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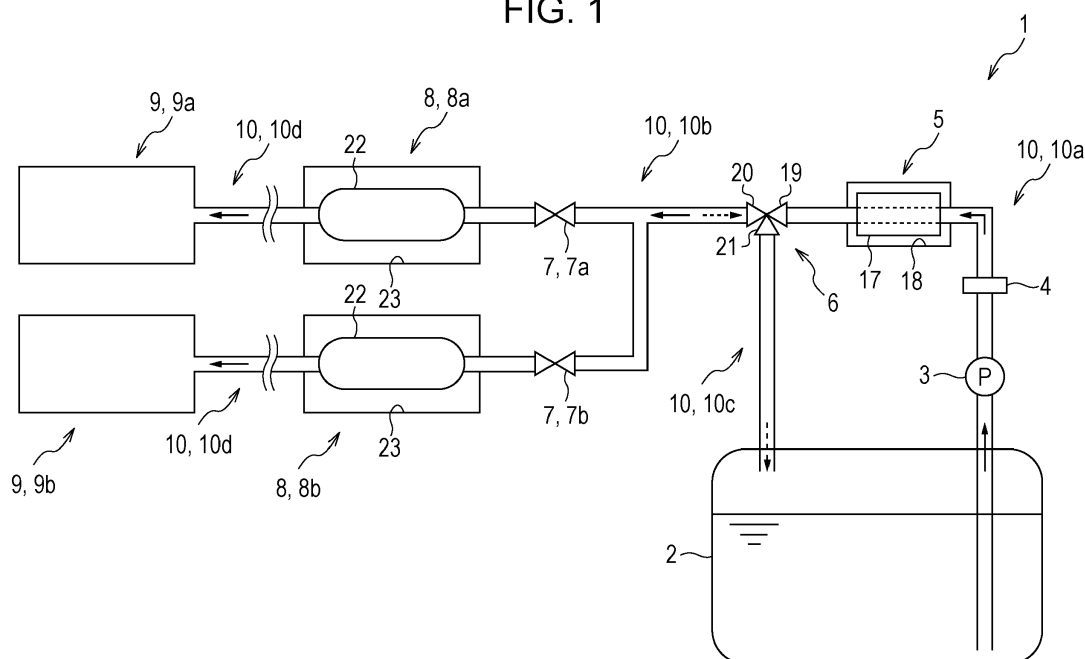
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(54) **LIQUID EJECTING APPARATUS AND METHOD OF REDUCING PRESSURE**

(57) A liquid ejecting apparatus includes an ejecting portion configured to eject a liquid; a liquid channel extending from a liquid reservoir to the ejecting portion; a liquid holder configured to hold the liquid supplied from the liquid reservoir and allow the liquid to be supplied to the ejecting portion; a liquid driving portion configured to cause the liquid in the liquid channel to flow; a liquid channel opening/closing portion configured to open and close the liquid channel; a circulation channel for the liquid; a circulation channel opening/closing portion configured to open and close the circulation channel; and a controller

configured to control drive of the liquid driving portion and opening/closing of the liquid channel performed by the liquid channel opening/closing portion. The controller is further configured, when pressure in the portion of the liquid channel between the liquid driving portion and the liquid holder is increased by the control, to control opening/closing of the circulation channel performed by the circulation channel opening/closing portion in such a manner that the increased pressure is released to the liquid reservoir through the circulation channel.

**FIG. 1**



## Description

### BACKGROUND

#### 1. Technical Field

**[0001]** The present invention relates to a liquid ejecting apparatus and a method of reducing pressure.

#### 2. Related Art

**[0002]** Liquid ejecting apparatuses such as a recording apparatus configured to record by ejecting a liquid such as ink on a medium have been traditionally used. Some of the liquid ejecting apparatuses include a liquid holder in a portion of the liquid channel between the liquid reservoir and the ejecting portion. The liquid holder is configured to hold the liquid supplied from the liquid reservoir and allow the liquid to be supplied to the ejecting portion. For example, JP-A-2012-162024 and JP-A-11-138850 each disclose a liquid ejecting apparatus including a sub tank as the liquid holder.

**[0003]** In the liquid ejecting apparatus including a liquid holder in the liquid channel, pressure in the liquid channel is increased by supply of the liquid from the liquid reservoir to the liquid holder. In the known liquid ejecting apparatus including the liquid holder in the liquid channel, the increased pressure remains as it is after the supply of the liquid to the liquid holder. Thus, a load is kept acting on the components of the liquid channel, leading to separation of the components of the liquid channel or loosening of the connection between the components. This may cause the liquid to leak from the liquid channel. The increase in the pressure in the liquid channel of the liquid ejecting apparatuses is not disclosed in JP-A-2012-162024 and JP-A-11-138850, and the liquid ejecting apparatuses are not configured to reduce the increased pressure in the liquid channel.

### SUMMARY

**[0004]** An advantage of some aspects of the invention is that pressure in a liquid channel increased by supply of a liquid to a liquid reservoir is reduced.

**[0005]** To solve the above-described problem, a liquid ejecting apparatus of a first aspect of the invention includes an ejecting portion configured to eject a liquid, a liquid channel extending from a liquid reservoir to the ejecting portion, a liquid holder disposed between the liquid reservoir and the ejecting portion and configured to hold the liquid supplied from the liquid reservoir and allow the liquid to be supplied to the ejecting portion, a liquid driving portion disposed between the liquid reservoir and the liquid holder and configured to cause the liquid in the liquid channel to flow, a liquid channel opening/closing portion disposed between the liquid driving portion and the liquid holder and configured to open and close the liquid channel, a circulation channel connected

to a portion of the liquid channel between the liquid driving portion and the liquid channel opening/closing portion at one end and connected to the liquid reservoir at another end, a circulation channel opening/closing portion connected to the liquid reservoir through the circulation channel and configured to open and close the circulation channel, and a controller configured to control drive of the liquid driving portion and opening/closing of the liquid channel performed by the liquid channel opening/closing portion. The controller is further configured, when pressure in the portion of the liquid channel between the liquid driving portion and the liquid holder is increased by the control, to control opening/closing of the circulation channel performed by the circulation channel opening/closing portion in such a manner that the increased pressure is released to the liquid reservoir through the circulation channel.

**[0006]** In this aspect, when the pressure in the portion of the liquid channel between the liquid driving portion and the liquid holder is increased by the drive of the liquid driving portion and the opening/closing of the liquid channel, the opening/closing of the circulation channel performed by the circulation channel opening/closing portion is controlled. This enables the increased pressure to be released to the liquid reservoir through the circulation channel. Thus, the pressure in the liquid channel increased by the supply of the liquid to the liquid holder is reduced. The "circulation channel" is a portion of the liquid channel that enables the liquid in the liquid channel to circulate.

