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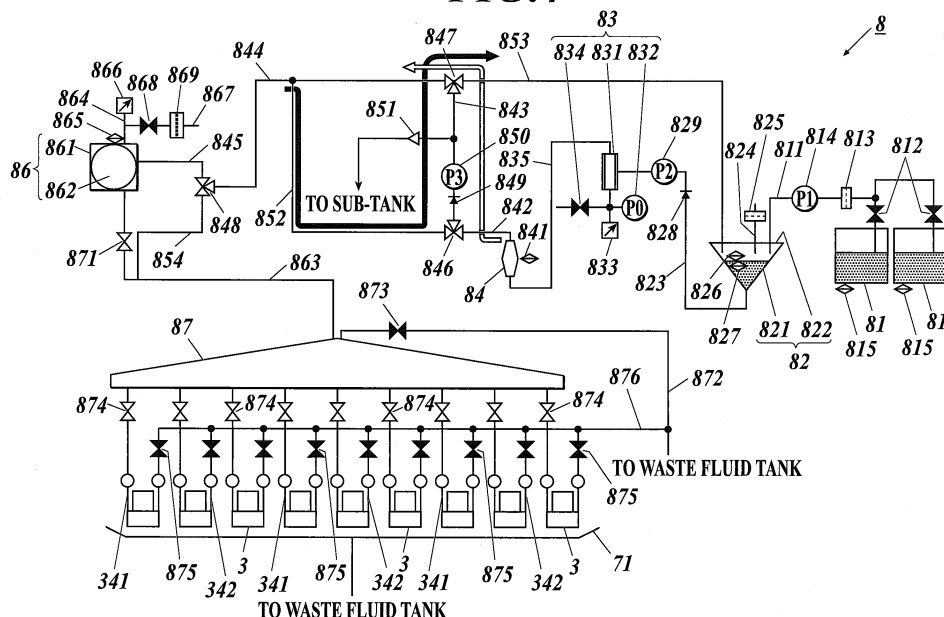
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(54) **INKJET RECORDING APPARATUS**

(57) This inkjet recording apparatus is provided with: a plurality of heads (3) that discharge the same color of ink onto a recording medium; an ink tank (84) that stores ink to be supplied to each of the plurality of heads; and a fluid delivery unit (850) that delivers ink from the ink tank to the head side. Each of the heads includes a manifold that is filled with ink and a first and a second ports (341, 342) in communication with the manifold (34). Ink

flow paths respectively connected to the first port and the second port of each head are fitted with open/close switchable valves (874, 875), and a control unit (9) that individually controls the opening and closing of the valves respectively connected to the first and the second ports of each head is provided. The heads can discharge ink individually such that maintenance can be performed quickly while ink consumption is suppressed.

FIG.4

Description

TECHNICAL FIELD

[0001] The present invention relates to an inkjet recording apparatus including an ink supply device to supply ink to heads.

BACKGROUND ART

[0002] Examples of recording devices which can form images on various types of recording media, such as plain paper and plastic thin sheets, include inkjet printers. Inkjet printers have heads to eject ink through nozzle holes. The nozzle holes of the heads eject fine ink droplets to a recording medium to form an image thereon.

[0003] The heads are connected to a tank storing ink from which the ink is supplied to the heads.

[0004] Dissolved gas, air bubbles, and foreign substance such as dust included in ink cause poor ejection, and thus conventional inkjet recording apparatuses maintain heads at their home position.

[0005] The head maintenance is performed by bringing the cap case of a capping means, disposed at the home position, into close contact with the nozzles of the heads; closing solenoid valves provided on ink flow paths to supply ink from the ink tank to the heads to bring the cap case at a negative pressure with a pump; reducing the pressure in the cap case to a target pressure; and opening the solenoid valves. This allows ink in the ink tank to flow into the cap case through the heads rapidly, enabling discharge of all of the air bubbles from the heads and dust or foreign substance adhering to the inside of the heads to the outside of the heads (see, for example, Patent Literature 1).

[0006] Another inkjet recording apparatus includes supply flow paths to supply ink to heads and collection flow paths to collect surplus ink from the heads. Such an inkjet recording apparatus supplies ink to the heads through the supply flow paths, allows the ink to circulate in the heads, and discharges the ink from the heads through the collection flow paths at the time of maintenance (see, for example, Patent Literature 2).

[0007] The heads have filters in front of the collection flow paths to remove dust and foreign substance. Circulation of ink in the heads allows impurity in the ink to be removed with the filters.

[0008] Still another inkjet recording apparatus has a plurality of heads each of which is provided with a supply port to supply ink and a discharge port to discharge the supplied ink. The discharge port of each head is connected to the supply port of another head, and thereby all the heads are connected in series. Ink is supplied from one end of the series-connected heads to perform maintenance of all the heads (see, for example, Patent Literature 3).

PRIOR ART LITERATURES

PATENT LITERATURES

[0009]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2001-113726

Patent Literature 2: Japanese Unexamined Patent Application Publication No. 2007-261234

Patent Literature 3: Japanese Unexamined Patent Application Publication No. 2009-285900

DISCLOSURE OF INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0010] The conventional inkjet recording apparatus disclosed in Patent Literature 1 simultaneously caps a plurality of heads and makes all the heads eject ink to the cap case. Unfortunately, therefore, the capping is simultaneously performed for the heads even if some of them have good ejection, leading to increase in waste of ink.

[0011] The inkjet recording apparatus disclosed in Patent Literature 2 collects ink which has passed through the heads using the collection flow paths and returns the ink to the ink tank, and thus does not waste ink. Unfortunately, however, the heads need filters so as to prevent impurity from coming in the ink tank to which ink is to be returned. Providing the filters for the heads requires regular inspections of the filters.

[0012] Further, the inkjet recording apparatus disclosed in Patent Literature 3, whose heads are connected in series, requires only one filter, but disadvantageously requires a long time for maintenance through the ink circulation.

