 and the ink in the upstream filter chamber 44. As a result, the air accumulated in the upper portion of the ink storage chamber 32 flows through the airflow pipe 40 and the second communication pipe 38 into the upstream filter chamber 44.

Second Air Discharge Operation

[0068] As shown in Fig. 8, as the liquid level of the upstream filter chamber 44 falls, the area of a liquid-contact filter portion 56 becomes extremely small. Consequently, the flow of ink is concentrated in the limited area. This locally increases the speed of the ink flow. Thus, a large pressure loss occurs at the filter 42. When the pressure loss becomes equal to or greater than the bubble point pressure of the filter 42, air can pass through the filter 42. Thus, the air in the upstream filter chamber 44 is discharged as bubbles 54 to the downstream filter chamber 46. The discharge of air raises the liquid level of the ink storage chamber 32.

Third Air Discharge Operation

[0069] Referring to Fig. 9, when the liquid level of the ink storage chamber 32 reaches the same level as the uppermost portion of the second communication pipe 38, ink starts to flow into the second communication pipe 38. Thus, the upstream filter chamber 44 is quickly filled with ink. Under this situation, the air in the upstream filter chamber 44 flows through the airflow pipe 40 to the ink storage chamber 32.

Fourth Air Discharge Operation

[0070] The above operations discharge some of the air that was accumulated in the ink storage chamber 32 and returns the liquid level of the intermediate reservoir 30 to the state prior to bubble accumulation as shown in Fig. 10. In this state, the second communication pipe 38 connects the ink storage chamber 32 and the upstream filter chamber 44 in a state in which pressure loss is small. Thus, even when the ejection head 12 performs ink suction again, a hydraulic head difference is not produced between the ink in the ink storage chamber 32 and the ink in the upstream filter chamber 44. Further, bubble discharge does not occur.

[0071] The state in which bubble discharge does not occur continues until bubble accumulation lowers the liquid level and empties the second communication pipe 38 of ink. When ink suction is performed for a purpose other than discharging air out of the intermediate reservoir 30, this mechanism reduces the frequency in which bubbles are discharged to the ejection head 12. Thus, defective ejection of ink from the ejection head 12 seldom occurs.

Printing State

[0072] Referring to Fig. 11, bubble discharge does not occur when printing is performed. This differs from ink suction. The ink flowrate during printing produces a hydraulic head difference H between the ink in the ink storage chamber 32 and the ink in the upstream filter chamber 44. However, the ink flowrate is low. Thus, the liquid level of the upstream filter chamber 44 does not become low enough for bubble discharge to occur. To realize the mechanism in which bubble discharge does not occur during printing, the pressure loss caused by the first communication pipe 36 needs to be properly adjusted.

[0073] More specifically, the pressure loss needs to be adjusted so that the liquid level of the upstream filter chamber 44 does not fall to a level that would cause defective ejection at the printing flowrate and so that a hydraulic head difference produced between the ink in the ink storage chamber 32 and the ink in the upstream filter chamber 44 is greater than or equal to the length of the upstream filter chamber 44 in the gravitational direction at the flowrate during ink suction.

[0074] The first embodiment has the advantages described below.

(1) In the intermediate reservoir 30, the first communication pipe 36 is located downward in the gravitational direction from the second communication pipe 38 and the airflow pipe 40, and the pressure loss caused by the first communication pipe 36 produces a hydraulic head difference between the ink in the ink storage chamber 32 and the ink in the upstream filter chamber 44 that is greater than or equal to the length of the upstream filter chamber 44 in the gravitational direction. Thus, when ink suction is performed, the pressure loss caused by the first communication pipe 36 produces a hydraulic head difference between the ink in the ink storage chamber 32 and the ink in the upstream filter chamber 44 that is greater than or equal to the length of the upstream filter chamber 44 in the vertical direction. This lowers the liquid level of the upstream filter chamber 44 and covers substantially the entire surface of the filter 42 with air. Consequently, the flow of ink concentrates at the portion of the filter 42 that is not covered with air. This locally raises the flowrate of ink and increases the pressure loss of the intermediate reservoir 30. Thus, a pressure that is greater than or equal to the bubble point pressure is applied to the intermediate reservoir 30, and air is discharged out of the upstream filter chamber 44 to the downstream filter chamber 46. Accordingly, the inkjet printer 1 allows the bubbles 54 accumulated in the intermediate reservoir 30 to be discharged through a structure that is not complicated and lowers costs.

(2) The second communication pipe 38 is bent to project upward in the gravitational direction. Further, the uppermost position of the second communica-

tion pipe 38 is located downward in the gravitational direction from the uppermost position of the ink storage chamber 32. Thus, when bubble discharge is performed through ink suction, the liquid level of the ink storage chamber 32 rises to the uppermost portion of the second communication pipe 38. As bubbles subsequently enter from the upstream side, the liquid level of the ink storage chamber 32 falls. However, as long as the liquid level of the ink storage chamber 32 is higher than or equal to the portion connecting the ink storage chamber 32 and the second communication pipe 38, ink continuously flows between the ink storage chamber 32 and the filter chamber 34 under the siphon principle. Even when ink suction is performed in this state, most of the ink flows through the second communication pipe 38. Thus, pressure loss of the first communication pipe 36 does not lower the liquid level of the filter chamber 34. That is, the discharge of the bubbles 54 is limited. This maintains the flow of ink in the second communication pipe 38 until the liquid level of the ink storage chamber 32 becomes lower than the portion connecting the ink storage chamber 32 and the second communication pipe 38. Thus, the bubbles 54 are not discharged until a certain amount or greater of the bubbles 54 flows in. Accordingly, when ink suction is performed for a purpose other than the discharge of air from the intermediate reservoir 30, the frequency in which the bubbles 54 enter the ejection head 12 is lowered. This reduces the occurrence of defective ejection.

(3) The upper surface of the ink storage chamber 32 is located upward in the gravitational direction from the upper surface of the upstream filter chamber 44. Thus, residual air mainly collects in the ink storage chamber 32. This decreases the area of the filter 42 covered with air and increases the area of the filter 42 through which ink can pass. Accordingly, the usage efficiency of the filter 42 can be increased.

(4) The pressure loss of the second communication pipe 38 is smaller than the pressure loss of the first communication pipe 36. Thus, when ink flows through the second communication pipe 38, the hydraulic head difference is smaller between the ink of the ink storage chamber 32 and the ink of the filter chamber 34. This limits the fall in the liquid level of the upstream filter chamber 44 when ink suction is performed in a state in which ink flows through the second communication pipe 38. Consequently, the discharge of the bubbles 54 is limited, and the bubbles 54 are not discharged even when ink suction is performed unless bubbles 54 are newly accumulated. Accordingly, when performing ink suction for a purpose other than the discharge of air from the intermediate reservoir 30, the frequency in which the bubbles 54 enter the ejection head 12 is lowered. This reduces defective ejection of ink from the ejection head 12.

(5) The position where the airflow pipe 40 is connected to the ink storage chamber 32 is located upward in the gravitational direction from the position where the second communication pipe 38 is connected to the ink storage chamber 32. Thus, the air above the portion of the ink storage chamber 32 connected to the second communication pipe 38 can be discharged through the airflow pipe 40 during ink suction. This raises the liquid level of the ink storage chamber 32 to a location above the portion connected to the second communication pipe 38. Thus, even when new bubbles 54 enter subsequently, the liquid level does not immediately become lower than the portion connected to the second communication pipe 38. As long as air does not flow into the second communication pipe 38, bubble discharge is restricted. Thus, once the bubbles 54 are discharged, the bubble discharge is not performed regardless of the entrance of a certain amount of bubbles 54. Accordingly, when performing ink suction for a purpose other than the discharge of air from the intermediate reservoir 30, the frequency in which the bubbles 54 enter the ejection head 12 is reduced. This reduces the occurrence of defective ejection of ink from the ejection head 12.

Second Embodiment

[0075] A second embodiment of the inkjet printer 1 will now be described with reference to the drawings.

[0076] In the second embodiment, the intermediate reservoir 30 of the first embodiment is modified as an intermediate reservoir 30a shown in Fig. 12. Accordingly, same reference numerals are given to those components of the second embodiment that are the same as the corresponding components of the first embodiment. Such components will not be described.

[0077] As shown in Fig. 12, the intermediate reservoir 30a has the same structure as the intermediate reservoir 30 of the first embodiment but differs in shape from the intermediate reservoir 30. More specifically, the upper space of an ink storage chamber 32a is expanded in the horizontal direction and extends to immediately above a filter chamber 34a. An airflow pipe 40a is connected to the lower surface of the ink storage chamber 32a in the upper space extending to immediately above the filter chamber 34a. Thus, the upper portion of the ink storage chamber 32a holds more air than the intermediate reservoir 30 of the first embodiment. This improves the damping effect of the intermediate reservoir 30a in comparison with the intermediate reservoir 30 of the first embodiment.

[0078] The filter chamber 34a is partitioned by a filter 42a in the horizontal direction and separated into an upstream filter chamber 44a and a downstream filter chamber 46a. Thus, even though the area of the filter 42a is increased, the height of the upstream filter chamber 44a in the gravitational direction is not increased. Accordingly, the area of the filter 42a can be increased while keeping the pressure loss caused by the first communication pipe 36 low. More specifically, the amount of foreign matter of which passage through the intermediate reservoir 30a is restricted can be increased without an increase in pressure loss causing a decrease in the ink ejection capability of the ejection head 12. The downstream filter chamber 46a includes an ink outlet 50a, and the ink outlet 50a is connected through the head connection tube 52 to the ejection head 12.

[0079] The operation of the intermediate reservoir 30a will now be described.

[0080] The operation of the intermediate reservoir 30 is basically the same as the intermediate reservoir 30 of the first embodiment. Thus, the description will focus on the second air discharge operation that differs greatly from the intermediate reservoir 30 of the first embodiment.

Second Air Discharge Operation

[0081] As shown in Fig. 12, the liquid level of the upstream filter chamber 44a falls when ink suction is performed, and the area of a liquid-contact filter portion 56a becomes extremely small. The flow of ink is concentrated within a limited area. This locally increases the speed of the ink flow and produces a large pressure loss at the filter 42a. When the pressure loss becomes greater than or equal to the bubble point pressure of the filter 42a, air passes through the filter 42a. Thus, air is discharged as bubbles 54 out of the upstream filter chamber 44a and into the downstream filter chamber 46a. The discharge of the bubbles 54 raises the liquid level of the ink storage chamber 32a.

[0082] In this manner, the intermediate reservoir 30a allows bubble discharge to be performed through ink suction in the same manner as the intermediate reservoir 30 of the first embodiment.

[0083] In addition to advantages (1) to (5), the second embodiment has the advantages described below.

(6) In comparison with the first embodiment, the damping capability can be improved, and the amount of foreign matter of which passage is restricted can be increased.

Third Embodiment

[0084] A third embodiment of the inkjet printer 1 will now be described with reference to the drawings focusing on points that differ from the first embodiment. Points that are the same as the first embodiment will not be described. The intermediate reservoir 30 of the first embodiment is modified to an intermediate reservoir 60 in the third embodiment as shown in Figs. 13 to 15.

[0085] As shown in Figs. 13 and 14, the intermediate reservoir 60 has the form of a generally rectangular cuboid as a whole with one side surface including recesses or grooves that are in communication with one another. As shown in Fig. 15, in a state in which a filter 61 is arranged inside the intermediate reservoir 60, a film sheet 62 is fused onto one surface of the intermediate reservoir 60 to close the recesses or grooves. This forms various flow passages, through which ink or air flows, and chambers, which store ink, inside the intermediate reservoir 60. Although the intermediate reservoir 60 includes the filter 61 and the film sheet 62, Figs. 13 and 14 show the intermediate reservoir 60 without the filter 61 and the film sheet 62.

[0086] As shown in Figs. 13 and 14, the intermediate reservoir 60 includes a first storage chamber 63 and a second storage chamber 64 that are capable of storing ink. The first storage chamber 63 extends from the central portion toward the lower portion in the intermediate reservoir 60. The second storage chamber 64 is located at the side of the first storage chamber 63 that is closer to the corresponding ink tank 9 (refer to Fig. 3), namely, the upstream side. More specifically, the second storage chamber 64 is located inside the upper portion of the intermediate reservoir 60 at the upper side of the first storage chamber 63.

[0087] The intermediate reservoir 60 includes an upper communication passage 65 and a lower communication passage 66. The first storage chamber 63 and the second storage chamber 64 are in communication with each other through the upper communication passage 65 that is located upward from the first storage chamber 63 and the second storage chamber 64. Further, the first storage chamber 63 and the second storage chamber 64 are in communication with each other through the lower communication passage 66 that is located downward from the upper communication passage 65. In the present embodiment, the upper communication passage 65 and the lower communication passage 66 are located at opposite sides of the first storage chamber 63 and the second storage chamber 64.

[0088] The lower communication passage 66 includes a lower second communication port 66a, which is the communication port located at the side of the second storage chamber 64, and a lower first communication port 66b, which is the communication port located at the side of the first storage chamber 63. The upper communication passage 65 includes an upper second communication port 65a, which is the communication port located at the side of the second storage chamber 64, and the upper first communication port 65b, which is the communication port located at the side of the first storage chamber 63. The lower second communication port 66a is designed to be smaller than the upper second communication port 65a.

[0089] A connection pipe 67 is arranged on the outer upper end of the intermediate reservoir 60. One end of the corresponding connection tube 10 (refer to Fig. 3) is connected to the connection pipe 67. The other end of the connection tube 10 is connected to the corresponding ink tank 9 (refer to Fig. 3). The upper side of the second storage chamber 64 in the intermediate reservoir 60 includes a communication flow passage 68. The connection pipe 67 and the second storage chamber 64 are in communication through the communication flow passage 68. The communication flow passage 68 extends from the connection pipe 67 around the second storage chamber 64 and to the lower end of the second storage chamber 64.

[0090] The communication port of the communication flow passage 68 located at the side of the second storage chamber 64 defines an inlet 68a through which the ink supplied from the corresponding ink tank 9 (refer to Fig. 3) flows and enters the second storage chamber 64. More specifically, ink is supplied from the ink tank 9 (refer to Fig. 3) through the connection tube 10 (refer to Fig. 3), the connection pipe 67, the communication flow passage 68, and the inlet 68a to the second storage chamber 64. The inlet 68a opens laterally toward the second storage chamber 64. That is, the opening direction of the inlet 68a coincides with the horizontal direction.