**[0007]** In the liquid ejecting apparatus of a second aspect according to the first aspect, the liquid channel may include a first channel and a second channel, and the circulation channel opening/closing portion may be connected to the liquid driving portion, the liquid channel opening/closing portion, and the liquid reservoir through the first channel, the second channel, and the circulation channel, respectively, in such a manner that the circulation channel opening/closing portion opens and closes the first channel, the second channel, and the circulation channel.

**[0008]** In this aspect, the circulation channel opening/closing portion, which is connected to the liquid driving portion, the liquid channel opening/closing portion, and the circulation channel through the first channel, the second channel, and the circulation channel, respectively, is able to open and close the first channel, the second channel, and the circulation channel. Thus, the use of the three-way valve having such a configuration as the circulation channel opening/closing portion reduces the pressure in the liquid channel increased by the supply of the liquid to the liquid holder and enables the liquid to effectively circulate in the first channel and the circulation channel (for example, a precipitate component in the liquid is able to be stirred, if any).

**[0009]** In the liquid ejecting apparatus of a third aspect according to the second aspect, when the pressure in the portion of the liquid channel between the liquid driving

portion and the liquid holder increases, the controller may control the circulation channel opening/closing portion such that the circulation channel opening/closing portion repeatedly performs an operation to close the second channel and open both of the first channel and the circulation channel and an operation to close the circulation channel and open both of the first channel and the second channel so as to release the increased pressure to the liquid reservoir through the circulation channel.

**[0010]** In the configuration in which the circulation channel opening/closing portion is connected to the liquid driving portion, the liquid channel opening/closing portion, and the liquid reservoir through the first channel, the second channel, and the circulation channel, respectively, the pressure in the liquid channel is not sufficiently reduced in some cases by one set of the operation to close the second channel and open the first channel and the circulation channel and the operation to close the circulation channel and open the first channel and the second channel. However, in the above-described aspect, the operation to close the second channel and open the first channel and the circulation channel and the operation to close the circulation channel and open the first channel and the second channel are repeated when the pressure in the portion of the liquid channel between the liquid driving portion and the liquid reservoir is increased. Thus, the pressure in the liquid channel is effectively reduced.

**[0011]** The liquid ejecting apparatus of a fourth aspect of the invention according to any one of the first to third aspects may further include a deaerator disposed between the liquid reservoir and the ejecting portion and configured to deaerate the liquid to be supplied to the ejecting portion.

**[0012]** If the liquid to be ejected from the ejecting portion is not (sufficiently) deaerated, an ejection defect may occur. However, in the above-described aspect, the deaerator configured to deaerate the liquid to be supplied to the ejecting portion is further provided between the liquid reservoir and the ejecting portion. Thus, the liquid is deaerated before being supplied to the ejecting portion, reducing the ejection defect caused by the insufficiently deaerated liquid.

**[0013]** The liquid ejecting apparatus of a fifth aspect of the invention according to any one of the first to fourth aspects may further include a filter disposed between the liquid reservoir and the ejecting portion.

**[0014]** In the fifth aspect, the filter is provided between the liquid reservoir and the ejecting portion. The filter catches a foreign substance or the like in the liquid.

**[0015]** A method of reducing pressure of a sixth aspect of the invention is performed in a liquid ejecting apparatus including an ejecting portion configured to eject a liquid, a liquid channel extending from a liquid reservoir to the ejecting portion, a liquid holder disposed between the liquid reservoir and the ejecting portion and configured to hold the liquid supplied from the liquid reservoir and allow the liquid to be supplied to the ejecting portion, a

liquid driving portion disposed between the liquid reservoir and the liquid holder and configured to cause the liquid in the liquid channel to flow, a liquid channel opening/closing portion disposed between the liquid driving portion and the liquid holder and configured to open and close the liquid channel, a circulation channel connected to a portion of the liquid channel between the liquid driving portion and the liquid channel opening/closing portion at one end and connected to the liquid reservoir at another end, and a circulation channel opening/closing portion connected to the liquid reservoir through the circulation channel and configured to open and close the circulation channel. The method includes opening the liquid channel by the liquid channel opening/closing portion, driving the liquid driving portion, closing the liquid channel by the liquid channel opening/closing portion, and opening the circulation channel by the circulation channel opening/closing portion, when pressure in the portion of the liquid channel between the liquid driving portion and the liquid holder is increased by the opening, driving, and closing steps, in such a manner that the increased pressure is released to the liquid reservoir through the circulation channel.

**[0016]** In this aspect, when the pressure in the portion of the liquid channel between the liquid driving portion and the liquid holder is increased by the opening, driving, and closing steps (i.e., by a liquid supply step in which the liquid is supplied from the liquid reservoir to the liquid holder), the circulation channel opening/closing portion opens the circulation channel to release the increased pressure in the liquid channel to the liquid reservoir through the circulation channel. Thus, the pressure in the liquid channel increased by the supply of the liquid to the liquid reservoir in the opening, driving, and the closing steps is reduced.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0017]** Embodiments of the invention will now be described by way of example only with reference to the accompanying drawings, wherein like numbers reference like elements.

Fig. 1 is a schematic view illustrating a recording apparatus according to a first embodiment of the invention.

Fig. 2 is a block diagram illustrating the recording apparatus according to the first embodiment of the invention.

Fig. 3 is a schematic view illustrating a recording apparatus according to a second embodiment of the invention.

Figs. 4A to 4D are schematic views for explaining a method of reducing pressure according to one embodiment of the invention.

Fig. 5 is a flow chart of a method of reducing pressure according to one embodiment of the invention.

## DESCRIPTION OF EXEMPLARY EMBODIMENTS

**[0018]** Hereinafter, a recording apparatus as a liquid ejecting apparatus according to an embodiment of the invention is described in detail with reference to the drawings.

### First Embodiment

**[0019]** First, a recording apparatus 1 according to a first embodiment of the invention is briefly described with reference to Fig. 1 and Fig. 2. Fig. 1 is a schematic view illustrating a recording apparatus 1 of the first embodiment.

**[0020]** As illustrated in Fig. 1, the recording apparatus 1 according to the first embodiment includes an ink tank 2, which corresponds to a liquid reservoir for storing ink, and recording heads 9, which correspond to an ejecting portion through which the ink is ejected. The ink is an example of a liquid. The ink tank 2 and the recording heads 9 are connected to each other through an ink channel 10, which corresponds to a liquid channel. The ink tank 2 may be an ink tank fixed in the recording apparatus 1 and having an inlet (not illustrated) through which the ink is supplied to the ink tank 2, or may be a cartridge ink tank 2 detachably attached to the recording apparatus 1. As illustrated in Fig. 1, in the recording apparatus 1 according to the first embodiment, ink is supplied from one ink tank 2 to two recording heads 9 (recording heads 9a and 9b). However, the ink may be supplied from one ink tank 2 to one recording head 9 or may be supplied from one ink tank 2 to three or more recording heads 9.