[0013] An object of the present invention is to provide an inkjet recording apparatus which achieves speedy maintenance of heads while reducing ink consumption.

MEANS FOR SOLVING PROBLEMS

[0014] In order to solve the above-mentioned problems, the present invention includes a plurality of heads to eject ink of the same color onto a recording medium; an ink tank to store ink to be supplied to the heads; and a fluid supplying unit to supply ink from the ink tank toward the heads, wherein each of the heads includes a manifold to be filled with ink, and a first port and a second port each communicating with the manifold; an ink flow path is connected to each of the first and second ports of each of the heads, the ink flow path being provided with an open/close switchable valve; and a control unit is provided to individually control opening and closing of the valve for each of the first and second ports of each of the heads.

[0015] Further, the present invention may include a common flow path to which the first ports of all the heads

are connected in parallel, with the valve between each of the first ports and the common flow path. Ink may be supplied to the heads through the common flow path.

[0016] Further, the present invention may include a discharge flow path connected to the common flow path to discharge ink from the common flow path, and an open/close switchable valve provided on the discharge flow path. The control unit may control opening and closing of the valve on the discharge flow path.

[0017] Further, the present invention may include a negative pressure forming unit disposed on an ink flow path between the ink tank and the heads, the negative pressure forming unit keeping the heads at a negative pressure lower than an atmospheric pressure; a bypass flow path to supply ink without using the negative pressure forming unit; and open/close switchable valves provided ahead of and behind the negative pressure forming unit, respectively, to shut off a pressure for the ink supply.

EFFECTS OF THE INVENTION

[0018] In order to solve the above-mentioned problems, the present invention includes a valve for each of a first port and a second port of each of the heads, and the control unit individually controls opening and closing of each valve. When one/some of the heads require(s) maintenance, therefore, ink supply can be selectively performed for only the target head(s) to be maintained, reducing ink consumption for the maintenance.

[0019] Since ink consumption for the maintenance is reduced without returning the ink used for the maintenance to the ink tank, a filter is not necessary for every head. This avoids clogging of the nozzles of the heads which would be caused by foreign substance collected with filters, and eliminates the need for inspection of the filters.

[0020] Further, maintenance is required only for one/some of the heads unlike the case in which maintenance is performed for all the heads series-connected. This largely shortens the required time.

[0021] The common flow path, to which the first ports of all the heads are connected in parallel with a valve between each first port and the common flow path, prevents air bubbles and impurity in a head from moving to another head, enabling efficient maintenance in a short time, unlike the case of series-connected heads.

[0022] The common flow path enables the pressure adjustment for all the heads collectively at one time.

[0023] The discharge flow path to discharge ink from inside of the common flow path enables easy discharge of air bubbles generated in the common flow path.

[0024] Further, providing the negative pressure forming unit and the bypass flow path can avoid the effects of a high pressure when a pressure higher than usual is applied to any of the heads at the time of maintenance. Specifically, closing the valves provided ahead of and behind the negative pressure forming unit, respectively, can avoid the effects of such a high pressure. This can

protect the negative pressure forming unit.

BRIEF DESCRIPTION OF DRAWINGS

5 **[0025]**

FIG. 1 is a perspective view of an inkjet recording apparatus;

FIG. 2 is a plan view showing the layout of heads on a carriage;

FIG. 3 is a cross-sectional view showing the internal structure of a head;

FIG. 4 is a typical view schematically showing an ink supply device;

FIG. 5 is an explanatory diagram showing the connection state between a common flow path and the heads;

FIG. 6 is a block diagram showing the control system of the inkjet recording apparatus;

FIG. 7 is a flowchart showing the fluid level monitoring control;

FIG. 8 is a flowchart showing the maintenance control for one/some of the heads, i.e., target head(s) to be maintained;

FIG. 9 is a flowchart showing the fluid supplying control;

FIG. 10 is a flowchart showing the control for adjustment of back pressure of a negative pressure forming unit;

FIG. 11 is a flowchart showing the wiping control;

FIG. 12A is a chart illustrating the states of recovery from clogging of the nozzles, with the supply pressure changed in a stepwise fashion at the time of maintenance while the recording operation valve(s) for given head(s) is (are) open and the maintenance valve(s) for the given head(s) is (are) closed;

FIG. 12B is a chart illustrating the states of removal of air bubbles from the heads, with the supply pressure changed in a stepwise fashion at the time of maintenance while both the recording operation valve(s) and the maintenance valve(s) for given head(s) are open;

FIG. 13 is a flowchart showing the maintenance control for all the heads;

FIG. 14A is a schematic front view of a modification of the common flow path with its right end connected to an eighth ink flow path;

FIG. 14B is a schematic front view of a modification of the common flow path with its left end connected to an eighth ink flow path; and

FIG. 14C is a schematic front view of a modification of the common flow path with its center connected to an eighth ink flow path.

55 EMBODIMENT FOR CARRYING OUT THE INVENTION

[0026] An inkjet recording apparatus 10 provided with an ink supply device, which is an embodiment of the

present invention, is described below with reference to FIGS. 1 to 13. FIG. 1 is a perspective view showing the whole of the inkjet recording apparatus 10.

[0027] The inkjet recording apparatus 10 mainly includes a conveying device 2 to convey recording media in the horizontal direction, a carriage 4 provided with a plurality of heads 3 (see FIG. 2) to eject ink from above onto a conveyed recording medium, a main-scanning device 5 to move the carriage 4 in the horizontal direction perpendicular to the conveying direction of recording media, a maintenance unit 7 to maintain the heads 3 on the carriage 4, a nozzle moistener unit 6 to moisten the nozzles 311 of the heads 3 on the carriage 4, an ink supply device 8 (see FIG. 4) to supply ink to the heads 3 on the carriage 4, a control device 9 (see FIG. 6) as a control unit to control these components, and a frame 100 to support the whole structure.