[0091] The lower second communication port 66a is located downward from the inlet 68a next to the inlet 68a. In the present embodiment, the lower second communication port 66a opens toward the second storage chamber 64, which is located upward from the lower second communication port 66a. Accordingly, the opening direction of the lower second communication port 66a intersects (is orthogonal to) the opening direction of the inlet 68a. That is, the lower second communication port 66a opens in a direction that differs from the opening direction of the inlet 68a.

[0092] The lower communication passage 66 includes an upstream path 66c, which extends from the lower second communication port 66a to a location lower than the lower second communication port 66a, and a downstream path 66d, which extends upward from the downstream side of the upstream path 66c. Thus, the lower end of the lower communication passage 66 defines a downwardly curved, U-shaped curved portion 66e. More specifically, the upstream path 66c extends straight down from the lower second communication port 66a toward the curved portion 66e, and the downstream path 66d extends straight up from the curved portion 66e and is in communication with the first storage chamber 63 from the side. In the present embodiment, one half of the curved portion 66e forms part of the upstream path 66c, and the remaining half of the curved portion 66e forms part of the downstream path 66d.

[0093] As shown in Figs. 14 and 15, a connection projection 69 is formed integrally with the lower end surface of the intermediate reservoir 60. The connection projection 69 is connected to the ejection head 12 (refer to Fig. 3). Accordingly, in the present embodiment, the connection projection 69 is used instead of the head connection tube 52 (refer to Fig. 3) to form part of the liquid supply passage.

[0094] The lower portion of the first storage chamber 63 includes the filter 61 that is generally pentagonal. The filter 61 partitions the first storage chamber 63 into a downstream cavity 70, which is located at the side of the ejection head 12 (refer to Fig. 3), and an upstream cavity 71, which is located at the side of the second storage chamber 64. The downstream cavity 70 is defined by a recess 74, which is recessed to be generally pentagonal, and the open area surrounded by the filter 61. Further, the downstream cavity 70 is smaller than the upstream cavity 71.

[0095] The filter 61 includes a large number of pores 61a (refer to Fig. 20) that are meshes allowing for the passage of ink. The upper end of the downstream cavity 70 is in communication with one end of a discharge passage 72 through a through hole 73. The other end of the discharge passage 72 is in communication with the connection projection 69. The lower second communication port 66a is located upward from the filter 61.

[0096] The filter 61 will now be described.

[0097] The filter 61 may be, for example, a meshed body such as a wire mesh or a resin mesh, a porous body, or a metal plate including fine through holes. Specific examples of a meshed body include a metal mesh filter and metal fibers. For example, a felt of fine wires of stainless steel (SUS), a metal sinter filter that is compressed and sintered, an electroformed metal filter, an electronic beam-processed metal filter, or a laser beam-processed metal filter may be used.

[0098] In particular, it is preferred that the bubble point pressure be uniform in the filter 61 and that the filter 61 have an extremely fine pore diameter. The bubble point pressure is the pressure that breaks the meniscus formed at each pore 61a (pore opening) of the filter 61. Further, it is preferred that the filtration grain size of the filter 61 be approximately 15μm (0.015mm) that is smaller than the diameter (e.g., 20 μm (0.020mm)) of the opening in the nozzle 12a so that foreign matter in the ink does not reach the nozzle 12a (refer to Fig. 3).

[0099] When employing a mesh filter of stainless steel as the filter 61, it is preferred that the filtration grain size of the filter 61 be that of a twill dutch weave (filtration grain size 10 um), which is smaller than the diameter (e.g., 20 μm) of the opening in the nozzle 12a so that foreign matter in the ink does not reach the nozzle 12a. In this case, the bubble point pressure produced by ink (e.g., surface tension is approximately 28 mN/M) is 3 to 5 kPa. Further, the bubble point pressure produced by ink when employing a twill dutch weave (filtration grain size 5 um) is 10 to 15 kPa.

[0100] When the filter 61 is a metal plate filter obtained by forming fine through holes that extend through a metal plate (e.g., flat metal plate (e.g., thickness of 15 μm) formed from a metal material such as stainless steel including a large number of fine through holes (e.g., hundreds of thousands of pores having an inner diameter of 15 μm per 1 cm^2) and cut into disks), the filter 61 that is used may have a diameter of, for example, approximately 8 to 9 mm.

[0101] It is preferred that the inner diameter of the through hole be smaller than the diameter of the opening of the nozzle 12a (e.g., 20 μm). The through holes of the filter 61 may be a square or hexagonal hole. In this case, the length of the diagonal lines of each through hole need only be set to be smaller than the diameter of the opening of the nozzle 12a. The pores 61a of the filter 61 in the present embodiment are set so that the pitch between the adjacent pores 61a is approximately 4 μm.

[0102] The operation of the intermediate reservoir 60 will now be described.

Initial Full State

[0103] As shown in Fig. 16, in a state immediately after the discharge unit 18 (refer to Fig. 2) performs ink suction from the ejection head 12 and fills the intermediate reservoir 60 with ink, the downstream cavity 70 and the lower communication passage 66 are fully filled with ink. In this case, the liquid level (liquid surface) of the ink in the intermediate reservoir 60 is located upward from the lower first communication port 66b and the lower second communication port 66a of the lower communication passage 66 and downward from the upper first communication port 65b and the upper second communication port 65a of the upper communication passage 65. This state is referred to as the normal state. In this state, air remains in the upper portion of the first storage chamber 63, the upper portion of the second storage chamber 64, and the upper communication passage 65. The air produces a damping effect and limits pressure fluctuation of the ink.

After Long Term Non-Use

[0104] As shown in Fig. 17, when the inkjet printer 1 is left without being used over a long term, atmospheric air may enter the connection tube 10 and form bubbles 54. The bubbles 54 are carried with the ink through the connection pipe 67 and the communication flow passage 68 and enter the second storage chamber 64 from the inlet 68a. The bubbles 54 entering the second storage chamber 64 are integrated and accumulated with the air in the upper portion of the first storage chamber 63 and the air in the upper portion of the second storage chamber 64. As the amount of the bubbles 54 entering the second storage chamber 64 increases, the liquid level of the ink in the first storage chamber 63 and the liquid level of the ink in the second storage chamber 64 fall.

[0105] When the liquid level of the ink in the first storage chamber 63 falls to a certain level or less, for example, the filter 61 is closed by air. This causes defective ejection of ink from the ejection head 12. In other words, there is a limit to the amount of the bubbles 54 accumulated in the first storage chamber 63 and the second storage chamber 64. Accordingly, the bubbles 54 (air) need to be discharged before the liquid level of the ink in the first storage chamber 63 falls to the certain level or less. A special discharge operation (long-time cleaning) is performed to discharge the bubbles 54.

[0106] In the special discharge operation of the present embodiment, the discharge unit 18 (refer to Fig. 2) draws ink from the nozzle 12a and discharges the ink over a longer time than when performing a discharge operation (normal cleaning). That is, the special discharge operation (long-time cleaning) is performed for a longer time than the normal discharge operation (normal cleaning). In the special discharge operation (long-time cleaning), the suction force of the nozzle 12a for drawing ink is the same as the discharge operation (normal cleaning).

First Special Discharge Operation

[0107] Referring to Fig. 18, when the discharge unit 18 (refer to Fig. 2) draws ink from the nozzle 12a to perform the special discharge operation (long-time cleaning), ink flows from the second storage chamber 64 to the upstream cavity 71 (first storage chamber 63) only through the lower communication passage 66. The pressure loss at the lower communication passage 66 produces a hydraulic head difference H between the ink in the upstream cavity 71 and the ink in the second storage chamber 64. Thus, the liquid level of the ink in the upstream cavity 71 falls. As a result, the air accumulated in the upper portion of the second storage chamber 64 flows through the upper communication passage 65 to the upstream cavity 71.

Second Special Discharge Operation

[0108] Referring to Fig. 19, the discharge unit 18 (refer to Fig. 2) then draws ink from the nozzle 12a and gradually lowers the liquid level of the ink in the upstream cavity 71 (the first storage chamber 63) until the liquid level falls to the lower end of the filter 61. Accordingly, the discharge unit 18 performs the special discharge operation to draw and discharge ink from the nozzle 12a so that the liquid level (liquid surface) of the ink in the upstream cavity 71 (first storage chamber 63) contacts the filter 61. Thus, the special discharge operation is performed so that the liquid level (liquid surface) of the ink in the upstream cavity 71 (first storage chamber 63) falls from the height of the normal state to the height that contacts the filter 61.

[0109] Consequently, the area of a liquid-contact filter portion 75, which is the portion in the upstream surface of the filter 61 that contacts the ink, becomes extremely small. This concentrates the flow of ink at the limited area. Thus, the flow of ink becomes locally high, and the filter 61 produces a large pressure loss. When the pressure loss becomes greater than or equal to the bubble point pressure of the filter 61, air passes though the filter 61, and air is discharged from the upstream cavity 71 to the downstream cavity 70 as bubbles 54. The discharge of air from the upstream cavity 71 to the downstream cavity 70 raises the liquid level of the ink in the second storage chamber 64.

[0110] Each pore 61a of the filter 61 (refer to Fig. 20) is configured so that the pressure difference between the downstream cavity 70 and the upstream cavity 71 when ink flows through the intermediate reservoir 60 during the special discharge operation performed by the discharge unit 18 breaks the meniscus of the ink formed at the pore 61a of the filter 61. In other words, air does not flow through the filter 61 as long as the meniscus formed on the pore 61a of the filter 61 does not break.

[0111] The pressure that breaks the meniscus formed at the pore 61a of the filter 61 will now be described with reference to Fig. 20.

[0112] First, P represents the pressure when bubbles form (bubble point pressure), γ represents the surface tension of ink, ρ represents the ink density, θ represents the wetting angle, and D represents the pore diameter.

[0113] The pressure $P\gamma$ produced by the interface tension of the ink liquid surface and the filter 61 is $P\gamma=4\gamma\cos\theta D\pi/(\pi D^2)=4\gamma\cos\theta/D$. When bubbles form (when meniscus formed at pore 61a of filter 61 breaks), the bubble point pressure P and the pressure $P\gamma$ are in an equilibrium. More specifically, $P=P\gamma$ is satisfied. Thus, $P=P\gamma=4\gamma\cos\theta/D$ is satisfied.

Third Special Discharge Operation

[0114] Referring to Fig. 21, when the discharge unit 18 (refer to Fig. 2) ends the ink suction from the nozzles 12a, the discharge of bubbles 54 (air) from the upstream cavity 71 to the downstream cavity 70 immediately stops. However, ink continues to flow through the lower communication passage 66, and the height of the liquid level of the ink in the first storage chamber 63 and the liquid level of the ink in the second storage chamber 64 become the same. Under this situation, the accumulated bubbles 54 have already been discharged. Thus, the liquid level (liquid surface) of the ink in the intermediate reservoir 60 returns to the height of the normal state. This completes the special discharge operation.

Discharge Operation

[0115] Referring to Fig. 22, when the discharge unit 18 (refer to Fig. 2) draws ink from the nozzle 12a to perform the discharge operation (normal cleaning), the suction time during which ink is drawn from the nozzle 12a is shorter in the discharge operation than the special discharge operation. Thus, the liquid level of the ink in the upstream cavity 71 (first storage chamber 63) does not fall to the filter 61.

[0116] More specifically, the discharge operation ends before the liquid level of the ink in the upstream cavity 71 (first storage chamber 63) falls to the filter 61. Accordingly, the bubbles 54 in the upstream cavity 71 do not pass through the filter 61 and are not discharged into the downstream cavity 70. This reduces defective ejection of ink from the nozzle 12a of the ejection head 12 that would be caused by the bubbles 54 immediately after the discharge operation.

[0117] The volume of the first storage chamber 63 needs to be properly adjusted for the discharge unit 18 (refer to Fig. 2) to selectively perform the discharge operation and the special discharge operation, which differ in the time ink is drawn from the nozzle 12a, and control the discharge of bubbles 54 from the nozzle 12a. In the present embodiment, the volume of the first storage chamber 63 is set so that the liquid level of the ink in the upstream cavity 71 does not fall to the filter 61 during the discharge operation (normal cleaning) and so that the liquid level of the ink in the upstream cavity 71 falls to the lower end of the filter 61 during the special discharge operation (long-time cleaning).

Printing State

[0118] Referring to Fig. 23, when performing printing in a normal state, the bubbles 54 in the upstream cavity 71 do not pass through the filter 61 and are not discharged into the downstream cavity 70. This is because the ink flow rate is lower than the discharge operation even though the ink flow rate during printing produces a hydraulic head difference H between the ink in the second storage chamber 64 and the ink in the upstream cavity 71 (first storage chamber 63). Thus, the liquid level of the ink in the upstream cavity 71 does not fall to the filter 61.

[0119] To realize a mechanism in which the bubbles 54 in the upstream cavity 71 do not pass through the filter 61 and are not discharged into the downstream cavity 70 during printing, the pressure loss caused by the lower communication passage 66 needs to be properly adjusted. In the present embodiment, the flow passage resistance of the lower communication passage 66 and the flow passage resistance of the upper communication passage 65 are set so that the air-liquid interface (liquid surface) of the ink in the upstream cavity 71 (first storage chamber 63) does not contact the filter 61 when the ejection head 12 ejects ink onto the printing paper 20 in a normal state.

[0120] The third embodiment described above in detail has the advantages described below.

(7) In the intermediate reservoir 60, the lower second communication port 66a is smaller than the upper second communication port 65a. Thus, the bubbles 54 that enter the second storage chamber 64 through the inlet 68a are restricted from entering the lower communication passage 66 through the lower second communication port 66a. Accordingly, the entrance of the bubbles 54 into the ejection head 12 is restricted.

(8) In the intermediate reservoir 60, the lower second communication port 66a opens toward the upper side. Since the bubbles 54 in the ink easily float upward, the entrance of the bubbles 54 from the lower second communication port 66a into the lower communication passage 66 can easily be restricted.