**[0021]** In the ink channel 10, a pump 3, a filter 4, a deaerator 5, a three-way valve 6, opening/closing valves 7 (opening/closing valves 7a and 7b), and sub tanks 8 (sub tanks 8a and 8b) are disposed in this order from the side of the ink tank 2 to the side of the recording heads 9. The ink channel 10 branches at a position between the three-way valve 6 and the opening/closing valves 7 into an ink channel 10 connected to the opening/closing valve 7a, the sub tank 8a, and the recording head 9a and an ink channel 10 connected to the opening/closing valve 7b, the sub tank 8b, and the recording head 9b.

**[0022]** The ink channel 10 of the recording apparatus 1 according to the first embodiment includes a first channel 10a and a second channel 10b. The first channel 10a extends from the ink tank 2 to the three-way valve 6 through the pump 3, the filter 4, and the deaerator 5. The second channel 10b extends from the three-way valve 6 to the sub tanks 8 through the opening/closing valves 7. In addition, the ink channel 10 includes a third channel 10c extending from the three-way valve 6 to the ink tank 2. The third channel 10c, which corresponds to a circulation channel, enables circulation of the ink by allowing the ink flowing from the ink tank 2 through the first channel 10a to flow back to the ink tank 2. The ink channel 10 further includes fourth channels 10d extending from the sub tanks 8 to the recording heads 9. The "circulation

channel" is a portion of the ink channel 10 that enables the ink in the ink channel 10 to circulate.

**[0023]** The pump 3, which functions as a liquid driving portion, is configured to cause the ink in the ink channel 10 to flow from the side of the ink tank 2 to the side of the recording heads 9 when driven. In addition, the pump 3 is configured to cause the ink in the first channel 10a to flow toward the third channel 10c for circulation of the ink in the ink tank 2.

**[0024]** The filter 4 is disposed in the ink channel 10 (between the ink tank 2 and the recording heads 9) so as to catch a foreign substance or the like in the ink. The filter 4 may be replaceable so as to prevent a filter 4 that has caught a large amount of foreign substances or the like from interrupting the ink flow in the ink channel 10.

**[0025]** The deaerator 5 disposed in the ink channel 10 is configured to deaerate the ink to be supplied to the recording heads 9. If the ink ejected from the recording heads 9 is not (sufficiently) deaerated, an ejection defect may occur. However, since the recording apparatus 1 according to the first embodiment includes the deaerator 5, which is disposed between the ink tank 2 and the recording heads 9 and is configured to deaerate the ink to be supplied to the recording heads 9, the ink is deaerated before being supplied to the recording heads 9. This reduces the ejection defect caused by the insufficiently deaerated ink.

**[0026]** Specifically, the deaerator 5 may include a cylindrical hollow fiber membrane 17, which is a portion of the ink channel 10, and a decompression mechanism (not illustrated) configured to decompress the liquid in the ink channel 10 for deaeration, for example. In such a case, the decompression mechanism includes a decompression chamber 18 storing the hollow fiber membrane 17 and a pump (not illustrated) configured to reduce the pressure in the decompression chamber 18. When the decompression chamber 18 is decompressed by the pump, the space outside the hollow fiber membrane 17 is decompressed, resulting in suction of the gas dissolved in the ink in the hollow fiber membrane 17 to the outside of the hollow fiber membrane 17. Thus, the ink in the hollow fiber membrane 17 is deaerated. However, the configuration of the deaerator 5 is not limited to this configuration.

**[0027]** The three-way valve 6 is connected to three components, i.e., the deaerator 5, the opening/closing valves 7, and the ink tank 2, through the ink channel 10. Specifically, the three-way valve 6 includes opening/closing valves 19, 20, and 21. The opening/closing valve 19 is connected to the deaerator 5 through the first channel 10a, the opening/closing valve 20 is connected to the opening/closing valves 7 through the second channel 10b, and the opening/closing valve 21 is connected to the ink tank 2 through the third channel 10c. When the pump 3 is driven while the opening/closing valves 19 and 20 are opened and the opening/closing valve 21 is closed, the ink flows from the side of the opening/closing valve 19 (side of the first channel 10a) to the side of the

opening/closing valve 20 (side of the second channel 10b). In addition, when the pump 3 is driven while the opening/closing valves 19 and 21 are opened and the opening/closing valve 20 is closed, the ink flows (circulates) from the side of the opening/closing valve 19 (side of the first channel 10a) to the side of the opening/closing valve 21 (side of the third channel 10c). The three-way valve 6 in this embodiment is configured such that the opening/closing valves 20 and 21 are not both opened while the opening/closing valve 19 is closed so as to prevent the ink from being supplied to the sub tanks 8 without passing through the filter 4 that catches a foreign substance in the ink and the deaerator 5 that deaerates the ink (prevent the ink from flowing from the third channel 10c to the second channel 10b).

**[0028]** The opening/closing valves 7 (opening/closing valves 7a and 7b) are configured to open and close the second channel 10b. When the pump 3 is driven after the opening/closing valves 19 and 20 are opened and the opening/closing valve 21 is closed with the opening/closing valve 7a opened, the ink is supplied from the ink tank 2 to the sub tank 8a. The supply of the ink from the ink tank 2 to the sub tank 8a stops when the opening/closing valve 7a is closed. When the pump 3 is driven after the opening/closing valves 19 and 20 are opened and the opening/closing valve 21 is closed with the opening/closing valve 7b opened, the ink is supplied from the ink tank 2 to the sub tank 8b. The supply of the ink from the ink tank 2 to the sub tank 8b stops when the opening/closing valve 7b is closed.

**[0029]** The sub tanks 8 (the sub tanks 8a and 8b) each include a holding bag 22 in a holding chamber 23. Thus, the sub tanks 8 each function as a liquid holder configured to hold the ink supplied from the ink tank 2 and allow the ink to be supplied to the recording head 9. In the recording apparatus 1 according to the embodiment, the sub tanks 8 are disposed downstream of the three-way valve 6 and the opening/closing valves 7 in a direction extending from the side of the ink tank 2 to the side of the recording heads 9 in the ink channel 10. This configuration enables, when the opening/closing valve 20 of the three-way valve 6 or the opening/closing valve 7 is closed, the ink tank 2 to be refilled with the ink or to be replaced during the supply of the ink from the sub tank 8 to the recording head 9 (or during ejection of the ink from the recording head 9).

**[0030]** The recording head 9 in this embodiment includes a common liquid chamber (not illustrated) and a plurality of nozzles connected to the common liquid chamber. The ink supplied to the common liquid chamber is ejected through the nozzles.