[0028] In the following description, the horizontal direction along the conveying direction of recording media is referred to as a Y-axis direction; the horizontal direction along the carrying direction of the carriage 4 is referred to as an X-axis direction or main-scanning direction; and the vertical direction is referred to as a Z-axis direction.

[Conveying device]

[0029] The conveying device 2 includes a driving roller 21 and a driven roller (not shown), a driving motor 22, and a conveyor belt 23.

[0030] The driving roller 21 and the driven roller are supported to be rotatable about their respective axes, and the driving roller 21 is disposed so as to extend in the main-scanning direction X. The driving motor 22 is a drive source for the rotary drive of the driving roller 21 and is attached to one end of the driving roller 21.

[0031] The conveyor belt 23 is an endless belt and is stretched across the driving roller 21 and the driven roller. Rotations of the driving roller 21 make the conveyor belt 23 rotate on the driving roller 21 and the driven roller to convey a recording medium placed on the upper surface of the conveyor belt 23 in the conveying direction F along the Y-axis direction. Stopping of the rotations of the driving roller 21 makes the conveyor belt 23 stop rotating on the rollers and stop the conveyance of a recording medium.

[0032] When the heads 3 complete one-way scanning in the X-axis direction, the driving motor 22 drives the driving roller 21 to rotate by a predetermined amount to allow a recording medium to advance by a predetermined distance in the conveying direction and then to stop. When the heads 3 start scanning in the opposite direction along the main-scanning direction X and complete the scanning, the driving motor 22 again drives the driving roller 21 to rotate by a predetermined amount to allow the recording medium to advance by a predetermined distance in the conveying direction F and then to stop. The driving motor 22 repeats this processing in accordance with the control by the control device 90. The driving

motor 22 thus performs so-called intermittent conveyance of a recording medium.

[0033] As the recording media, resin film and metal or the like can be used as well as paper and cloth.

[Frame]

[0034] As shown in FIG. 1, the frame 100 is mainly constituted of a rectangular main body part 101 extending in the X-axis direction, a first base part 102 supporting one end portion of the main body part 101 with respect to the X-axis direction, and a second base part 103 supporting the other end portion of the main body part 101 with respect to the X-axis direction.

[0035] The first base part 102 contains and holds the maintenance unit 7 therein and supports the one end portion of the main body part 101 from below. The second base part 103 contains and holds the nozzle moistener unit 6 therein and supports the other end portion of the main body part 101 from below.

[0036] The main body part 101 contains and holds a pair of carriage rails 51 and 51 of the main-scanning device 5 (described later) therein with the rails 51 and 51 extending in the X-axis direction. The carriage 4 is carried in the X-axis direction in the main body part 101.

[0037] The first and second base parts 102 and 103 are disposed on both sides of the conveying device 2 with respect to the X-axis direction, and the main body part 101 is disposed over the conveying device 2. This enables the carriage 4 to be carried in the direction perpendicular to the direction in which the conveying device 2 conveys recording media, while the heads 3 on the carriage 4 eject ink to perform image formation.

[Main-scanning device and carriage]

[0038] The main-scanning device 5 includes a pair of rod-like carriage rails 51 and 51 supported so as to extend in the X-axis direction in the main body part 101 of the frame 100. The pair of carriage rails 51 and 51 are disposed over the conveyor belt 23 of the conveying device 2. The box carriage 4 is supported on the carriage rails 51 and 51 so as to move back and forth in the X-axis direction.

[0039] The carriage 4 is a substantially rectangular case with its upper part open. The bottom plate of the carriage 4 is provided with a plurality of heads 3. As shown in FIG. 1, the face of each side of the carriage 4 has arm portions 42 and 42 at its upper part projecting in the direction of both sides with respect to the Y-axis direction. The arm portions 42 and 42 are placed on the respective carriage rails 51 and 51 with linear guides therebetween, enabling the carriage 4 to slide on the carriage rails 51 and 51 in the X-axis direction.

[0040] Linear motors are provided between the carriage rails 51 and 51 and the arm portions 42 and 42 of the carriage 4. Specifically, each of the carriage rails 51 and 51 is provided with a stator of the linear motor, and

each of the arm portions 42 and 42 of the carriage 4 is provided with a movable element. Controlling the current of the coils of the stators allows the carriage 4 to move in the X-axis direction.

[0041] FIG. 2 is a schematic explanatory diagram of the bottom plate 41 of the carriage 4 seen from above. The inkjet recording apparatus 10 has nine heads 3 for each of nine colors: yellow (Y), light magenta (Lm), orange (Or), magenta (M), black (Bk), blue (B1), light black (Lk), cyan (C), and light cyan (Lc). A total of 81 heads 3 are provided on the bottom plate of the carriage 4.

[0042] The head groups of the respective colors, Y, Lm, Or, M, Bk, B1, Lk, C, and Lc, are arranged in this order in the X-axis direction as illustrated, and the nine heads 3 of each head group are arranged in a staggered manner in the Y-axis direction.

[0043] The bottom plate 41 has slit-like openings extending in the Y-axis direction at the positions of the heads 3. The heads 3, which are attached to the bottom plate 41 from above, can eject ink drops through the openings to just below the carriage 4.

[0044] Arranging the nine heads 3 in a staggered manner for each color as described above enables ejection of ink of each color to any position within almost full width of the bottom plate 41 of the carriage 4 with respect to the Y-axis direction.

[Heads]

[0045] FIG. 3 is a cross-sectional view roughly showing the structure of a head 3. The head 3 mainly includes a nozzle plate 31 having a plurality of nozzles 311 to eject ink; a head chip 32 including a plurality of channels 321 to lead ink to the nozzles 311 and a plurality of piezoelectric elements 322 to change the sizes of the channels 321 to eject ink; a circuit board 33 to apply drive voltage to the piezoelectric elements 322 of the head chip 32; and a manifold 34 to introduce ink to the channels 321 of the head chip 32 through the filter 343.