(9) In the intermediate reservoir 60, the lower communication passage 66 includes the upstream path 66c, which extends from the lower second communication port 66a at a lower position than the lower second communication port 66a, and the downstream path 66d, which extends upward from the downstream side of the upstream path 66c. Thus, even when the bubbles 54 enter the lower communication passage 66 from the lower second communication port 66a, the upstream path 66c extends from the lower second communication port 66a at a lower position than the lower second communication port 66a. Thus, the buoyance of the bubbles 54 entering the lower communication passage 66 returns the bubbles 54 to the second storage chamber 64. In addition, the lower communication passage 66 includes the upstream path 66c and the downstream path 66d. Thus, a high flow passage resistance may be set for the lower communication passage 66 without increasing the distance between the first storage chamber 63 and the second storage chamber 64.

(10) In the intermediate reservoir 60, the lower second communication port 66a is located upward from the filter 61. Thus, even when the bubbles 54 enter the lower communication passage 66 from the lower second communication port 66a, the bubbles 54 in the ink easily float upward. This restricts the passage of the bubbles 54 through the filter 61 and into the ejection head 12.

In the intermediate reservoir 60, the lower second communication port 66a is located downward from the inlet 68a and opens in a direction that differs from the opening direction of the inlet 68a. This restricts the entrance of the bubbles 54, which are suspended in the ink and enter the second storage chamber 64 from the inlet 68a, into the lower communication passage 66 from the lower second communication port 66a.

(12) In the intermediate reservoir 60, the flow passage resistance of the lower communication passage 66 and the flow passage resistance of the upper communication passage 65 are set so that the air-liquid interface (liquid surface) of the first storage chamber 63 does not contact the filter 61 when the ejection head 12 ejects ink on the printing paper 20 to perform printing in a normal state. This limits decrease in the capacity for supplying ink to the ejection head 12 during printing and restricts the passage of bubbles 54 (air) through the filter 61 and into the ejection head 12 during printing. Accordingly, the printing quality is unaffected.

(13) In the intermediate reservoir 60, the pores 61a of the filter 61 are configured so that the pressure difference between the downstream cavity 70 and the upstream cavity 71 produced by the flow of ink in the intermediate reservoir 60 when the discharge unit 18 performs the special discharge operation breaks the meniscuses formed on the pores 61a of the filter 61. Thus, the special discharge operation discharges the bubbles 54 remaining in the second storage chamber 64 out of the upstream cavity 71 to the downstream cavity 70.

Fourth Embodiment

[0121] A fourth embodiment of the inkjet printer 1 will now be described focusing on points that differ from the third embodiment. Points that are the same as the third embodiment will not be described. As shown in Fig. 24, in the fourth embodiment, a pressure regulation valve 80, which regulates the pressure of ink, is arranged between the intermediate reservoir 60 of the third embodiment and the ejection head 12, and an ink cartridge 81 is employed in lieu of the ink tank 9 as one example of the liquid supplying source, and the ink of the ink cartridge 81 is pressurized and supplied to the ejection head 12.

[0122] As shown in Fig. 24, the inkjet printer 1 includes a holder 82, to which the ink cartridge 81 serving as one example of a liquid supplying source is attached in a removable manner, and a supply passage 83, which serves as a liquid supply passage that supplies ink from the ink cartridge 81 to the ejection head 12. A supply pump 84 that moves the ink in a supply direction A, the intermediate reservoir 60 that is capable of storing ink, and the pressure regulation valve 80 that regulates the pressure of ink are arranged in the supply passage 83.

[0123] The supply passage 83 includes first to fourth supply paths 85 to 88. More specifically, the first supply path 85 connects the ink cartridge 81 and the supply pump 84, the second supply path 86 connects the supply pump 84 and the intermediate reservoir 60, the third supply path 87 connects the intermediate reservoir 60 and the pressure regulation valve 80, and the fourth supply path 88 connects the pressure regulation valve 80 and the ejection head 12.

[0124] The supply pump 84 includes a diaphragm pump 89 that has a pump chamber with a variable volume, a suction valve 90 located at an upstream side of the diaphragm pump 89, and a discharge valve 91 located at a downstream side of the diaphragm pump 89. The suction valve 90 and the discharge valve 91 each function as a one-way valve that allows ink to flow from the ink cartridge 81 toward the ejection head 12 in a supplying direction A and restricts the flow of ink from the ejection head 12 toward the ink cartridge 81 in the reverse direction.

[0125] Accordingly, as the volume of the pump chamber in the diaphragm pump 89 increases, the supply pump 84 draws ink from the ink cartridge 81 through the suction valve 90. As the volume of the pump chamber decreases, the supply pump 84 discharges ink toward the ejection head 12 through the discharge valve 91. The ejection head 12, which is connected to the downstream end of the supply passage 83, includes an in-head filter 92 that captures bubbles and foreign matter from the ink.

[0126] The pressure regulation valve 80 includes a supply chamber 93 supplied with ink from the third supply path 87, a pressure chamber 95 that is in communication with the supply chamber 93 through a communication hole 94, a valve member 96 arranged between the pressure chamber 95 and the supply chamber 93, and an urging member 97 that urges the valve member 96 in a valve-closing direction. The valve member 96 is inserted through the communication hole 94 and urged by the urging member 97 to close the communication hole 94. The pressure regulation valve 80 forms part of the liquid supply passage.

[0127] The wall surface of the pressure chamber 95 includes a portion formed by a diaphragm 98 that is deformable in the urging direction of the urging member 97. The outer surface of the diaphragm 98 (left surface as viewed in Fig. 24) receives the atmospheric pressure, and the inner surface of the diaphragm 98 (right surface as viewed in Fig. 24) receives the pressure of the ink in the pressure chamber 95. Accordingly, the diaphragm 98 deforms and moves in accordance with the difference between the pressure of the pressure chamber 95 and the pressure received by the outer surface of the diaphragm 98.

[0128] The supply chamber 93 is held in a pressurized state by the pressurized ink sent from the ink cartridge 81. When the ink ejected from the nozzle 12a of the ejection head 12 increases the negative pressure of the pressure chamber 95 and the difference between the pressure of the pressure chamber 95 and the pressure received by the outer surface of the diaphragm 98 becomes greater than a predetermined value (e.g., 1000 Pa), the valve member 96 is urged in the valve-opening direction against the urging force of the urging member 97. In this state, the pressure chamber 95 is in communication with the supply chamber 93.

[0129] When the difference between the pressure of the pressure chamber 95 and the pressure received by the outer surface of the diaphragm 98 becomes equal to the predetermined value, the urging member 97 urges the valve member 96 in a valve-opening direction. In this state, the pressure chamber 95 and the supply chamber 93 are not in communication with each other. In this manner, the pressure regulation valve 80 regulates the pressure of the ejection head 12 that acts as the back pressure of the nozzles 12a. This regulates the pressure of the ink supplied from the ink cartridge 81 to the ejection head 12 through the supply passage 83.

[0130] In the same manner as the third embodiment, the fourth embodiment includes the discharge unit 18. The discharge unit 18 performs a special discharge operation to discharge the residual bubbles 54 in the second storage chamber 64 of the intermediate reservoir 60 from the upstream cavity 71 to the downstream cavity 70.

[0131] Further, the fourth embodiment includes a valve opening mechanism that forcibly opens the valve member 96 of the pressure regulation valve 80. The forcible opening of the valve member 96 allows the ink pressurized by the supply pump 84 to be discharged from the nozzles 12a of the ejection head 12 and perform pressurized cleaning. The pressurized cleaning may use the pressure difference between the downstream cavity 70 and the upstream cavity 71 when ink flows in the intermediate reservoir 60 to discharge residual bubbles 54 in the second storage chamber 64 of the intermediate reservoir 60 from the upstream cavity 71 to the downstream cavity 70 in the same manner as the special discharge operation performed by the discharge unit 18 in the third embodiment.

[0132] Additionally, the ink suction performed by the discharge unit 18 and the pressurized cleaning performed by the supply pump 84 may both be included in a discharge operation to discharge the residual bubbles 54 in the second storage chamber 64 of the intermediate reservoir 60 from the upstream cavity 71 to the downstream cavity 70 in the same manner as the special discharge operation performed by the discharge unit 18.

[0133] The fourth embodiment has the advantages described below.

(14) The inkjet printer 1 includes the pressure regulation valve 80 that regulates the pressure of ink between the intermediate reservoir 60 and the ejection head 12. The supply pump 84 pressurizes and supplies the ink of the ink cartridge 81 to the ejection head 12.

(15) The valve opening mechanism forcibly opens the valve member 96 of the pressure regulation valve 80. This allows pressurized cleaning to be performed in which the ink pressurized by the supply pump 84 to discharge the pressurized ink from to the nozzles 12a of the ejection head 12 in a state in which the valve member 96 is forcibly opened. By performing the pressurized cleaning, the pressure difference between the downstream cavity 70 and the upstream cavity 71 when ink flows through the intermediate reservoir 60 may be used to discharge the residual bubbles 54 in the second storage chamber 64 of the intermediate reservoir 60 from the upstream cavity 71 to the downstream cavity 70 in the same manner as the special discharge operation performed by the discharge unit 18 of the third embodiment.

Modified Examples

[0134] The above embodiments may be modified as described below.

[0135] As shown in Fig. 25, in the fourth embodiment, an ink container 100 may be used in lieu of the ink cartridge 81 as one example of the liquid supply source. In this case, the ink container 100 includes an ink inlet 101, and the ink container 100 may be filled with ink through the ink inlet 101. After filling the ink container 100 with ink, the ink inlet 101 is closed by a cap (not shown).

[0136] As shown in Fig. 26, in the fourth embodiment, an ink supply tube 102 may connect the ink cartridge 81 to a large-capacity tank 103 to supply the ink cartridge

81 with ink from the large-capacity tank 103 through the ink supply tube 102. In this case, the ink cartridge 81 functions as a sub-tank that temporarily stores the ink. In this case, the large-capacity tank 103 includes an ink inlet 104 and can be filled with ink through the ink inlet 104. After filling the large-capacity tank 103 with ink, the ink inlet 104 is closed by a cap (not shown). In this case, as shown in Figs. 24 and 26, the large-capacity tank 103 is arranged so that its lower surface 103a is located at a higher position than a nozzle plane 12b, which is the plane of the ejection head 12 where the nozzles 12a open. In this manner, the hydraulic head difference supplies ink from the large-capacity tank 103 to the ejection head 12.

[0137] In the fourth embodiment, the supply pump 84 may be changed to a tube pump.

[0138] In the third embodiment, the suction force that draws ink from the nozzles 12a with the discharge unit 18 when a special discharge operation (long-time cleaning) is performed may be stronger than that when a discharge operation (normal cleaning) is performed. That is, in the special discharge operation, the suction amount of ink per unit time may be greater than that of the discharge operation.

[0139] In the third embodiment, the filter 61 may have a shape that is circular, oval, rectangular, or triangular. In this case, it is preferred that the shape of the recess 74 be in correspondence with the shape of the filter 61.

[0140] In the third embodiment, the wall surface of the second storage chamber 64 in the intermediate reservoir 60 may be formed by a flexible member such as a film, and the flexible member may be deformed in a direction that decreases the volume of the second storage chamber 64 when the pressure of the second storage chamber 64 becomes negative. This flattens bubbles in the second storage chamber 64 when the pressure of the second storage chamber 64 becomes negative and allows the bubbles to easily move downward. In this case, the area of the flexible member can be increased and the depth of the second storage chamber 64 may be decreased so that the flexible member further easily presses and squeezes the bubbles.

[0141] In the first to third embodiments, the discharge unit 18 may be configured by a pressurizing mechanism (e.g., pressurizing pump) that pressurizes the ink in the liquid supply passage and allows the ink to be discharged from the nozzles 12a. Alternatively, the pressurizing mechanism and a suction mechanism (cap 14, suction tube 15, and suction pump 16), which allows ink to be drawn from the nozzles 12a and discharged, may both be used to configure the discharge unit 18.

[0142] In the third embodiment, the pores 61a of the filter 61 do not necessarily have to be configured to break the meniscuses of ink formed at the pores 61a by the pressure difference produced between the downstream cavity 70 and the upstream cavity 71 when ink flows in the intermediate reservoir 60 during the special discharge operation performed by the discharge unit 18.

[0143] In the third embodiment, the flow passage resistance of the lower communication passage 66 and the flow passage resistance of the upper communication passage 65 do not necessarily have to be set so that the air-liquid interface (liquid surface) of ink in the first storage chamber 63 does not contact the filter 61 when the ejection head 12 ejects ink onto the printing paper 20 and performs printing in a normal state.

[0144] In the third embodiment, the lower second communication port 66a does not necessarily have to be located below the inlet 68a. Further, the lower second communication port 66a does not necessarily have to open in a direction that differs from the opening direction of the inlet 68a. That is, the lower second communication port 66a may be located, for example, upward from the inlet 68a and open in the same direction as the opening direction of the inlet 68a.

[0145] In the third embodiment, the lower second communication port 66a does not necessarily have to be located upward from the filter 61. That is, the lower second communication port 66a may be located, for example, downward from the filter 61.

[0146] In the third embodiment, the lower communication passage 66 does not necessarily have to include the upstream path 66c, which extends from the lower second communication port 66a at a lower position than the lower second communication port 66a, and the downstream path 66d, which extends upward from the downstream side of the upstream path 66c. That is, the lower communication passage 66 extends, for example, straight as a whole.

[0147] In the third embodiment, the lower second communication port 66a does not necessarily have to open upward. That is, the lower second communication port 66a may, for example, open downward or open sideward.

[0148] In the third embodiment, the filter 61 may be omitted.

[0149] In each of the above embodiments, the inkjet printer 1 may be of a line head type that includes an elongated and fixed liquid droplet ejector corresponding to the entire width of the printing paper 20. In such a case, the liquid droplet ejector may have a printing range that extends over the entire width of the printing paper 20 by arranging units of heads, which include nozzles, in parallel. Alternatively, the liquid droplet ejector may have a printing range that extends over the entire width of the printing paper 20 by arranging multiple nozzles in a single elongated head over the entire width of the printing paper 20.