**[0031]** Next, an electrical configuration of the recording apparatus 1 according to the first embodiment is described. Fig. 2 is a block diagram of the recording apparatus 1 of the first embodiment. As illustrated in Fig. 2, the recording apparatus 1 of the first embodiment includes a controller 12 that controls the components of the recording apparatus 1 such as the pump 3, the three-

way valve 6, the recording heads 9, and the opening/closing valves 7. The controller 12 controls drive of the recording heads 9 in connection with the ink ejecting operation (recording operation). The controller 12 controls opening and closing of predetermined valves (the opening/closing valves 19, 20, and 21 of the three-way valve 6 and the opening/closing valves 7) and the drive of the pump 3 such that the ink is supplied to the sub tank 8 or such that the ink flows back to the ink tank 2. The controller 12 may include a plurality of controllers 12 each configured to control different components of the recording apparatus 1 or may include one controller configured to collectively control the components.

**[0032]** As described above, the recording apparatus 1 of this embodiment includes the recording heads 9 configured to eject the ink, the ink channel 10 extending from the ink tank 2 to the recording heads 9, and the sub tanks 8 disposed between the ink tank 2 and the recording heads 9 and configured to hold the ink supplied from the ink tank 2 and allow the ink to be supplied to the recording heads 9. The recording apparatus 1 further includes the pump 3, which is disposed between the ink tank 2 and the sub tanks 8 and configured to cause the ink in the ink channel 10 to flow, and the opening/closing valves 7, which are disposed between the pump 3 and the sub tanks 8 and configured to open and close the ink channel 10. The opening/closing valve 7 corresponds to a liquid channel opening/closing portion. The recording apparatus 1 further includes the third channel 10c, which is connected to a portion of the ink channel 10 between the pump 3 and the opening/closing valves 7 at one end and connected to the ink tank 2 at the other end, and the three-way valve 6, which is connected to the ink tank 2 through the third channel 10c. The three-way valve 6 corresponds to a circulation channel opening/closing portion configured to open and close the third channel 10c by the opening/closing valve 21. The controller 12 in this embodiment controls drive of the pump 3 and opening/closing of the ink channel 10 performed by the opening/closing valves 7 and, when the pressure in the portion of the ink channel 10 between the pump 3 and the sub tanks 8 is increased by such control, also controls opening/closing of the third channel 10c performed by the three-way valve 6 (additionally, opening/closing of the first channel 10a and opening/closing of the second channel 10b in this embodiment). This enables the increased pressure to be released to the ink tank 2 through the third channel 10c. In the recording apparatus 1 of this embodiment having the above-described configuration, the pressure in the ink channel 10 increased by the supply of the ink to the sub tanks 8 is reduced.

**[0033]** In addition, as illustrated in Fig. 1, in the three-way valve 6 of this embodiment, the opening/closing valve 19 is connected to the pump 3 through the first channel 10a of the ink channel 10, the opening/closing valve 20 is connected to the opening/closing valves 7 through the second channel 10b of the ink channel 10, and the opening/closing valve 21 is connected to the ink

tank 2 through the third channel 10c. The opening/closing valves 19, 20, and 21 are configured to open and close the first, second, and third channels 10a, 10b, and 10c, respectively. The use of the three-way valve 6 having the above-described configuration as the circulation channel opening/closing portion reduces the pressure in the ink channel 10 increased by the supply of the ink to the sub tank 8 as described above. In addition, the use of the three-way valve 6 enables the ink to effectively circulate in the first and third channels 10a and 10c (for example, a precipitate component of the ink is able to be stirred, if any).

**[0034]** In addition, the controller 12 in this embodiment is configured to control the three-way valve 6, when the pressure in the portion of the ink channel 10 between the pump 3 and the sub tanks 8 increases, such that an operation to close the second channel 10b and open the first and third channels 10a and 10c and an operation to close the third channel 10c and open the first and second channels 10a and 10b are repeated. This enables the increased pressure to be released to the ink tank 2 through the third channel 10c. In the configuration in which both of the opening/closing valves 20 and 21 are not able to be opened while the opening/closing valve 19 is closed, the pump 3 may be configured to cause the ink to flow from the ink tank 2 through the first channel 10a only in a direction toward the sub tank 8 (forward) or the pump 3 may be configured to cause the ink to flow in a direction opposite to the forward direction (inverse direction). In such configurations, the increased pressure may be required to be released without driving of the pump 3. The pressure in the ink channel 10 is not sufficiently reduced in some cases if the operation to close the second channel 10b and open the first and third channels 10a and 10c and the operation to close the third channel 10c and open the first and second channels 10a and 10b are performed only one time. The operation to close the second channel 10b and open the first and third channels 10a and 10c enables the ink to flow to the ink tank 2 through the third channel 10c (the ink flows to the ink tank 2 having a large space), and thus the pressure in the first channel 10a is effectively reduced. The operation to close the third channel 10c and open the first and second channels 10a and 10b only enables the ink in the second channel 10b to flow through the first channel 10a (the ink flows through a narrow space extending from the pump 3 to the three-way valve 6) when the pump 3 is switched off, and thus the pressure in the second channel 10b is not sufficiently reduced. However, the recording apparatus 1 of this embodiment is configured to repeat the operation to close the second channel 10b and open the first and third channels 10a and 10c and the operation to close the third channel 10c and open the first and second channels 10a and 10b when the pressure in the portion of the ink channel 10 between the pump 3 and the sub tanks 8 increases. This configuration enables the pressure in the ink channel 10 to be gradually reduced, and thus the pressure in the ink channel 10 is effectively

reduced. The control may but need not be carried out based on one or more pressure sensors positioned for example in a/the sub-tank(s) 8, the channel 10b and/or the channel 10a.

## Second Embodiment

**[0035]** A recording apparatus according to a second embodiment of the invention is described with reference to Fig. 3. Fig. 3 is a schematic view of a recording apparatus 1 according to the second embodiment. Fig. 3 corresponds to Fig. 1 illustrating the recording apparatus 1 of the first embodiment. Components of the second embodiment identical to those of the first embodiment are assigned the same reference numerals as those in the first embodiment, and are not described in detail. The recording apparatus 1 of this embodiment differs from the recording apparatus 1 of the first embodiment in the configuration of the section between the ink tank 2 and the opening/closing valves 7.

**[0036]** As described above, the recording apparatus 1 of the first embodiment includes the three-way valve 6 as the circulation channel opening/closing portion. As illustrated in Fig. 3, the recording apparatus 1 according to the second embodiment includes an opening/closing valve 11, instead of the three-way valve 6, as the circulation channel opening/closing portion in the third channel 10c. This makes the configuration of the recording apparatus 1 of the second embodiment simpler. In addition, this makes the control by the controller 12 simpler, because the controller 12 is only required to close the opening/closing valve 7 and open the opening/closing valve 11 one time to reduce the pressure in the ink channel 10 of the recording apparatus 1 of this embodiment. In addition, since the ink having the increased pressure in the first and second channels 10a and 10b of the ink channel 10 flows to the ink tank 2 having a large space, the pressure in the ink channel 10 is effectively reduced by opening the opening/closing valve 11 only one time.