[0046] The nozzle plate 31 is a rectangular flat plate whose flat face is parallel to the X-Y plane and whose long side is parallel to the Y-axis direction with the heads 3 on the carriage 4.

[0047] The nozzle plate 31 has a plurality of through holes, the nozzles 311, arranged in a row in the Y-axis direction.

[0048] The head chip 32 has the shape of a rectangular parallelepiped, and the nozzle plate 31 is attached to the bottom face of the head chip 32. The head chip 32 has a plurality of channels 321 arranged in a row in the Y-axis direction, the positions of the channels 321 coinciding with those of the nozzles 311 of the nozzle plate 31. The channels 321 are ink flow paths vertically penetrating the head chip 32 and can lead the ink in the manifold 34 individually to the respective nozzles 311. A piezoelectric element 322 is provided next to each channel 321. Selectively applying voltage to any piezoelectric element 322 expands and contracts the piezoelectric element

322, enabling ejection of ink from the corresponding nozzle 311.

[0049] The circuit board 33 is provided on the upper face of the head chip 32. The circuit board 33 is connected to a head drive circuit (not shown) with a flexible substrate therebetween and is wired for applying the drive voltage from the head drive circuit to the piezoelectric elements 322 of the head chip 32.

[0050] The circuit board 33 is attached to the manifold 34 so as to cover the open bottom of the manifold 34 and has a rectangular opening so that the ink in the manifold 34 comes toward the channels 321 of the head chip 32.

[0051] The manifold 34 is a hollow rectangular parallelepiped disposed with its long side extending in the Y-axis direction. The bottom of the manifold 34 is open but the circuit board 33 is fitted to the opening to cover it as described above.

[0052] The manifold 34 has a cylindrical first port 341 and second port 342 at its one end portion and the other end portion, respectively, with respect to the Y-axis direction at the upper part of the manifold 34. The ports 341 and 342 communicate with the inside.

[0053] The inside of the manifold 34 is divided into two parts, upper and lower parts, by the filter 343 which strains ink to remove impurity. The upper part is connected to the first and second ports 341 and 342, and the lower part is connected to the head chip 32. The ink supplied from outside into the manifold 34 through the first port 341 or second port 342 is thus strained with the filter 343, goes to the head chip 32, and then is ejected from the nozzles 311.

[Maintenance unit]

[0054] The maintenance unit 7 maintains the heads 3 when recording operation is not performed. The maintenance unit 7 is disposed at one end portion of the carriage rails 51 and 51, a place different from the position of the conveying device 2. Specifically, the maintenance is performed with the carriage 4 at the one end portion of the carriage rails 51 and 51 to face the maintenance unit 7.

[0055] The maintenance unit 7 includes a cleaning device which wipes out the bottom faces of the nozzle plates 31 of the heads 3, and an ink tray 71 (see FIG. 4) which serves as a pan of ink ejected from the target head(s) to be maintained.

[0056] The cleaning device is mainly constituted of a cleaning roller rotatable about the axis extending in the X-axis direction to slidably contact with the bottom faces of the nozzle plates 31 and a roller conveyance mechanism to convey the cleaning roller in the Y-axis direction. The width of the cleaning roller with respect to the X-axis direction is set in such a way that the cleaning roller can wipe out the head groups of three colors among those of nine colors provided on the carriage 4. One and a half round trip of the cleaning roller cleans all the heads 3. Clogging of the nozzles 311 due to ink solidification is thus prevented.

[0057] The ink ejection toward the ink tray 71 for the maintenance is performed not by the drive of the piezo-electric elements 322 of the heads 3 but by the ink supply pressure from the ink supply device 8. The clogging of the ink flow paths in the heads 3 are thus overcome.

[Nozzle moistener unit]

[0058] The nozzle moistener unit 6 is disposed at the other end portion of the carriage rails 51 and 51, a place different from the position of the conveying device 2. Specifically, when recording operation is not performed, the carriage 4 moves to the other end portion of the carriage rails 51 and 51 to face the nozzle moistener unit 6 so that the nozzle moistener unit 6 moistens the nozzles 311 of the heads 3.

[0059] Specifically, the nozzle moistener unit 6 is to come into close contact with the nozzles 311 of the nozzle plates 31 so that the interior of each nozzle is connected to the moistener fluid storage section. The nozzle moistener unit 6 is mainly constituted of the moistener fluid storage section and a mechanism to move the storage section up and down.

[Ink supply device]

[0060] FIG. 4 is a schematic explanatory diagram roughly showing the structure of the ink supply device 8. The inkjet recording apparatus 10 has the ink supply device 8 for each color.

[0061] The ink supply device 8 mainly includes two main tanks 81 and 81 as a first tank to store ink; a sub-tank 82 as a second tank to which ink is supplied from the main tanks 81 and 81; a deaeration device 83 disposed downstream of the sub-tank 82 in the ink supply direction; an intermediate tank 84 disposed downstream of the deaeration device 83 in the ink supply direction as an ink tank to temporarily store ink; a negative pressure forming unit 86 disposed downstream of the intermediate tank 84 in the ink supply direction; and a common flow path 87 to which the first ports 341 of the heads 3 are connected in parallel to supply ink to the heads 3.

[0062] FIG. 4 also shows the ink tray 71 of the maintenance unit 7.

[0063] Each of the two main tanks 81 and 81 is a container with its upper part open to atmosphere and is detachable from the inkjet recording apparatus 10 to be replaced when it gets empty. When one of the two main tanks 81 and 81 is empty or is being replaced, the other main tank 81 can supply ink, and thus the inkjet recording apparatus 10 can avoid interruption of recording operation. A larger number of main tanks 81 may be provided.