[0150] In each of the above embodiments, the liquid ejection device may be a liquid ejection device that discharges liquid other than ink. The fine amount of liquid ejected from the liquid ejection device as a liquid droplet may be in a state that is particulate, tear-like, or shaped in a tailed manner. The liquid referred to here may be any material that can be ejected from the liquid ejection device. For example, the liquid may be a substance that is in a liquid phase state. Thus, the liquid may be a fluidal body such as a liquid body having low or high viscosity, a sol, gel water, other inorganic solvents, an organic solvent, a liquid solution, a liquefied resin, or a liquefied metal (metal melt). Further, the liquid is just not one state of a substance and includes a liquid in which the particles of a functional material formed by a solid such as pigments or metal particles is dissolved, dispersed, or mixed. Representative examples of liquid ink, such as that described in the above embodiments, liquid crystal and the like. Ink includes typical water-based ink and oil-based ink and various liquid compositions such as gel ink and hot melt ink. Specific examples of a liquid ejection device includes a liquid ejection device that ejects liquid in which material such as electrode material or coloring material is dispersed or dissolved. Such material is used to manufacture a liquid crystal display, an electroluminescence (EL) display, a planar light emission display, a color filter, and the like. Further, the liquid ejection device may eject a bioorganic substance used to manufacture biochips or a liquid that forms samples used as precision pipettes. The liquid ejection device may be a textile printing device, a micro-dispenser, or the like. The liquid ejection device may eject lubrication oil in a pinpoint manner onto a precision machine such as a clock or a camera or eject a transparent resin liquid such as an ultraviolet curing resin to form a micro-semispherical lens (optical lens) used in an optical communication element or the like. Further, the liquid ejection device may eject an acid or alkali etching liquid to etch a substrate or the like.

Claims

1. A liquid ejection device comprising:

an ejection head that ejects liquid from a nozzle onto a medium;
a liquid supply passage that supplies the ejection head with the liquid that is held in a liquid supply source; and
an intermediate reservoir arranged in the liquid supply passage and capable of storing the liquid, wherein the intermediate reservoir includes

a first storage chamber capable of storing the liquid,
a second storage chamber capable of storing the liquid and located at an upstream side of the first storage chamber,
an upper communication passage that connects the first storage chamber and the second storage chamber, and
a lower communication passage that connects the first storage chamber and the second storage chamber at a location lower than the upper communication passage,
wherein the lower communication passage includes a lower communication port that opens in the second storage chamber, the upper communication passage includes an upper communication port that opens in the second storage chamber, and the lower communication port is smaller than the upper communication port.

2. The liquid ejection device according to claim 1, wherein the lower communication port opens upward.

3. The liquid ejection device according to claim 1 or 2, wherein the lower communication passage includes an upstream path that extends from the lower communication port to a location lower than the lower communication port and a downstream path that extends upward from a downstream side of the upstream path.

4. The liquid ejection device according to any one of claims 1 to 3, further comprising a filter arranged in the first storage chamber, wherein the filter partitions the first storage chamber into a downstream cavity that is connected to the ejection head and an upstream cavity that is connected to the second storage chamber, and the filter includes a pore that allows for the passage of the liquid,
wherein the lower communication port is located upward from the filter.

5. The liquid ejection device according to any one of claims 1 to 4, wherein
the liquid supply passage includes an inlet that opens in the second storage chamber, and the liquid supplied from the liquid supply source enters the second storage chamber through the inlet; and
the lower communication port is located downward from the inlet and opens in a direction that differs from an opening direction of the inlet.

6. The liquid ejection device according to claim 4, wherein:

the upper communication port is an upper second communication port, and the upper communication passage further includes an upper first communication port that opens in the first storage chamber;
the lower communication port is a lower second communication port, and the lower communication passage further includes a lower first communication port that opens in the first storage chamber;
the lower communication passage has a flow passage resistance and the upper communication passage has a flow passage resistance that are set so that when the liquid is ejected onto the medium from the ejection head in a normal

state in which a liquid surface of the liquid in the intermediate reservoir is located upward from the lower first communication port and the lower second communication port and downward from the upper first communication port and the upper second communication port, the liquid surface of the first storage chamber does not contact the filter.

7. The liquid ejection device according to claim 6, further comprising a discharge unit configured to perform a discharge operation that discharges the liquid from the nozzle, wherein
the discharge unit is configured to perform a special discharge operation in which the liquid surface of the first storage chamber comes into contact with the filter by discharging the liquid from the nozzle in the normal state, and
the pore of the filter is configured so that a pressure difference between the downstream cavity and the upstream cavity produced as the liquid flows through the liquid supply passage when the special discharge operation is performed breaks a meniscus of the liquid formed at the pore of the filter.

8. An intermediate reservoir capable of storing liquid and arranged in a liquid supply passage that supplies the liquid held in a liquid supply source to an ejection head that ejects the liquid from a nozzle onto a medium, the intermediate reservoir comprising:

a first storage chamber capable of storing the liquid;
a second storage chamber capable of storing the liquid and located at an upstream side of the first storage chamber;
an upper communication passage that connects the first storage chamber and the second storage chamber; and
a lower communication passage that connects the first storage chamber and the second storage chamber at a location lower than the upper communication passage;
wherein the lower communication passage includes a lower communication port that opens in the second storage chamber, the upper communication passage includes an upper communication port that is in communication with the second storage chamber, and the lower communication port is smaller than the upper communication port.

9. A liquid ejection device comprising:

an ejection head that ejects liquid;
a liquid supply passage that supplies the ejection head with the liquid from a liquid holder that holds the liquid; and
a filter unit located in the liquid supply passage and including a filtering member that removes foreign matter from the liquid, wherein
the filter unit includes a filter chamber that accommodates the filtering member and an ink storage chamber that stores the liquid,
the filter chamber includes an upstream filter chamber and a downstream filter chamber that are partitioned by the filtering member,
the ink storage chamber and the upstream filter chamber are in communication through a first communication pipe, a second communication pipe, and an airflow pipe,
the first communication pipe is located downward in a gravitational direction from the second communication pipe and the airflow pipe, and
the first communication pipe is configured so that pressure loss caused by the first communication pipe produces a hydraulic head difference between the ink storage chamber and the upstream filter chamber that is greater than or equal to a length of the upstream filter chamber in the gravitational direction.

10. The liquid ejection device according to claim 9, wherein
the second communication pipe is shaped to project upward in the gravitational direction, and
the second communication pipe includes an uppermost portion that is located downward in the gravitational direction from the uppermost portion of the ink storage chamber.

11. The liquid ejection device according to claim 9, an upper surface of the ink storage chamber is located upward in the gravitational direction from an upper surface of the upstream filter chamber.

12. The liquid ejection device according to claim 9, wherein the first communication pipe has a larger flow passage resistance than the second communication pipe.

13. The liquid ejection device according to claim 9, wherein the airflow pipe is coupled to the ink storage chamber at a position located upward in the gravitational direction from where the second communication pipe is coupled to the ink storage chamber.