**[0037]** In the recording apparatus 1 of the second embodiment, the pump 3 is driven while the opening/closing valves 7 are closed and the opening/closing valve 11 is opened for circulation of the ink. At this time, the ink circulates while being mixed up in the second channel 10b. Thus, the recording apparatus 1 of the first embodiment has high circulation accuracy compared to that of the second embodiment. Furthermore, the recording apparatus 1 of the second embodiment does not include the filter 4 and the deaerator 5 to simplify the configuration of the recording apparatus 1. Thus, compared to the recording apparatus 1 of the second embodiment, the recording apparatus 1 of the first embodiment is advantageous to a reduction in deterioration of the ink flow in the ink channel 10 and to an improvement in the ejection stability.

## Method of Reducing Pressure

**[0038]** An example of a method of reducing pressure in the ink channel 10 of the recording apparatus 1 according to the first embodiment is described with reference to Figs. 4A to 4D and Fig. 5. Figs. 4A to 4D are schematic views for explaining the method of reducing pressure according to this embodiment. Fig. 5 is a flow chart of the method of reducing pressure according to this embodiment.

**[0039]** First, at a step S110 in Fig. 5, the controller 12 opens the opening/closing valves 7, 19, and 20 to open the ink channel 10 (the first and second channels 10a and 10b). At this time, the opening/closing valve 21 is closed. When the recording apparatus 1 of the second embodiment is used, only the opening/closing valves 7 are opened.

**[0040]** Then, at a step S120, the controller 12 drives the pump 3. Fig. 4A shows this state in which the ink flows in the ink channel 10 in a direction indicated by an arrow such that the ink is supplied from the ink tank 2 to the sub tanks 8. When the recording apparatus 1 of the second embodiment is used, the pump 3 is driven in the same manner.

**[0041]** After the ink is sufficiently supplied from the ink tank 2 to the sub tanks 8, the controller 12 closes the opening/closing valves 7 and 20 and stops the drive of the pump 3 at a step S130. Fig. 4B shows this state, in which the pressure in the portion of the ink channel 10 (the first and second channels 10a and 10b) between the pump 3 and the opening/closing valves 7 is high. If this state is maintained a long time, the ink may leak through the opening/closing valve 7 or any other valve, or the opening/closing valve 7 or any other valve may come off the ink channel 10, for example. When the recording apparatus 1 of the second embodiment is used, the controller 12 closes the opening/closing valves 7 and stops the drive of the pump 3.

**[0042]** Then, at a step S140, the opening/closing valve 21 of the three-way valve 6 is opened to open the circulation channel (the third channel 10c). This step enables a portion of the ink flowing through the portion of the ink channel 10 (the first channel 10a) between the pump 3 and the three-way valve 6 to flow to the ink tank 2 through the third channel 10c, and thus the pressure in the first channel 10a is reduced (the pressure in the second channel 10b remains high). Fig. 4C shows this state. When the recording apparatus 1 of the second embodiment is used, the opening/closing valve 11 is opened. This enables a portion of the ink in the first channel 10a and a portion of the ink in the second channel 10b to flow to the ink tank 2 through the third channel 10c. When the pressure in the first and second channels 10a and 10b is sufficiently reduced by this operation, the step according to the method of reducing pressure is terminated.

**[0043]** Then, at a step S150, the opening/closing valve 21 of the three-way valve 6 is closed to close the circulation channel (the third channel 10c) and the open-

ing/closing valve 20 is opened. This step enables a portion of the ink in the portion of the ink channel 10 (the second channel 10b) between the three-way valve 6 and the opening/closing valves 7 to flow to the first channel 10a, and thus the pressure in the second channel 10b is reduced (the pressure in the first channel 10a and the pressure in the second channel 10b become the same because pressure in the first channel 10a increases a little). Fig. 4D shows this state.

**[0044]** Then, at a step S160, the operations at the steps S140 and S150 are repeated a predetermined number of times (the state in Fig. 4C and the state in Fig. 4D are repeated) to gradually reduce the pressure in the first channel 10a and the pressure in the second channel 10b. When the pressure in the first channel 10a and the pressure in the second channel 10b are sufficiently reduced, the process according to the method of reducing pressure in this embodiment is terminated.

**[0045]** As described above, the method of reducing pressure according to this embodiment is able to be performed in the recording apparatus 1 including the recording heads 9 configured to eject the ink, the ink channel 10 extending from the ink tank 2 to the recording heads 9, the sub tanks 8 configured to hold the ink supplied from the ink tank 2 and allow the ink to be supplied to the recording heads 9, the pump 3 disposed between the ink tank 2 and the sub tanks 8 and configured to cause the ink in the ink channel 10 to flow, the opening/closing valves 7 disposed between the pump 3 and the sub tanks 8 and configured to open and close the ink channel 10, the third channel 10c connected to the portion of the ink channel 10 between the pump 3 and the opening/closing valves 7 at one end and connected to the ink tank 2 at the other end, and the three-way valve 6 (or the opening/closing valve 11) connected to the ink tank 2 through the third channel 10c and configured to open and close the third channel 10c.

**[0046]** The method of reducing pressure includes an ink supplying step in which the ink is supplied from the ink tank 2 to the sub tanks 8. The ink supplying step includes opening the opening/closing valves 7 to open the ink channel 10 (step S110), driving the pump 3 (step S120), and closing the opening/closing valves 7 to close the ink channel 10 (step S130). The method of reducing pressure further includes a pressure reducing step (steps S140 to S160) including opening the three-way valve 6 (or the opening/closing valve 11) to open the third channel 10c such that the pressure in the ink channel 10, which has been increased by the ink supplying step (the opening, driving, and closing steps), is released to the ink tank 2 through the third channel 10c. In other words, in the method of reducing pressure according to this embodiment, when the pressure in the portion of the ink channel 10 between the pump 3 and the sub tanks 8 is increased by the opening, driving, and closing steps (the ink supplying step in which the ink is supplied from the ink tank 2 to the sub tanks 8), the three-way valve 6 (or the opening/closing valve 11) is opened to open the third

channel 10c such that the increased pressure is released to the ink tank 2 through the third channel 10c. With this configuration, the pressure in the ink channel 10 increased by the supply of the ink to the sub tanks in the opening, driving, and closing steps is reduced.

**[0047]** The invention is not limited to the above-described embodiments. Various amendments may be added to the above-described embodiments within a scope of the invention described in the claims, and it is to be understood that such modified embodiments are in the scope of the invention.