[0064] The reference number 815s of FIG. 4 indicates remaining amount sensors to determine whether the ink in the main tanks 81 and 81 has been run out.

[0065] Between the main tanks 81 and 81 and the sub-tank 82, a first ink flow path 811 is provided. One end of the first ink flow path 811 branches off for the main tanks

81 and 81, and the other end is joined and reaches the sub-tank 82. The first ink flow path 811 has tank valves 812 and 812 as a connection switching unit near the main tanks 81 and 81. The tank valves 812 and 812 are solenoid valves switchable between open and closed states of the flow paths.

[0066] The first ink flow path 811 has a filter 813 in the middle portion of the first ink flow path 811 near the sub-tank 82 to remove impurity such as dirt and dust from ink. The first ink flow path 811 has a first fluid supplying pump 814 as a first fluid supplying unit, which is disposed nearer to the sub-tank 82 than the filter 813 is to the sub-tank 82, to supply ink toward the sub-tank.

[0067] The sub-tank 82 is in the shape of a funnel having a sidewall part 821 with its diameter smaller toward the bottom. The top of the sub-tank 82 is covered with a top plate 822.

[0068] The bottom center of the sub-tank 82 is connected to a second ink flow path 823 through which the ink in the sub-tank 82 can be supplied to the deaeration device 83.

[0069] The top plate 822 of the sub-tank 82 is provided with an air open tube 824 to keep the inside of the sub-tank 82 at an atmospheric pressure. The air open tube 824 is provided with a filter 825 to prevent dust and dirt from coming in from outside.

[0070] The tip of the first ink flow path 811 is connected to the top plate 822 of the sub-tank 82 with the tip coming in the sub-tank 82 through the top plate 822. The tip of the first ink flow path 811 comes to such a position as to contact or almost contact the inner face of the sidewall 822 of the sub-tank 82. The ink supplied from the first ink flow path 811 drops to the fluid surface in the sub-tank 82 along the sidewall 822. The upper limit position of the ink surface in the sub-tank 82 is determined by a fluid level monitoring control, described later, and the tip of the first ink flow path 811 supplies ink to the sidewall 822 from a position higher than the upper limit position of the ink surface.

[0071] Since the tip position of the first ink flow path 811 relative to the sub-tank 82 is set as described above, the ink supplied from the first ink flow path 811 always runs down the inner face of the sidewall part 822 of the sub-tank 82 before dropping to the fluid surface. This allows the ink to run gently down along the inclined surface to be collected in the sub-tank 82. Accordingly, when visually recognizable air bubbles enter the ink supplied from the first ink flow path 811, the air bubbles stay at the surface of the ink. The gentle flow of the ink along the inclined surface prevents new air bubbles from generating at the ink surface and from entering the ink.

[0072] Further, since the ink is supplied from the bottom part or deepest part of the sub-tank 82 to the downstream side through the second ink flow path 823, the ink supplied to the downstream side of the sub-tank 82 is free from air bubbles.

[0073] In other words, the sub-tank 82 serves as a defoaming means to defoam the ink.

[0074] In the sub-tank 82, a first fluid level sensor 826 and a second fluid level sensor 827 are provided. The first and second fluid level sensors 826 and 827 determine the upper and lower limit positions of the ink surface, respectively, in the later-described fluid level monitoring control.

[0075] The fluid level sensors 826 and 827 are float sensors having a float and can determine whether the fluid level is higher or lower than the upper or lower limit position based on the level of the float. The fluid level monitoring control is described in detail later.

[0076] The second ink flow path 823, described above, is provided between the sub-tank 82 and the deaeration device 83. The second ink flow path 823 has a non-return valve 828 and a second fluid supplying pump 829 in the middle portion of the flow path 823. The non-return valve 828 prevents ink from returning from the deaeration device 83 to the sub-tank 82. The second fluid supplying pump 829 serves as a second fluid supplying unit to supply ink from the sub-tank 82 to the deaeration device 83.

[0077] The deaeration device 83 includes a deaeration module 831 to which the end of the second ink flow path 823 is connected, a vacuum pump 832 to evacuate air from the deaeration module 831, a vacuum sensor 833 to detect the pressure in the deaeration module 831, and a leak valve 834 which is a solenoid valve to allow the inside of the deaeration module 831 to be open to the atmospheric pressure.

[0078] The deaeration module 831 includes a vacuum case to be evacuated by the vacuum pump 832, and a hollow fiber membrane through which the ink travels inward in the vacuum case. The evacuation vacuums out the gas dissolved in the ink through the hollow fiber membrane.

[0079] The vacuum sensor 833 is a detecting means to determine whether the pressure is reduced to a target pressure at the time of the evacuation. The leak valve 834 is controlled by the control device 9 to open to bring the deaeration module 831 from the vacuum state to the atmospheric-pressure state for the maintenance of the deaeration module 831 when the inkjet recording apparatus 10 is powered off.

[0080] Between the deaeration module 831 and the intermediate tank 84, a third ink flow path 835 is provided. The supply pressure given by the second fluid supplying pump 829 allows ink to be supplied to the intermediate tank 84 through the second and third ink flow paths 823 and 835.

[0081] The intermediate tank 84 is formed of a flexible bag and expands/contracts according to the change in amount of ink stored therein.

[0082] The intermediate tank 84 is provided with a fluid volume sensor 841 to detect the state in which a predetermined amount of ink is stored. At the time of the ink supply from the sub-tank 82, the second fluid supplying pump 829 supplies ink until the fluid volume sensor 841 detects the ink reaching the predetermined amount.

[0083] Between the intermediate tank 84 and the neg-

ative pressure forming unit 86, fourth to seventh ink flow paths 842 to 845 are provided through which ink is supplied. A first three-way switching valve 846, which is a solenoid switching valve, is disposed between the fourth and fifth ink flow paths 842 and 843; a second three-way switching valve 847, which is a solenoid switching valve, is disposed between the fifth and sixth ink flow paths 843 and 844; and a third three-way switching valve 848, which is a solenoid switching valve, is disposed between the sixth and seventh ink flow paths 844 and 845.