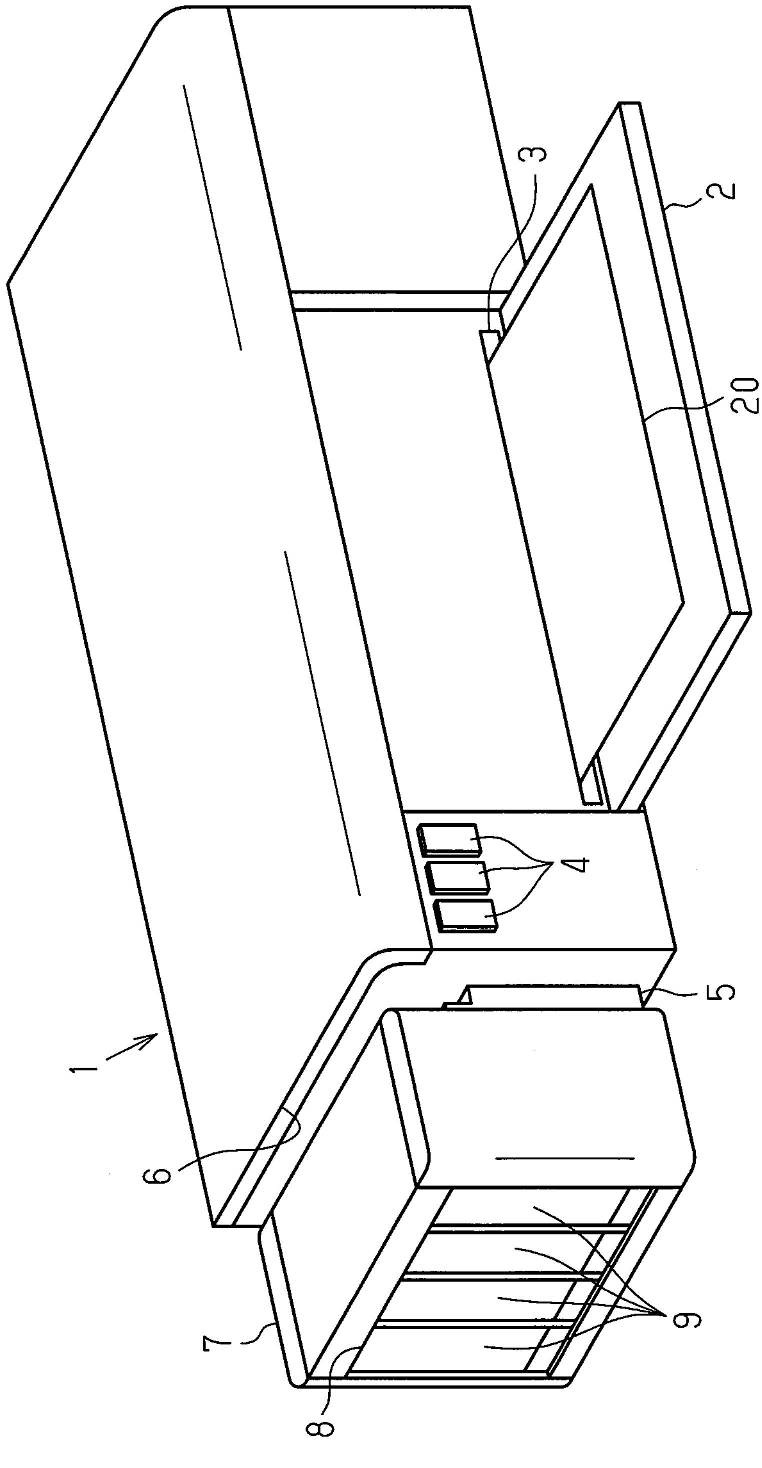


Fig.1

Fig.2

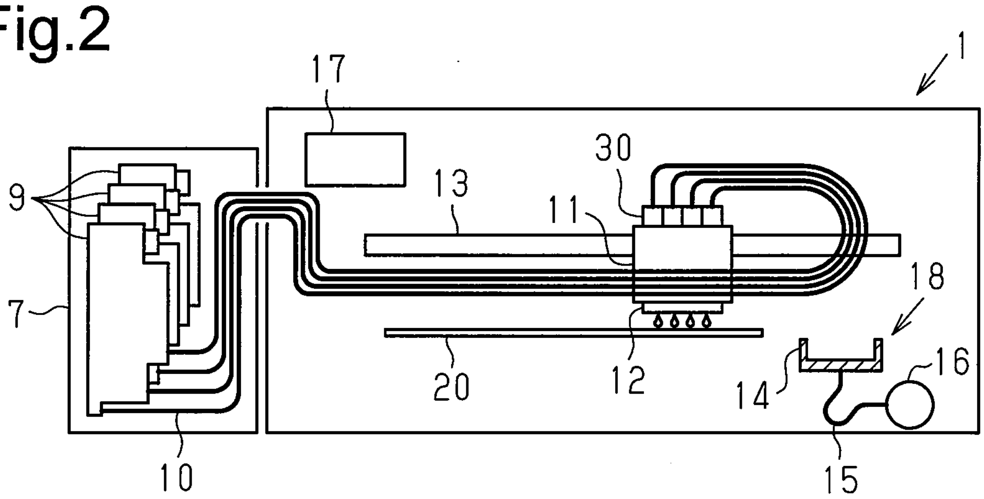

1
17
30
9
13
11
18
7
16
20
12
14
10
15

Fig.3

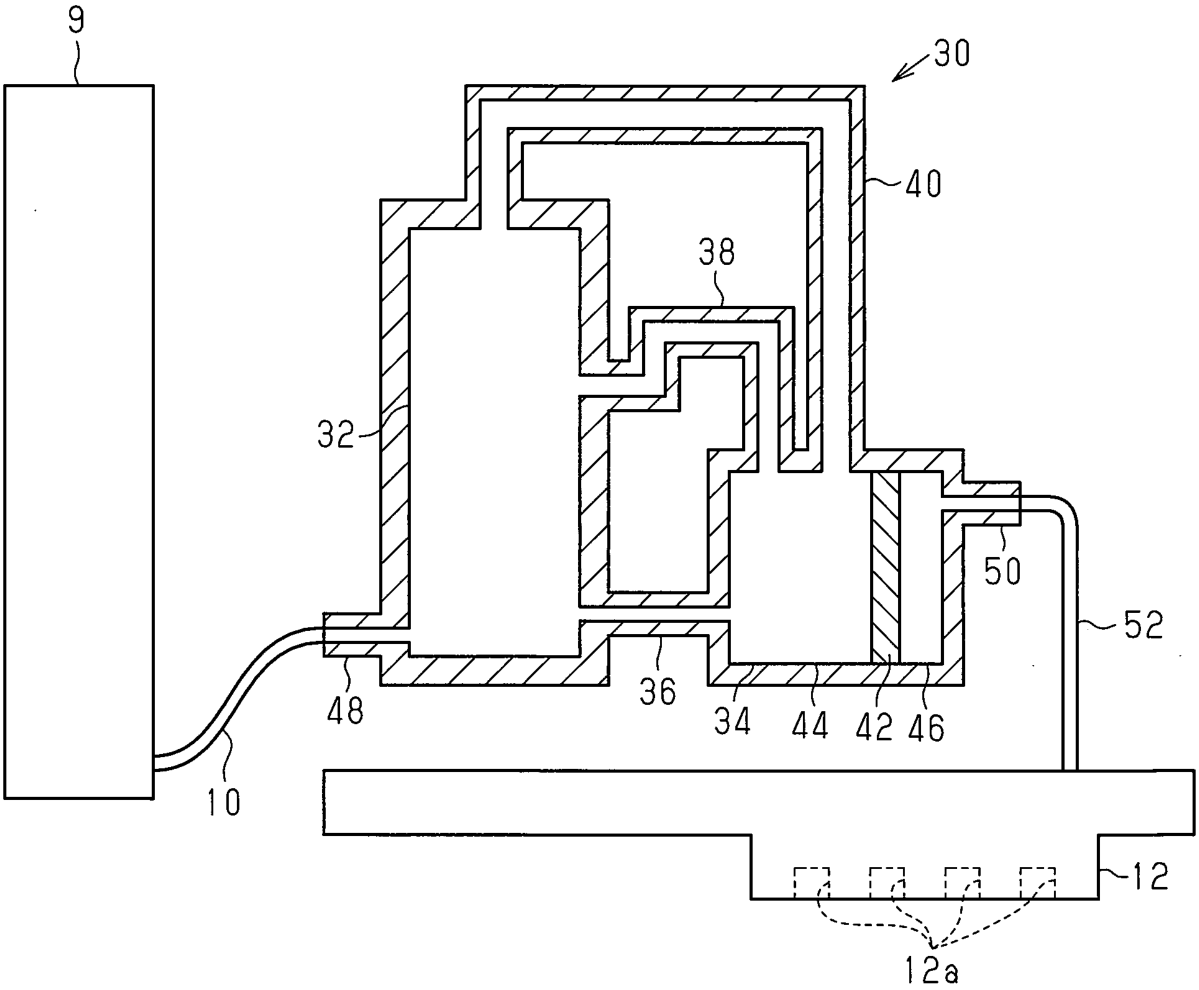

9
30
40
38
32
50
52
48
36
34
44
42
46
10
12
12a

Fig.4

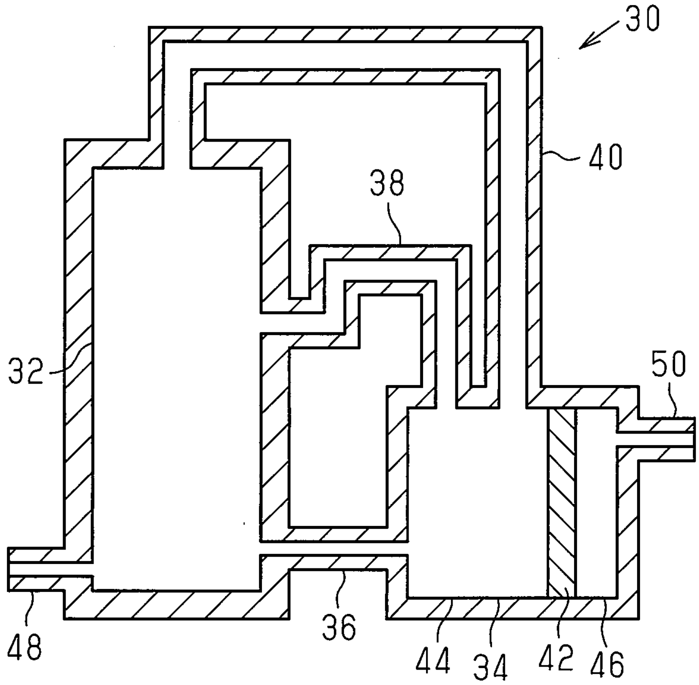


Fig.5

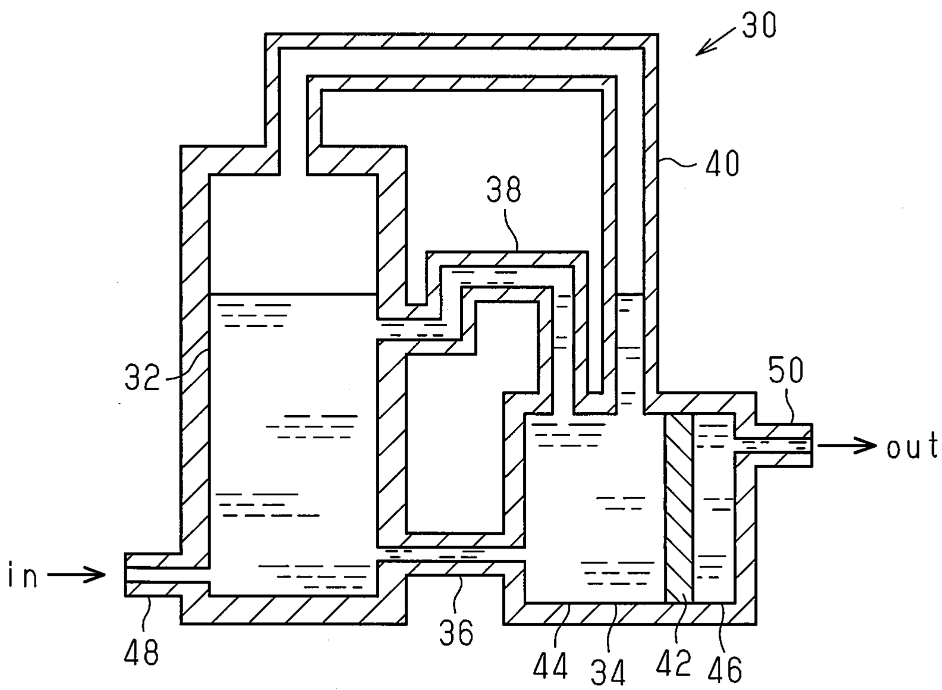


Fig.6

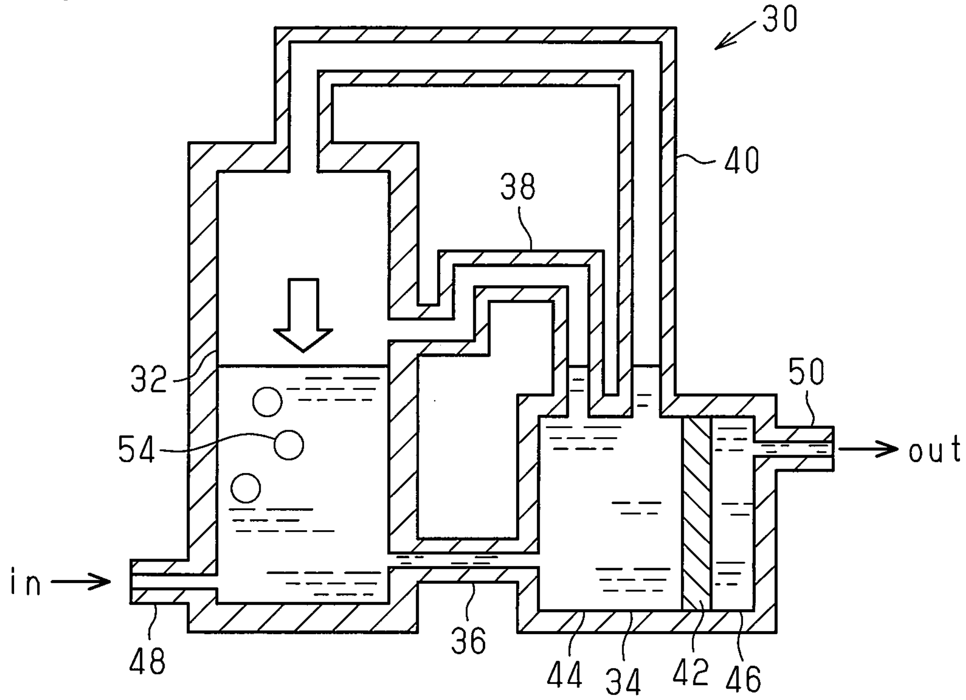

30
40
38
32
54
50
out
in
48
36
44
34
42
46

Fig.7

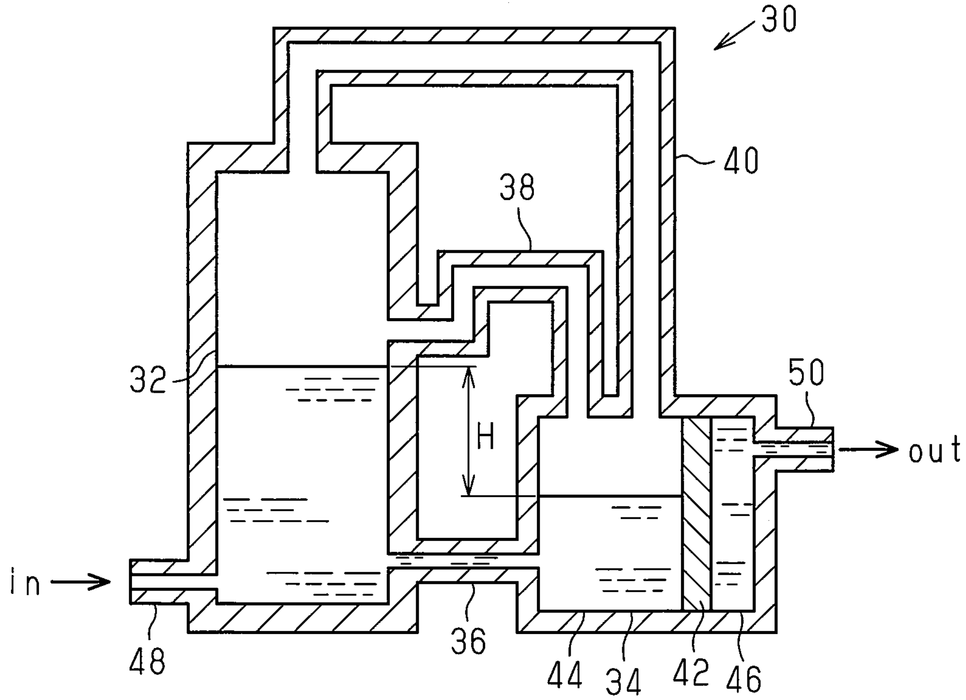

30
40
38
32
H
50
out
in
48
36
44
34
42
46

Fig.8

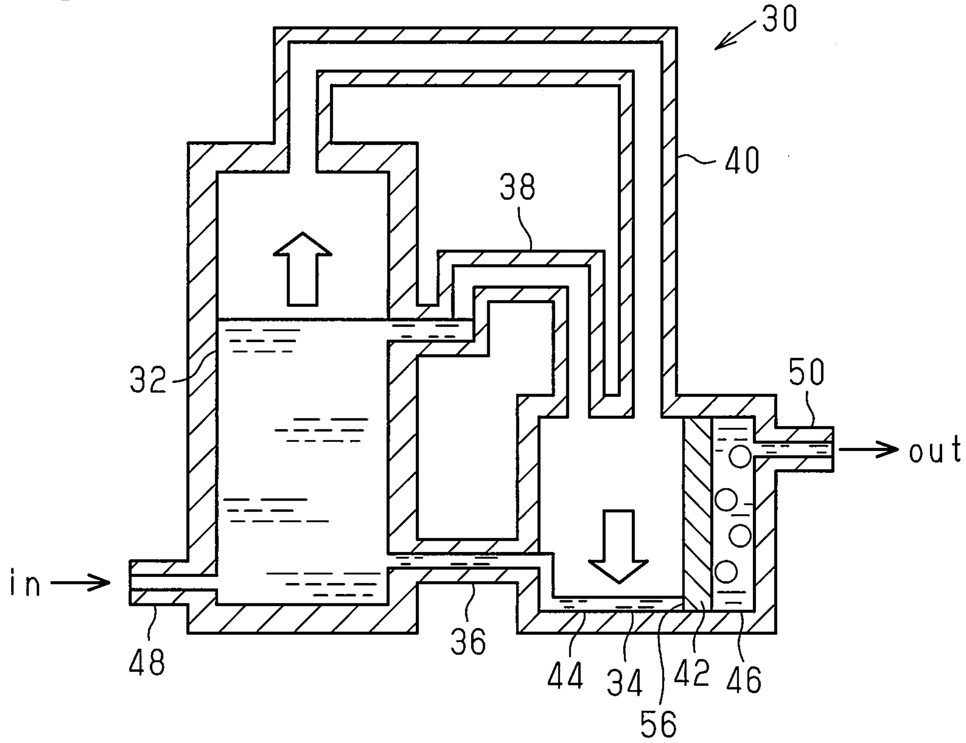

30
40
38
32
50
out
in
48
36
44
34
42
46
56

Fig.9

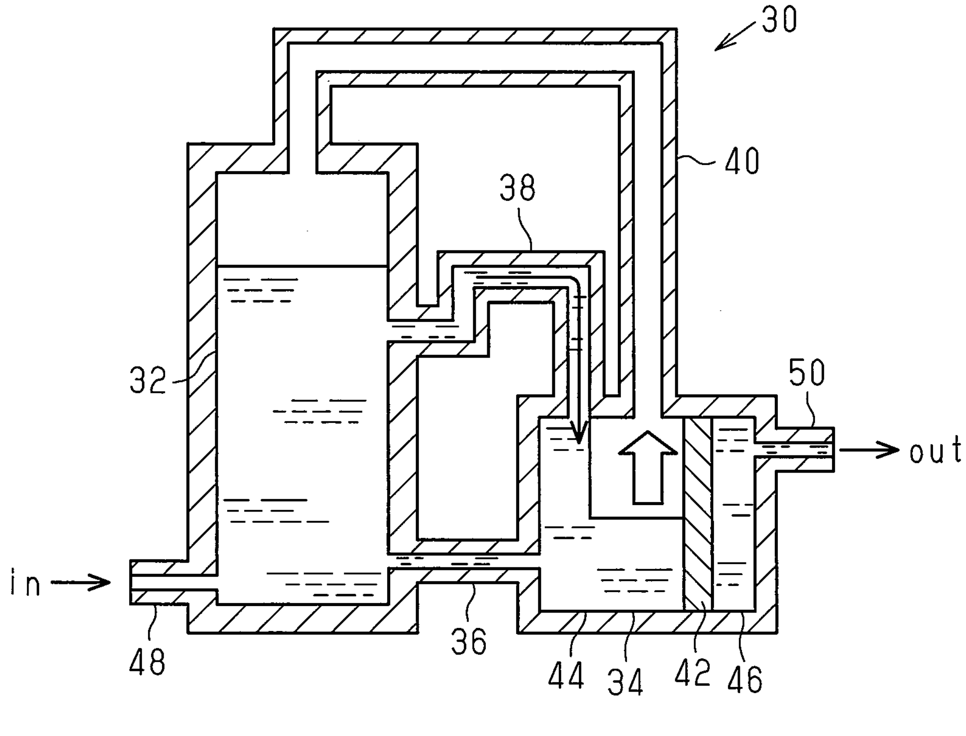

30
40
38
32
50
out
in
48
36
44
34
42
46

Fig.10

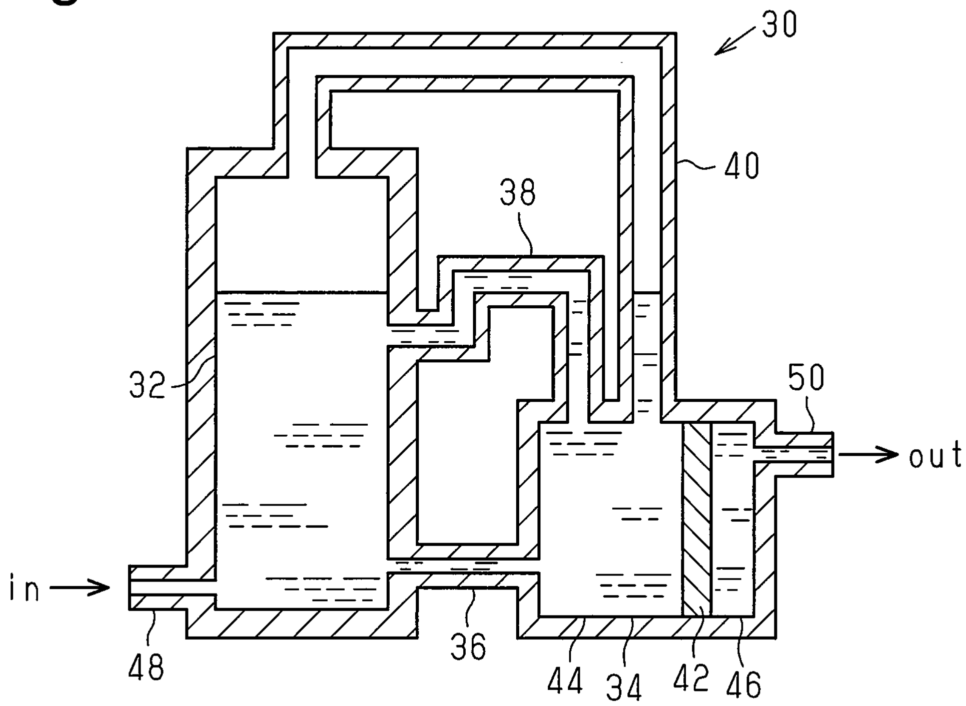

30
40
38
32
50
out
in
48
36
44
34
42
46

Fig.11

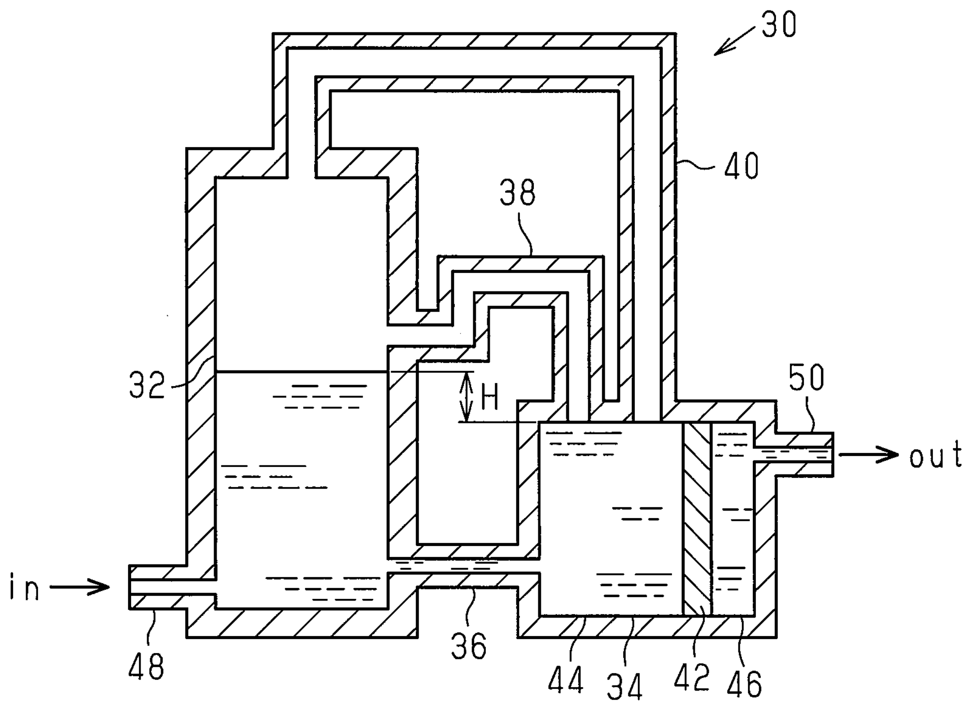

30
40
38
32
H
50
out
in
48
36
44
34
42
46

Fig.12

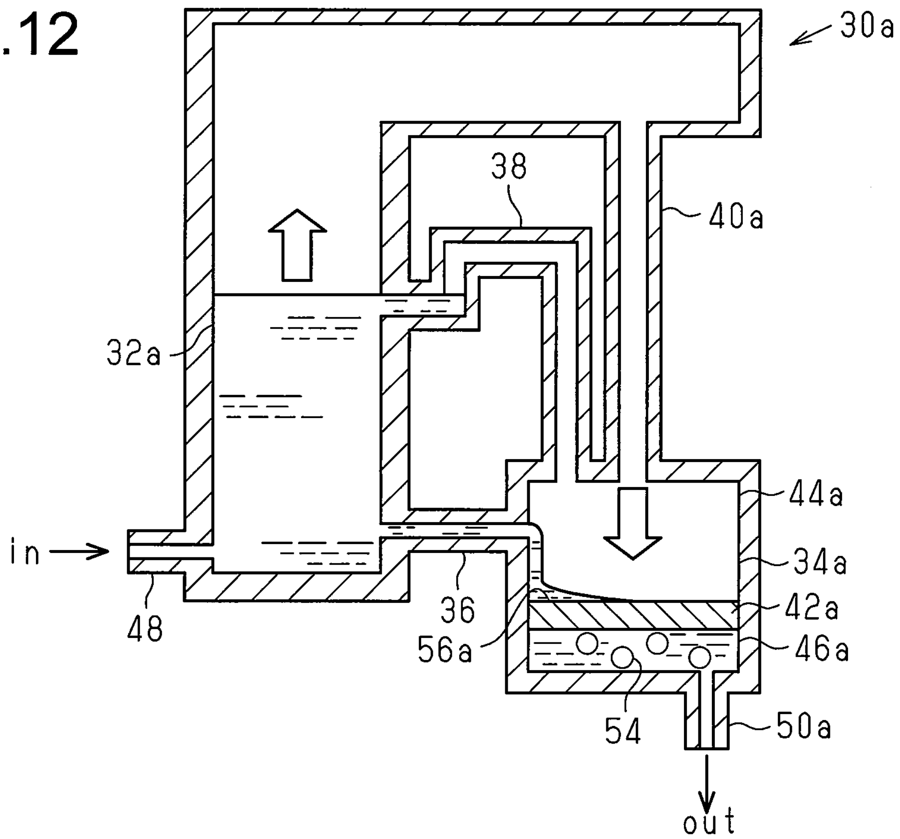

30a