## Claims

### 1. A liquid ejecting apparatus (1) comprising:

an ejecting portion (9) configured to eject a liquid;  
 a liquid channel (10) extending from a liquid reservoir (2) to the ejecting portion;  
 a liquid holder (8) disposed between the liquid reservoir and the ejecting portion and configured to hold the liquid supplied from the liquid reservoir and allow the liquid to be supplied to the ejecting portion;  
 a liquid driving portion (3) disposed between the liquid reservoir and the liquid holder and configured to cause the liquid in the liquid channel to flow;  
 a liquid channel opening/closing portion (7) disposed between the liquid driving portion and the liquid holder and configured to open and close the liquid channel;  
 a circulation channel (10c) connected to a portion of the liquid channel between the liquid driving portion and the liquid channel opening/closing portion at one end and connected to the liquid reservoir at another end;  
 a circulation channel opening/closing portion (6, 11) connected to the liquid reservoir through the circulation channel and configured to open and close the circulation channel; and  
 a controller (12) configured to control drive of the liquid driving portion and opening/closing of the liquid channel performed by the liquid channel opening/closing portion, the controller further being configured, when pressure in the portion of the liquid channel between the liquid driving portion and the liquid holder is increased by the control, to control opening/closing of the circulation channel performed by the circulation channel opening/closing portion in such a manner that the increased pressure is released to the liquid reservoir through the circulation channel.

### 2. The liquid ejecting apparatus according to Claim 1,

wherein the liquid channel includes a first channel (10a) and a second channel (10b), and the circulation channel opening/closing portion (6) is connected to the liquid driving portion (3), the liquid channel opening/closing portion (7), and the liquid reservoir (2) through the first channel, the second channel, and the circulation channel, respectively, in such a manner that the circulation channel opening/closing portion opens and closes the first channel, the second channel, and the circulation channel.

3. The liquid ejecting apparatus according to Claim 2, wherein, when the pressure in the portion of the liquid channel between the liquid driving portion and the liquid holder increases, the controller controls the circulation channel opening/closing portion such that the circulation channel opening/closing portion repeatedly performs an operation to close the second channel and open both of the first channel and the circulation channel and an operation to close the circulation channel and open both of the first channel and the second channel so as to release the increased pressure to the liquid reservoir through the circulation channel.

4. The liquid ejecting apparatus according to any one of the preceding claims, further comprising a deaerator (5) disposed between the liquid reservoir and the ejecting portion and configured to deaerate the liquid to be supplied to the ejecting portion.

5. The liquid ejecting apparatus according to any one of the preceding claims, further comprising a filter (4) disposed between the liquid reservoir and the ejecting portion.

6. A method of reducing pressure in a liquid ejecting apparatus (1), the liquid ejecting apparatus comprising:

an ejecting portion (9) configured to eject a liquid;  
 a liquid channel (10) extending from a liquid reservoir (2) to the ejecting portion;  
 a liquid holder (8) disposed between the liquid reservoir and the ejecting portion and configured to hold the liquid supplied from the liquid reservoir and allow the liquid to be supplied to the ejecting portion;  
 a liquid driving portion (3) disposed between the liquid reservoir and the liquid holder and configured to cause the liquid in the liquid channel to flow;  
 a liquid channel opening/closing portion (7) disposed between the liquid driving portion and the liquid holder and configured to open and close the liquid channel;  
 a circulation channel (10c) connected to a por-

tion of the liquid channel between the liquid driving portion and the liquid channel opening/closing portion at one end and connected to the liquid reservoir at another end; and

a circulation channel opening/closing portion (6) connected to the liquid reservoir through the circulation channel and configured to open and close the circulation channel, the method comprising:

opening the liquid channel by the liquid channel opening/closing portion;  
driving the liquid driving portion;  
closing the liquid channel by the liquid channel opening/closing portion; and  
opening the circulation channel by the circulation channel opening/closing portion, when pressure in a portion of the liquid channel between the liquid driving portion and the liquid holder is increased by the opening, driving, and closing steps, in such a manner that the increased pressure is released to the liquid reservoir through the circulation channel.