[0084] A non-return valve 849, a third fluid supplying pump 850, and a relief valve 851 are provided on the fifth ink flow path 843. The non-return valve 849 permits only the flow in the direction from the first three-way switching valve 846 toward the second three-way switching valve 847. The third fluid supplying pump 850 serves as a fluid supplying unit to supply fluid in the same direction as the direction which the non-return valve 849 permits. The relief valve 851 returns ink to the sub-tank 82 when the pressure exceeds a predetermined pressure on the downstream side of the third fluid supplying pump 850.

[0085] One end of a branching flow path 852 is connected to the middle portion of the sixth ink flow path 844, and the other end of the branching flow path 852 is connected to the first three-way switching valve 846. The control by the control device 9 allows the first three-way switching valve 846 to switch between the state in which the fifth ink flow path 843 is connected to the fourth ink flow path 842 and the state in which the fifth ink flow path 843 is connected to the branching flow path 852.

[0086] The second three-way switching valve 847 is also connected to a return flow path 853 to return ink to the sub-tank 82. The control by the control device 9 allows the second three-way switching valve 847 to switch between the state in which the fifth ink flow path 843 is connected to the sixth ink flow path 844 and the state in which the fifth ink flow path 843 is connected to the return flow path 853.

[0087] The switching controls of the first and second three-way switching valves 846 and 847 are combined and simultaneously performed by the control device 9. Specifically, the control device 9 performs control so as to switch between (i) the connection state for supply to supply ink from the intermediate tank 84 toward the negative pressure forming unit 86 through the fourth, fifth, and sixth ink flow paths 842, 843, and 844 (i.e., the white arrow of FIG. 4) and (ii) the connection state for return to supply ink from the negative pressure forming unit 86 toward the sub-tank 82 through the branching flow path 852, the fifth ink flow path 843, and the return flow path 853 (i.e., the black arrow of FIG. 4).

[0088] Specifically, the ink supply/collection to/from the negative pressure forming unit 86 can be freely and selectively performed using the pumping pressure of the third fluid supplying pump 850.

[0089] The third three-way switching valve 848 is also connected to a bypass flow path 854 to supply ink to the heads without using the negative pressure forming unit

86. The control by the control device 9 allows the switching between the state in which the sixth ink flow path 844 is connected to the seventh ink flow path 845 and the state in which the sixth ink flow path 844 is connected to the bypass flow path 854.

[0090] Specifically, this enables the switching between the state in which the ink supply/collection to/from the negative pressure forming unit 86 can be performed and the state in which the ink supply/collection to/from the heads 3 (or the common flow path 87 in a strict sense) can be performed.

[0091] The negative pressure forming unit 86 is mainly constituted of a rectangular body container 861 with its front side largely open, a film member 862 composed of a flexible resin film to cover the opening of the body container 861, and a spring (not shown) to push the center of the film member 862 from inside of the body container 861 outward.

[0092] The body container 861 is connected to the above-described seventh ink flow path 845 and an eighth ink flow path 863 leading to the common flow path 87 to which all the first ports 341 of the nine heads 3 are connected in parallel.

[0093] The film member 862, whose center is pushed outward by the spring, has a substantially conical shape projecting outward and is in a state of tension.

[0094] When the body container 861 is filled with ink at the same pressure as the atmospheric pressure and then the ink is collected from the body container 861 with the first and second three-way switching valves 846 and 847 in the connection state for return, the insides of the heads 3 are brought into a state of negative pressure lower than the atmospheric pressure through the common flow path 87. If the insides of the nozzles 3 are at the atmospheric pressure, the ink easily comes out of the nozzles 311 and thus easily adheres around the nozzles 311, leading to poor ejection and variation in dot diameter. The purpose of keeping the insides of the heads 3 at the negative pressure is to prevent such problems.

[0095] A target negative pressure can be controlled through the adjustment of the amount of ink to be collected from the body container 861.

[0096] A communication tube 864 is provided at the upper part of the body container 861 of the negative pressure forming unit 86. The communication tube 864 communicates with the inside of the body container 861 and extends upward. A fluid level sensor 865 is attached to the end portion of the communication tube 864 near the body container 861, and a pressure sensor 866 is attached to the upper end portion of the communication tube 864. A branching tube 867 is connected to the middle portion of the communication tube 864. The branching tube 867 horizontally extends, and its one end is open to the atmosphere. An opening valve 868 to open and close the branching tube 867 and an air filter 869 to filter the air are provided in the middle portion of the branching tube 867.

[0097] These are the configuration used to supply ink to the body container 861 and control the pressure to be a predetermined negative pressure. Specifically, ink is supplied to the body container 861 with the opening valve 868 open until the fluid level sensor 865 detects a fluid surface. The opening valve 868 is then closed and the ink is collected from the body container 861 until the pressure sensor 866 indicates a target negative pressure. In this way, the heads 3 are brought into the state of a predetermined negative pressure through the negative pressure forming unit 86.

[0098] The eighth ink flow path 863 extending from the negative pressure forming unit 86 joins the bypass flow path 854 and is connected to the common flow path 87. A protecting valve 871, which is a normally-open solenoid valve, is provided nearer to the negative pressure forming unit 86 than the point where the bypass flow path 854 joins the eighth ink flow path 863 is to the negative pressure forming unit 86.

[0099] The common flow path 87 is a flat hollow container having a substantially isosceles triangular shape (in a strict sense, having the shape of a pentagon obtained by vertically cutting off the both-side portions of the base of a isosceles triangle), when viewed from the front. The common flow path 87 is mounted on the carriage 4 in such a way that the bottom and inner bottom face of the common flow path 87 are horizontal.