38
40a
32a
44a
in
34a
42a
48
36
56a
46a
54
50a
out

Fig.13

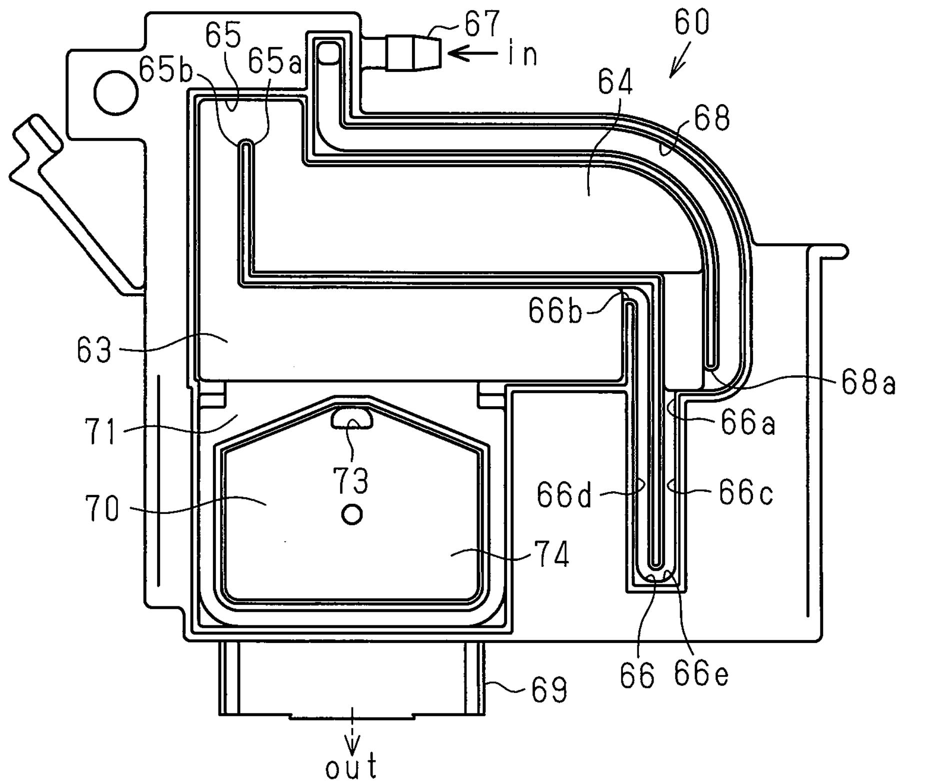

67
60
65
65b
65a
in
64
68
66b
63
68a
71
66a
73
66d
66c
70
74
66
66e
69
out

Fig.14

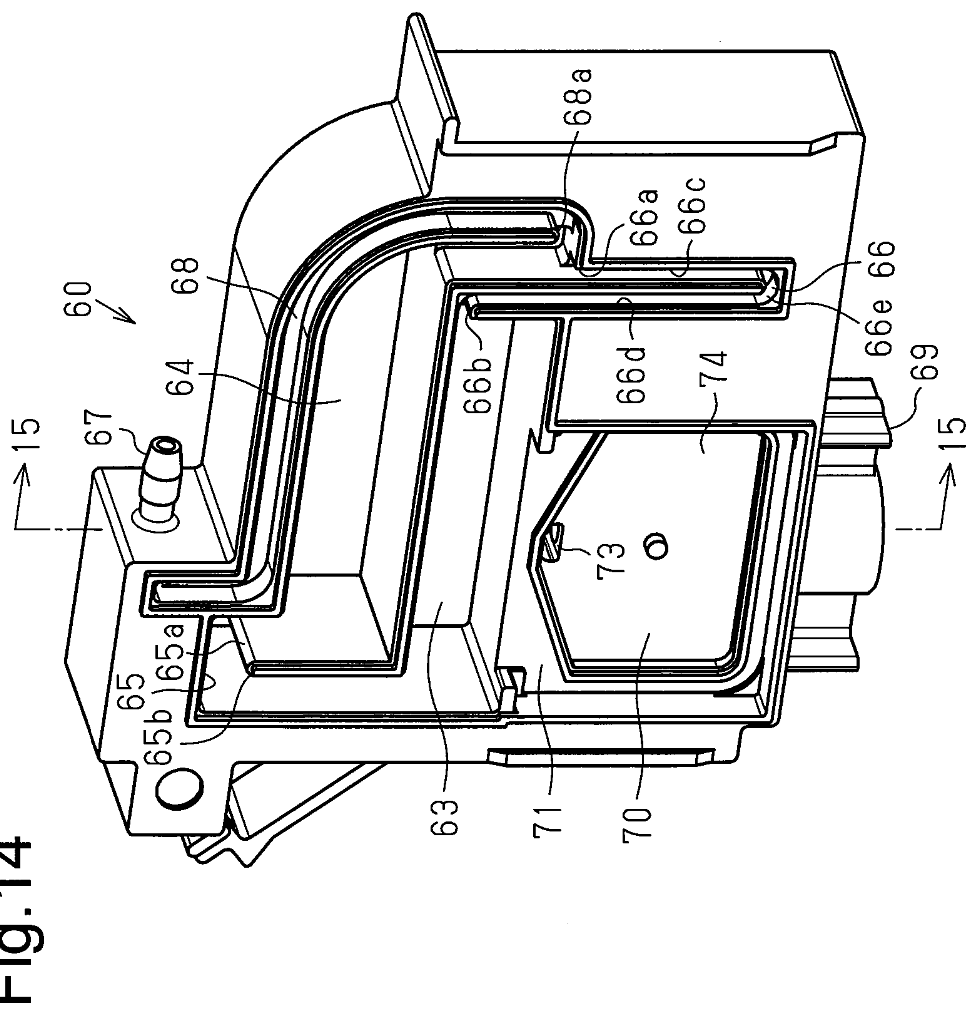

15
67
60
68
64
68a
66a
66c
66
66e
66b
66d
74
69
15
65a
65
65b
73
63
71
70

Fig.15

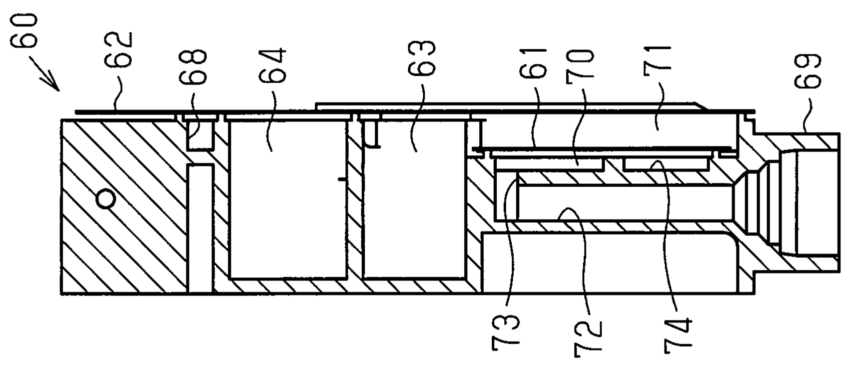

60
62
68
64
63
61
70
71
69
73
72
74

Fig.16

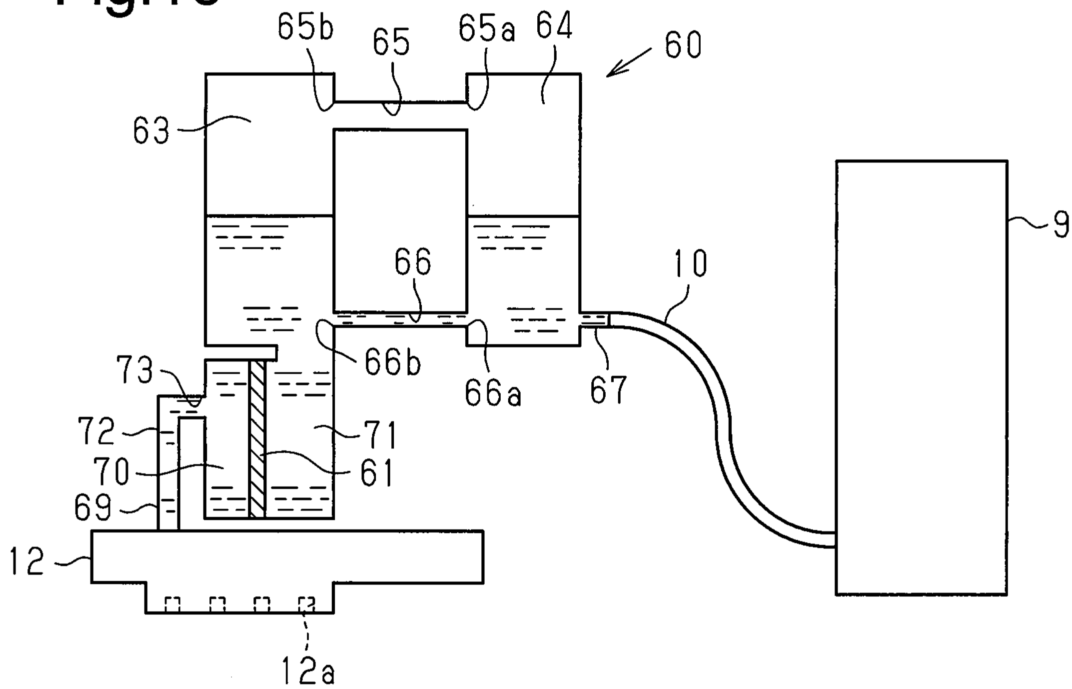

65b
65
65a
64
60
63
9
66
10
73
66b
66a
67
72
71
70
61
69
12
12a

Fig.17

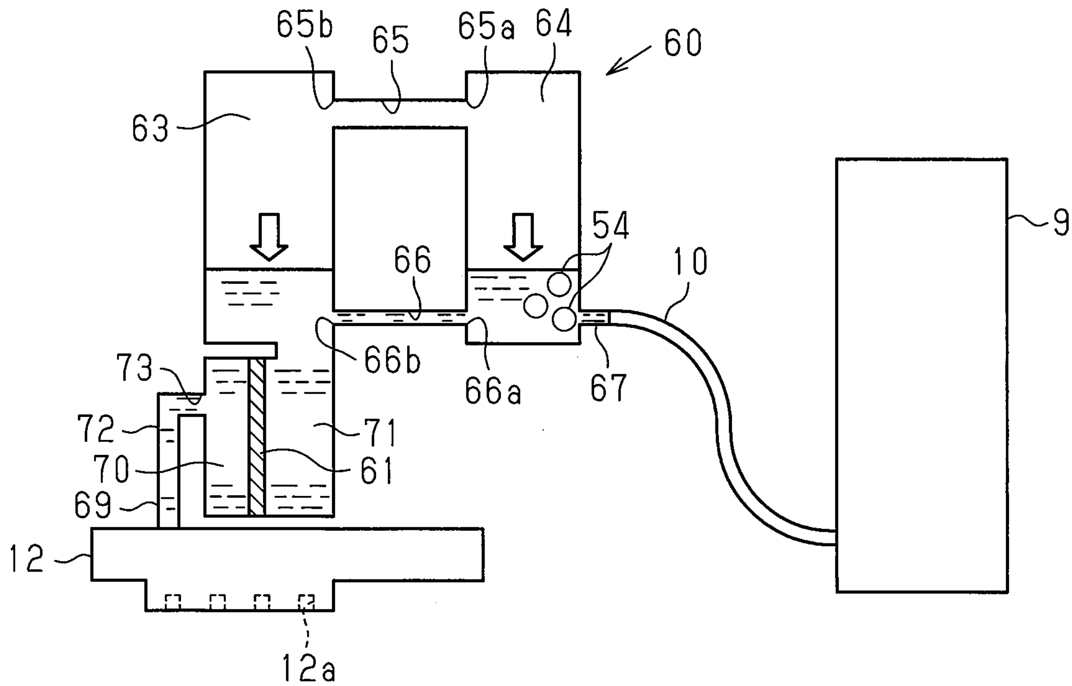

65b
65
65a
64
60
63
54
9
66
10
73
66b
66a
67
72
71
70
61
69
12
12a

Fig.18

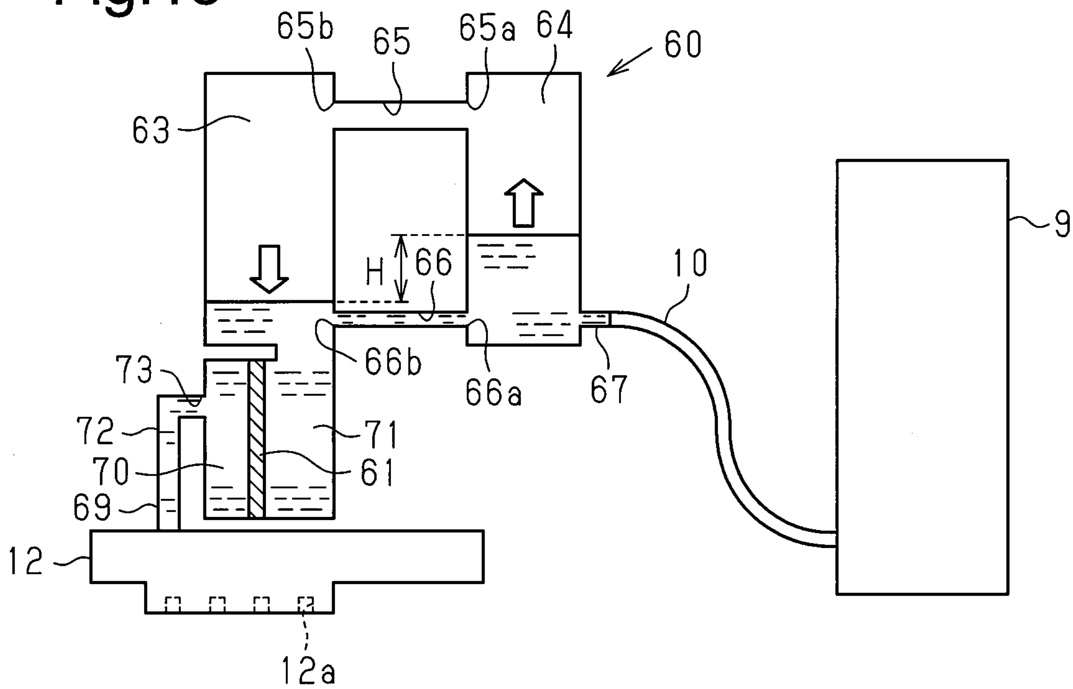

65b
65
65a
64
60
63
9
H
66
10
66b
66a
67
73
72
71
70
61
69
12
12a

Fig.19

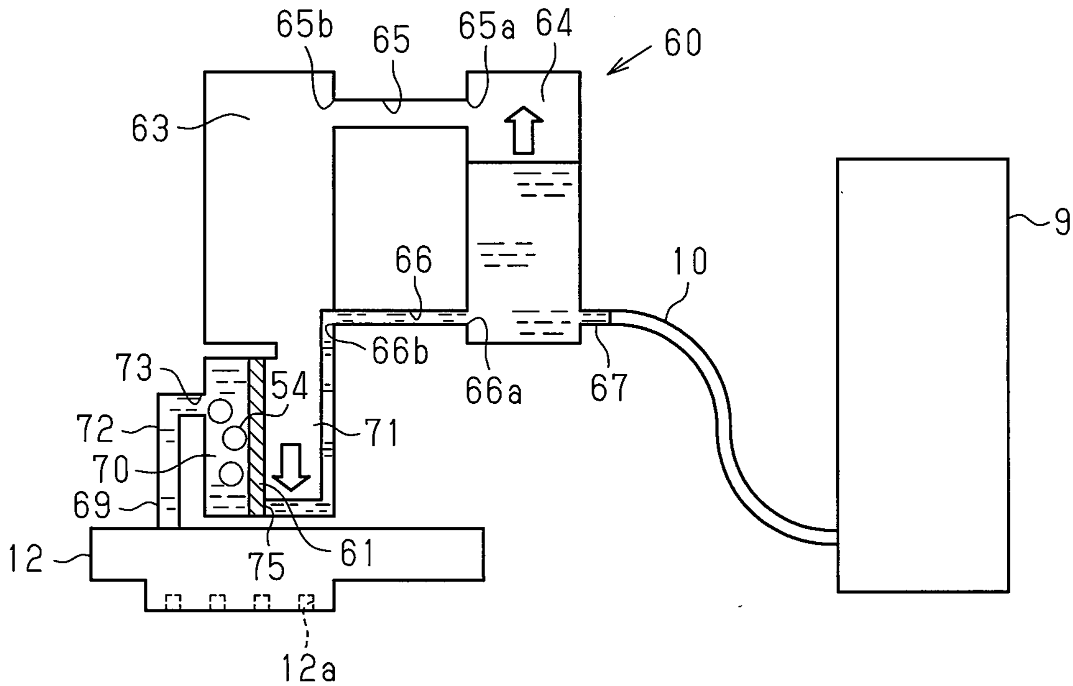

65b
65
65a
64
60
63
9
66
10
66b
66a
67
73
54
72
71
70
69
75
61
12
12a

Fig.20

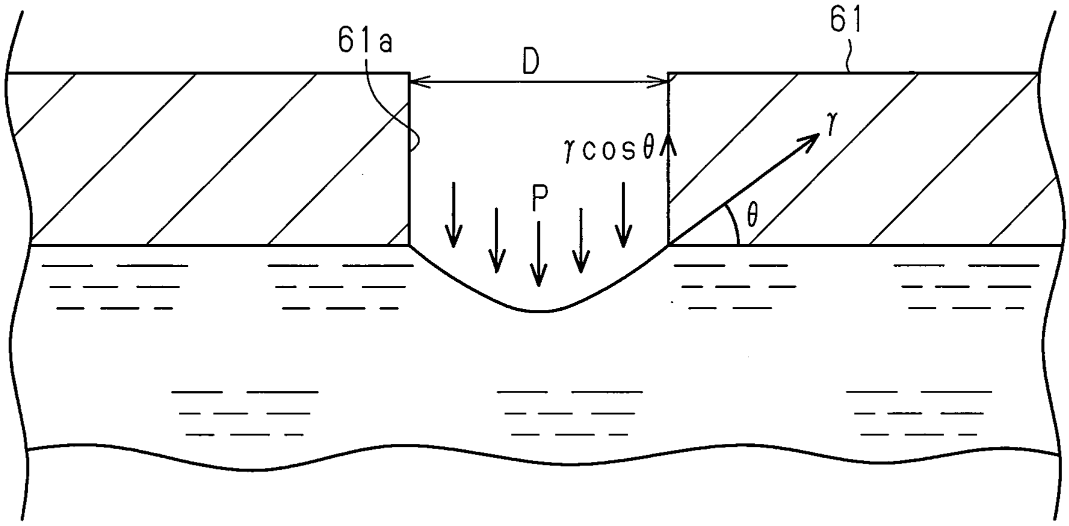

61a
D
61
γcosθ
γ
P
θ

Fig.21