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FIG. 1

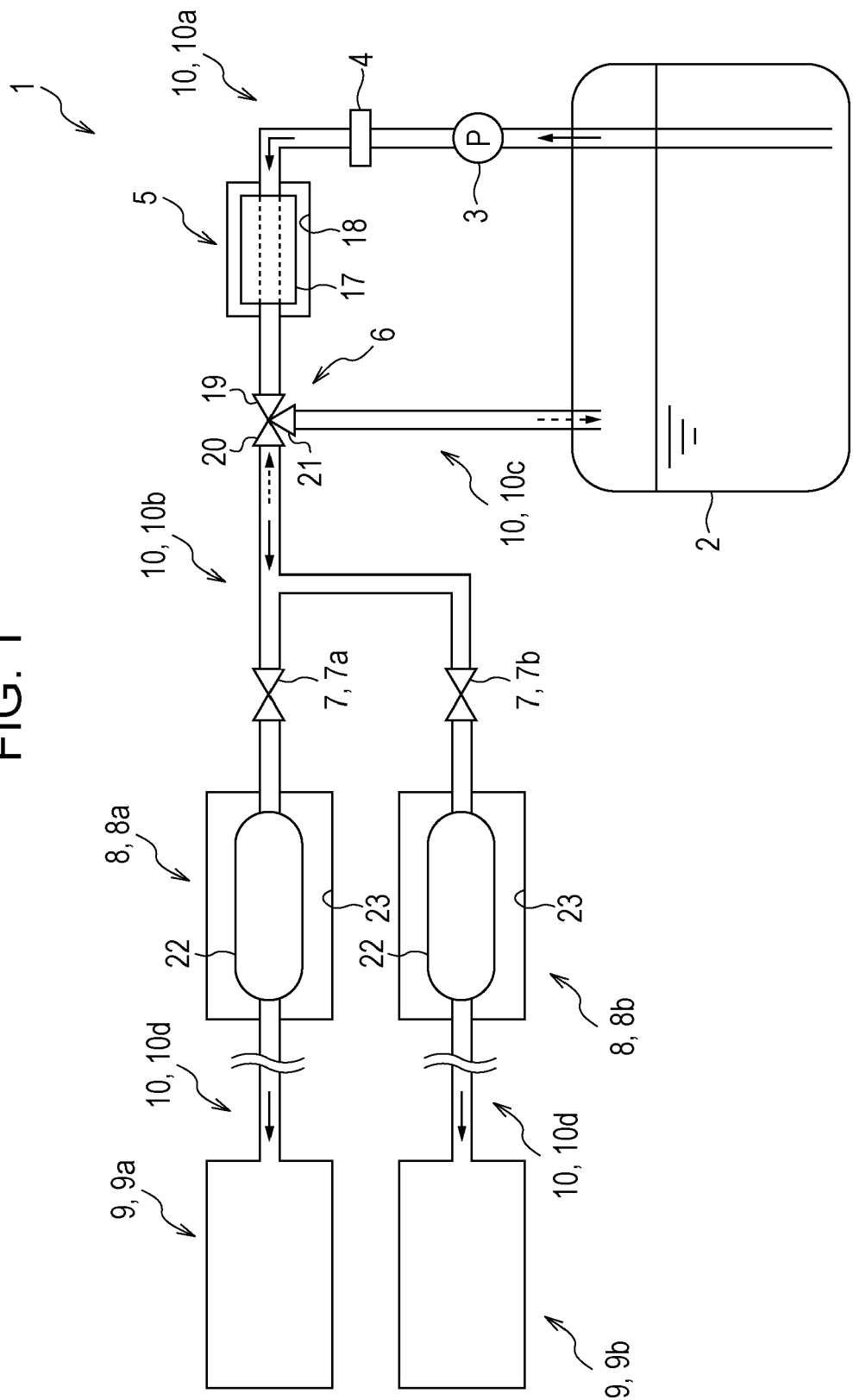


FIG. 2

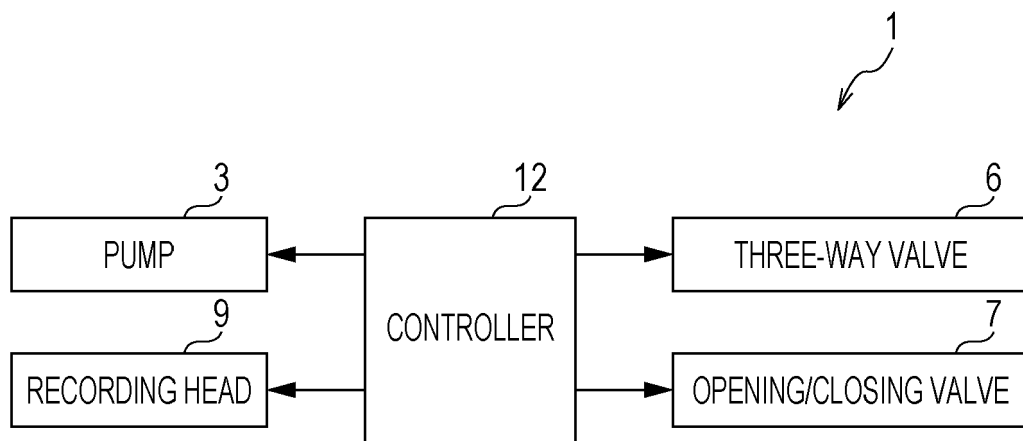
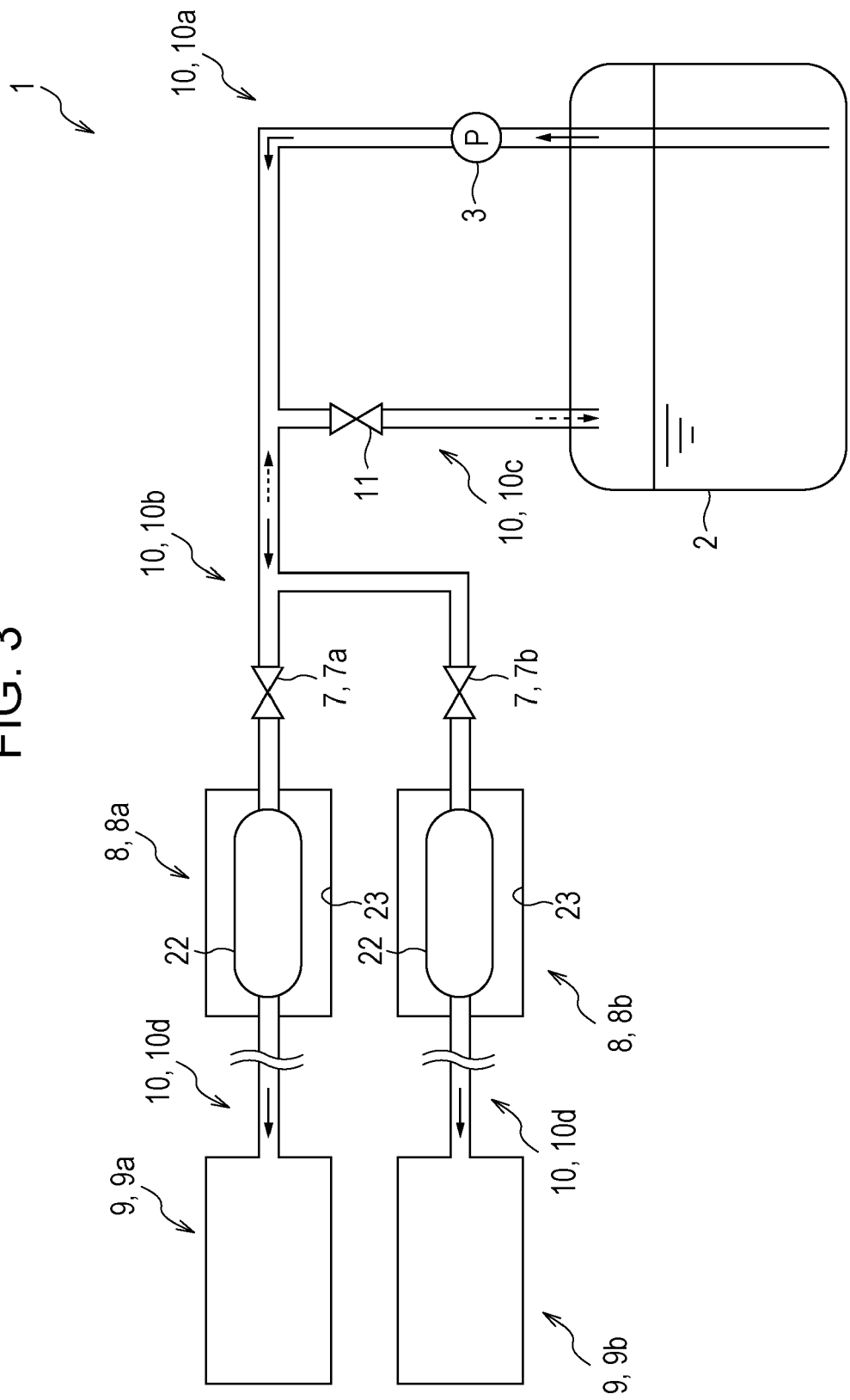