[0100] The eighth ink flow path 863 is connected to the portion, equivalent to the vertex of the isosceles triangle, of the common flow path 87; and the first ports 341 of the nine heads 3 for the same color are connected in parallel to the portion, equivalent to the base of the isosceles triangle, of the common flow path 87.

[0101] The common flow path 87 has an inner space substantially having the shape of a three-dimensional triangle, the same as its external shape. Ink passes through the inner space of the common flow path 87. Ink is supplied from the position of the vertex and thus the ink is evenly supplied to the heads 3 connected to the portions of the base without a large bias.

[0102] The common flow path 87 does not necessarily have to be substantially isosceles triangular in external shape but may have another external shape as long as the inner space, to which ink is to be supplied, is substantially isosceles triangular in shape when viewed from the front.

[0103] A waste fluid flow path 872 as a discharge flow path leading to a waste fluid tank (not shown) is connected to a place near the vertex of the common flow path 87. The waste fluid flow path 872 is provided with a waste fluid valve 873, which is a normally-closed solenoid valve. When the common flow path 87 is filled with ink, the waste fluid valve 873 is opened to discharge ink through the waste fluid flow path 872 to discharge air bubbles. The waste fluid flow path 872 is connected to the vertex or the upper end portion of the common flow path 87. When the common flow path 87 is filled with ink and ink is further supplied thereto, therefore, air bubbles float up in the

common flow path 87 and effectively go out along with the ink. This can remove air bubbles, which are the cause of poor ink ejection, and enables stable ejection.

[0104] FIG. 5 is an explanatory diagram showing the connection state between the common flow path 87 and the heads 3. As shown in FIGS. 4 and 5, the common flow path 87 is connected to the first ports 341 of the heads 3, with a recording operation valve 874 between each first port 341 and the common flow path 87. The recording operation valves 874 are normally-open solenoid valves.

[0105] The second ports 342 of the heads 3 are connected in parallel to a common waste fluid flow path 876, with a normally-closed maintenance valve 875 between each second port 342 and the common waste fluid flow path 876. The common waste fluid flow path 876 joins the waste fluid flow path 872 downstream of the waste fluid valve 873 and is connected to the waste fluid tank.

[0106] The main purpose of discharging ink through the waste fluid flow path 872 is to discharge air bubbles from the common flow path 87 and thus only the waste fluid flow path 872, not joining the common waste fluid flow path 876, may be connected to the sub-tank 82 for recycling the ink. In this case, the common waste fluid flow path 876 alone is connected to the waste fluid tank.

[Control device]

[0107] FIG. 6 is a block diagram showing the control system of the ink supply device 8. The control device 9 shown in FIG. 6 controls the overall inkjet recording apparatus 10, but only the configuration of the ink supply device 8 is shown here and the other configuration is omitted. For a plurality of components, only one of them is shown.

[0108] The control device 9 controls not only the ink supply device 8 but also the driving for each component of the inkjet recording apparatus 10, such as conversion of data of an image to be recorded on a recording medium inputted from an external device into the data corresponding to the nozzles 311 of the heads 3.

[0109] As shown in FIG. 6, the control device 9 is constituted of a general-purpose computer in which a CPU 91, a ROM 92, a RAM 93, a not-shown input/output interface, and the like are connected to a bus.

[0110] The first to third fluid supplying pumps 814, 829, and 850; the vacuum pump 832; the tank valves 812; the leak valve 834; the first to third three-way switching valves 846, 847, and 848; the opening valve 868; the protecting valve 871; the waste fluid valve 873; the recording operation valves 874; and the maintenance valves 875 are connected to the control device 9 to be controlled by the control device 9.

[0111] Further, the remaining amount sensors 815; the first and second fluid level sensors 826 and 827; the fluid volume sensor 841; the fluid level sensor 865; the vacuum sensor 833; and the pressure sensor 866 are also connected to the control device 9. Various types of de-

tection signals are inputted from these sensors to the control device 9.

[0112] Still further, an input operation unit 94 through which an operator inputs instructions to, for example, execute various types of operations; a display unit 95 to display various types of information such as error information; and the like are also connected to the control device 9.

[0113] In accordance with the detection information, the control device 9 performs control for the above-mentioned components, such as the fluid level monitoring control for the sub-tank 82 and the maintenance control for the heads 3.

[Liquid level monitoring control]

[0114] The fluid level monitoring control for the sub-tank 82 to be performed by the control device 9 is described in detail on the basis of the flowchart of FIG. 7.

[0115] The fluid level monitoring control is a control for supplying ink from a main tank 81 to the sub-tank 82 and keeping a constant amount of ink in the sub-tank 82. The fluid level monitoring control is repeatedly performed on a predetermined cycle.

[0116] The fluid level monitoring control is on the assumption that any one of the tank valves 812 of the main tanks 81 and 81 is open and that the other tank valve 812 is closed.

[0117] First, the control device 9 initializes a timer counter for determining whether the main tank 81 currently connected to the sub-tank 82 is empty (Step S1).

[0118] The control device 9 then determines whether the ink in the sub-tank 82 reaches the level to be detected by the first fluid level sensor 826 indicating that the sub-tank 82 is full, using the first fluid level sensor 826 (Step S3).

[0119] When it is determined that the ink reaches the level to be detected by the first fluid level sensor 826, the amount of ink in the sub-tank 82 reaches a target amount and thus the control device 9 ends the fluid level monitoring control.

[0120] When determining that the ink does not reach the level to be detected by the first fluid level sensor 826, the control device 9 starts counting with the timer for determining whether the main tank 81 is empty, and actuates the first fluid supplying pump 814 to execute ink supply from the main tank 81 to the sub-tank 82 (Step S5).

[0121] Next, the control device 9 determines whether the ink in the sub-tank 82 reaches the level to be detected by the second fluid level sensor 827 indicating that the ink is close to empty, using the second fluid level sensor 827 (Step S7).