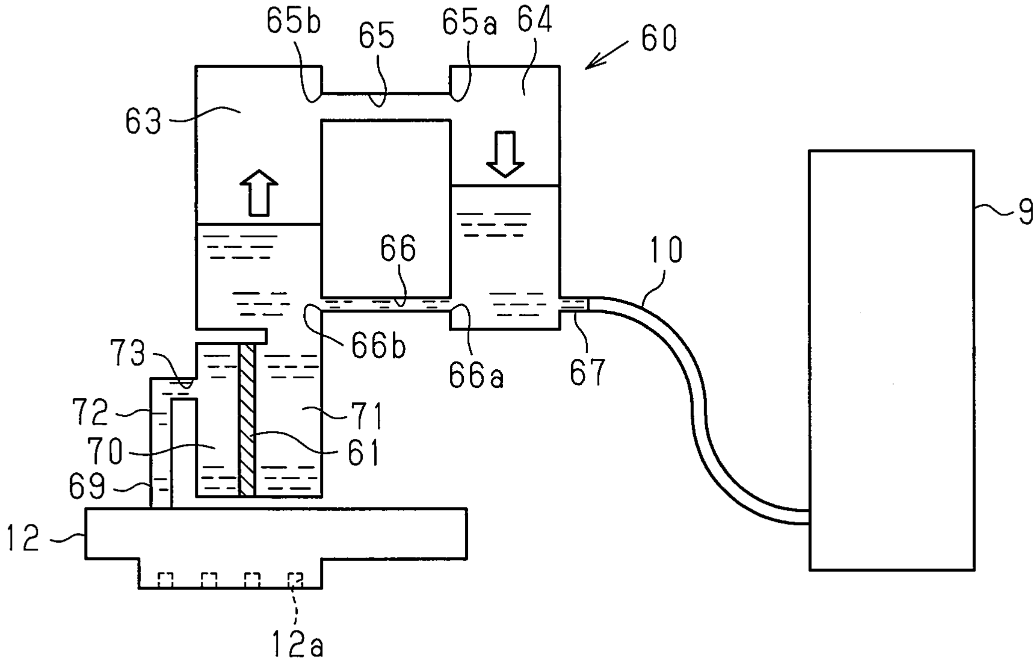

65b
65
65a
64
60
63
9
66
10
66b
66a
67
73
72
71
70
61
69
12
12a

Fig.22

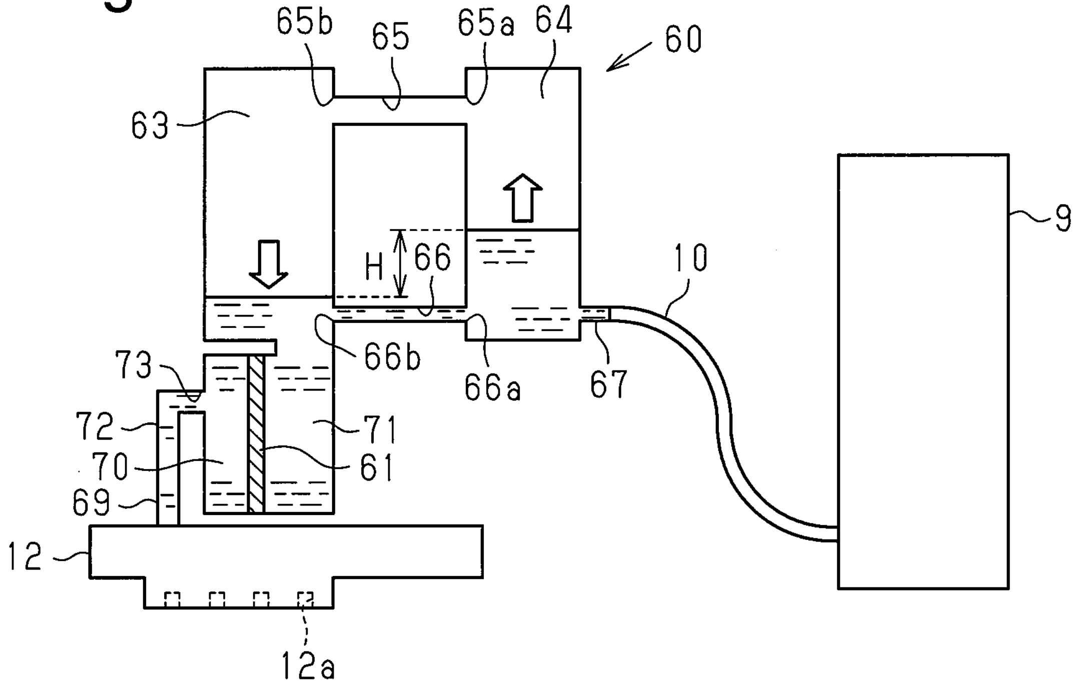

65b
65
65a
64
60
63
9
H
66
10
66b
66a
67
73
72
71
70
61
69
12
12a

Fig.23

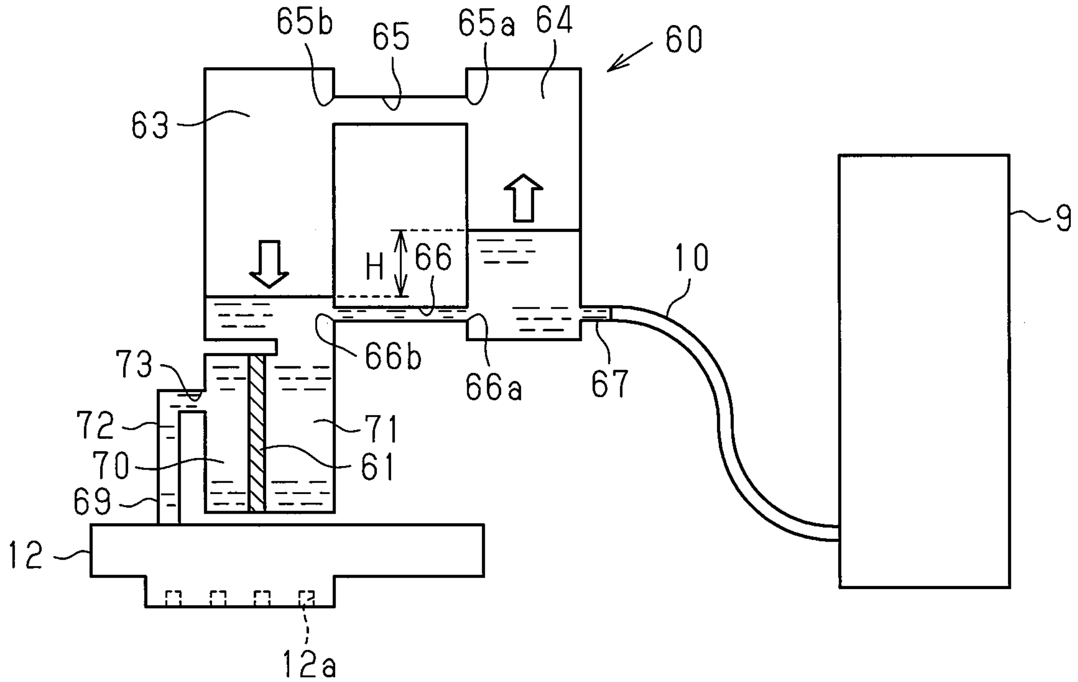

65b
65
65a
64
60
63
9
H
66
10
66b
66a
67
73
72
71
70
61
69
12
12a

Fig.24

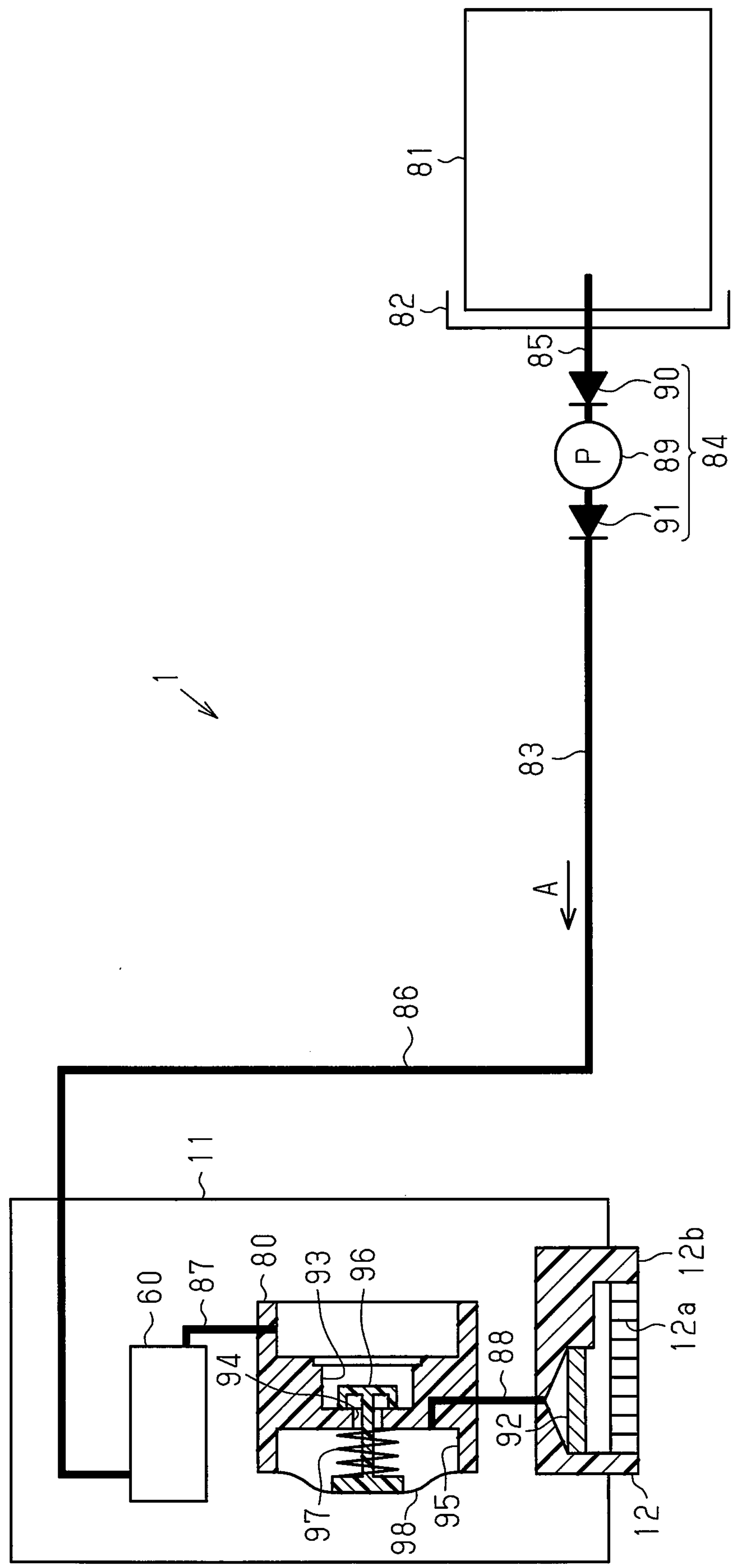

81
82
85
90
89
84
91
P
1
83
A
86
11
60
87
80
93
96
94
88
92
12b
12a
97
98
95
12

Fig.25

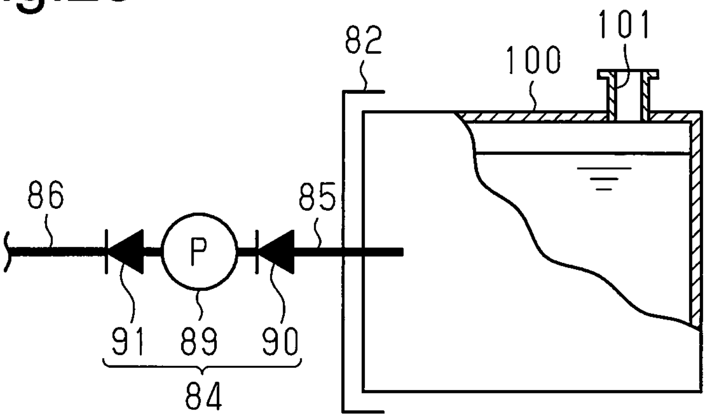
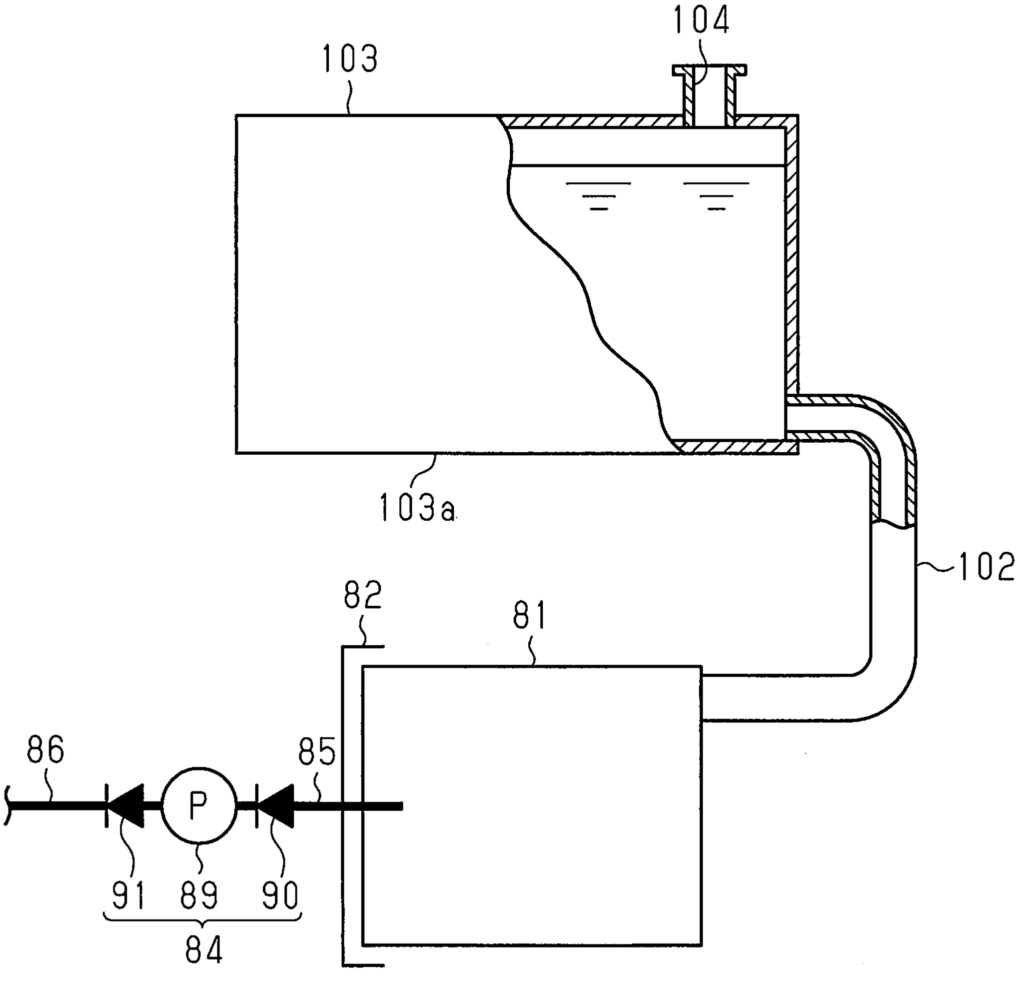

82
100
101
86
85
P
91
89
90
84

Fig.26


104
103
103a
102
82
81
86
85
P
91
89
90
84

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2016/051446

A. CLASSIFICATION OF SUBJECT MATTER
B41J2/175(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B41J2/01-215

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2013-158962 A (SII Printek Inc.), 19 August 2013 (19.08.2013), (Family: none)	1-13
A	JP 03-208665 A (Fujitsu Ltd.), 11 September 1991 (11.09.1991), (Family: none)	1-13
A	JP 10-029318 A (Canon Inc.), 03 February 1998 (03.02.1998), & US 6276784 B1 & EP 803362 A2 & DE 69716987 D	1-13
A	JP 2009-083374 A (Ishii Hyoki Co., Ltd.), 23 April 2009 (23.04.2009), (Family: none)	1-13

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
14 March 2016 (14.03.16)

Date of mailing of the international search report
22 March 2016 (22.03.16)

Name and mailing address of the ISA/
Japan Patent Office
3-4-3,Kasumigaseki,Chiyoda-ku,
Tokyo 100-8915,Japan

Authorized officer

Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/051446

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2008-012910 A (Samsung Electronics Co., Ltd.), 24 January 2008 (24.01.2008), & US 2008/0007604 A1 & EP 1876024 A1 & KR 10-2008-0004095 A & CN 101100137 A	1-13

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2010052210 A **[0004]**