FIG. 3



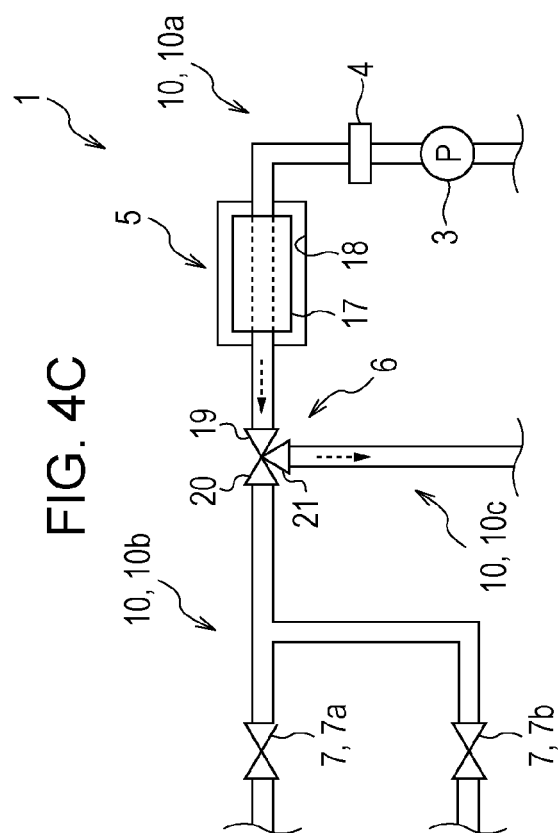
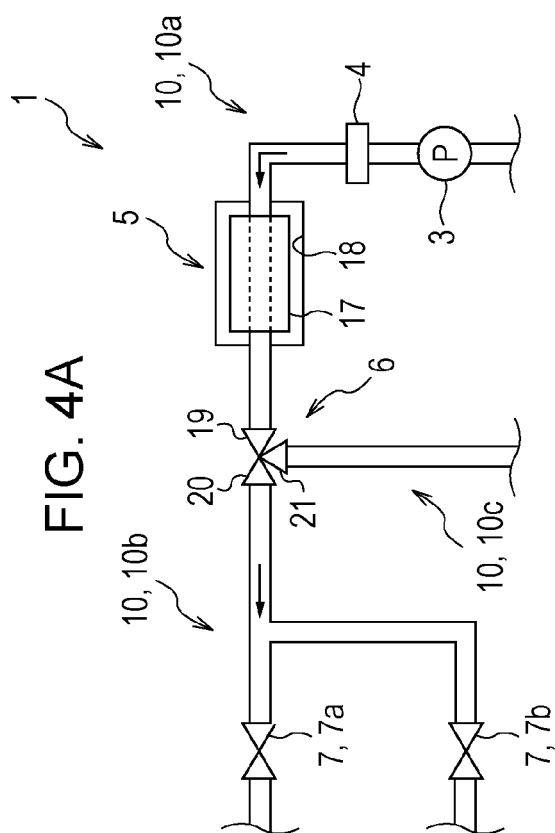
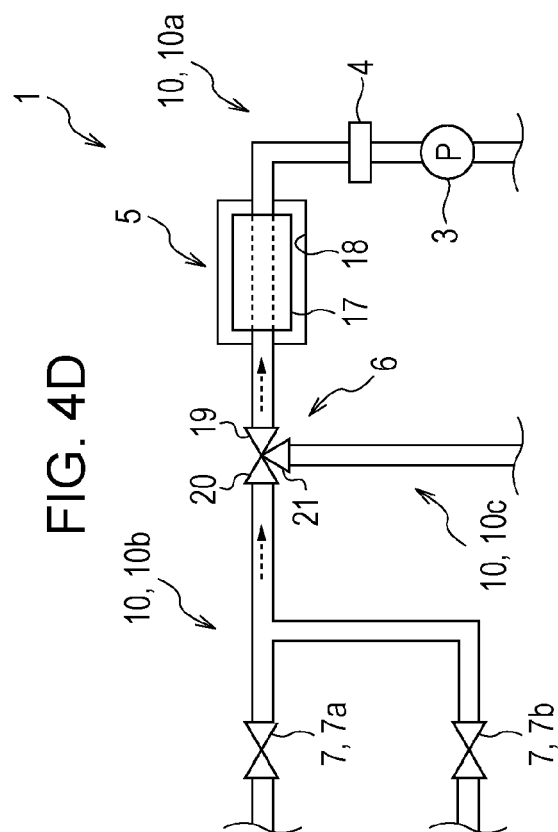
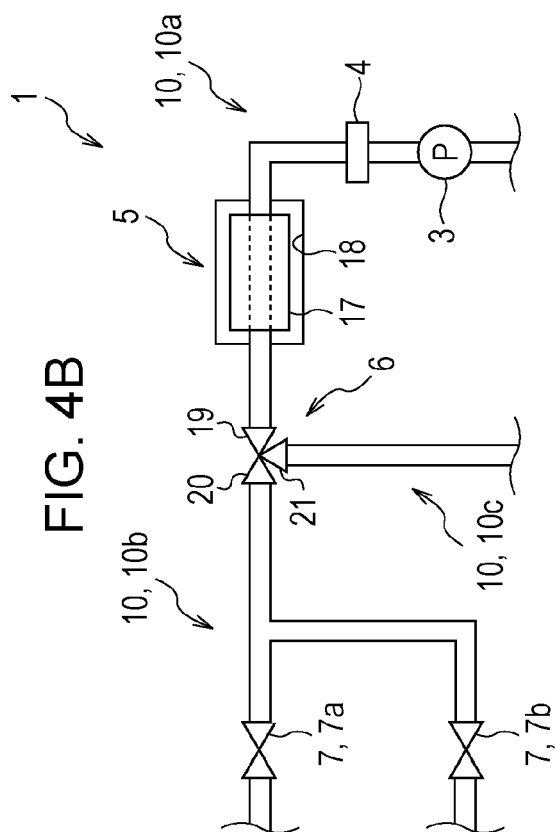
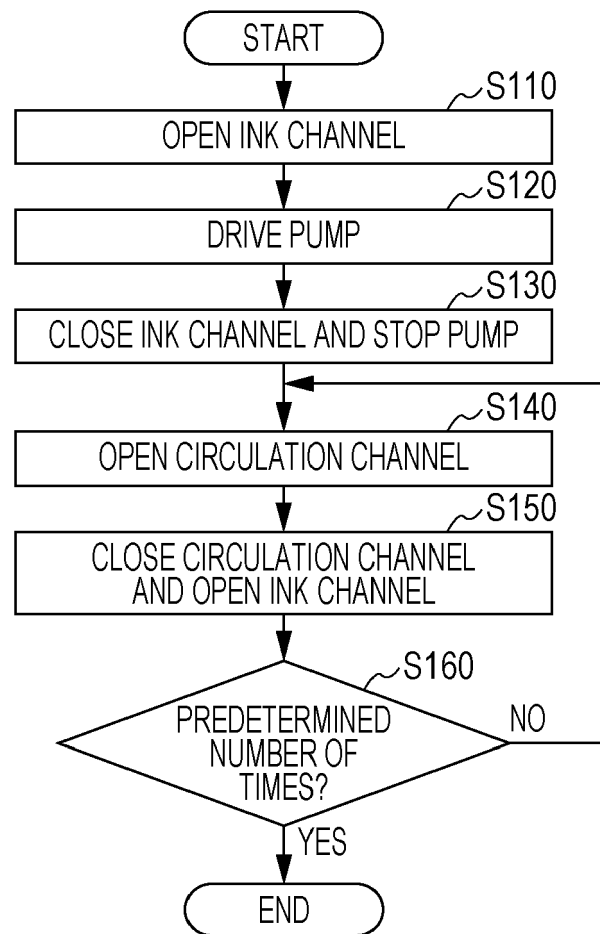


FIG. 5



**REFERENCES CITED IN THE DESCRIPTION**

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