[0122] When determining that the ink reaches the level to be detected by the second fluid level sensor 827, the control device 9 determines whether a predetermined time for supplying fluid has elapsed based on the time-keeping with the timer (Step S9).

[0123] If the predetermined time for supplying fluid has

not elapsed based on the timekeeping with the timer, the control device 9 returns the process to Step S3 and determines whether the sub-tank 82 is filled up.

[0124] The time for supplying fluid in the determination at Step S9 is set to a time enough to fill up the sub-tank 82 by the pumping capacity of the first fluid supplying pump. In other words, if the sub-tank 82 is not filled up after the passage of the time for supplying fluid, it is presumed that the main tank 81 is already empty.

[0125] The control device 9 thus stops the drive of the first fluid supplying pump 814 (Step S11), determines that the main tank 81 is empty (Step S13), closes the tank valve 812 which has been open, and opens the other tank valve 812 to switch main tanks for ink supply to the sub-tank 82 (Step S15). At this time, the control device 9 may control the display unit 95 to announce that one of the main tanks 81 is empty.

[0126] After switching the main tanks 81, the control device 9 returns the process to Step S1 and resumes the ink supply to the sub-tank 82.

[0127] If the sub-tank 82 is determined to be empty with the second fluid level sensor 827 at Step S7 even though the first fluid supplying pump 814 is pumping (Step S7: NO), both the main tanks 81 and 81 are empty and all the ink in the main tanks 81 and 81 and the sub-tank 82 is being exhausted. The control device 9 thus stops all the recording operation of the inkjet recording apparatus 10 to prevent recording operation defect during the recording operation. At this time, the control device 9 may control the display unit 95 to announce stoppage due to error or to warn that the ink is empty.

[Maintenance control (in the case in which one/some of the heads is/are to be maintained)]

[0128] The maintenance control for the heads 3 to be performed by the control device 9 is described in detail on the basis of the flowchart of FIG. 8. Here, it is assumed that ejection tests are done in advance for all the heads 3 to identify the head(s) 3 which need(s) maintenance, and that the target head(s) 3 to be maintained is (are) already inputted through the input operation unit 94.

[0129] It is also assumed that the carriage 4 stands by just above the maintenance unit 7.

[0130] First, the control device 9 switches the first and second three-way switching valves 846 and 847 to the connection state for supply (i.e., the connection indicated by the white arrow of FIG. 4), and switches the third three-way switching valve 848 so that the sixth ink flow path 844 is connected to the bypass flow path 854 (Step S21).

[0131] Further, the control device 9 performs control so as to open the waste fluid valve 873 for the common flow path 87, close the protecting valve 871, and close the recording operation valves 874 for all the heads 3 (Step S23).

[0132] The control device 9 executes the ink fluid supplying control (Step S25).

[0133] The fluid supplying control is described on the

basis of the flowchart of FIG. 9.

[0134] At the time of fluid supplying, the control device actuates the third fluid supplying pump 850 (Step S251), determines whether a predetermined actuation time T1 has elapsed during the actuation (Step S253), and allows the third fluid supplying pump 850 to continue actuating until the actuation time T1 has elapsed.

[0135] The actuation of the third fluid supplying pump 850 allows the ink in the intermediate tank 84 to be directly supplied to the common flow path 87 without passing through the negative pressure forming unit 86. At this time, the recording operation valves 874 for all the heads 3 are closed, and the maintenance valves 875 are normally-closed valves. The common flow path 87 is thus filled up with ink without supplying ink to the heads 3. When the common flow path 87 is filled up with ink, surplus ink is discharged through the waste fluid flow path 872. Continuation of such supply for a given time allows air bubbles to come up in the common flow path 87 and to be discharged through the waste fluid flow path 872.

[0136] When the actuation time T1 has elapsed, control device 9 stops the third fluid supplying pump 850 (Step S255) and waits until a standby time T2 has elapsed. This allows air bubbles, which appeared when ink flowed into the common flow path 87, to come up in the common flow path 87 to be collected.

[0137] When the standby time T2 has elapsed, the control device 9 determines whether the number of repeats of ink supply and standby has reached a predetermined target number N (Step S259).

[0138] If the number has not reached the target number, the control device 9 returns the process to Step S251 and performs the ink supply and standby again.

[0139] The actuation time T1, the standby time T2, and the target number N may be set in advance through the input operation unit 94 for the control device 9. The target repeat number N is preferably set to two or more so that the air bubbles which have come up in the common flow path 87 during the standby can be discharged at the time of the next ink supply.

[0140] The explanation returns to FIG. 8.

[0141] After the fluid supplying control, the control device 9 performs control so as to close the waste fluid valve 873 for the common flow path 87 (Step S27) and to open the recording operation valve (s) 874 and the maintenance valve (s) 875 for the target head(s) 3 to be maintained (Step S29).

[0142] The fluid supplying control is then executed again (Step S31). The actuation time T1, the standby time T2, and the target number N at this time may be set to the values identical to or different from those at Step S25.

[0143] At the time of the ink supply in this case, ink is supplied from the common flow path 87 to the target head(s) 3 to be maintained through the first port (s) 341. The supplied ink is discharged through the second port(s) 342 to the common waste fluid flow path 876, and part of the supplied ink is ejected through the nozzles 311 of

the head(s) 3 to the ink tray 71.

[0144] At the completion of the second fluid supplying control, the control device 9 closes the maintenance valve(s) 875 for the target head(s) 3 to be maintained (Step S33).

[0145] The third fluid supplying control is then executed (Step S35). The actuation time T1, the standby time T2, and the target number N at this time, too, may be set to the values identical to or different from those at Step S25 or S31.

[0146] At the time of the ink supply in this case, ink is supplied from the common flow path 87 to the target head(s) 3 to be maintained through the first port (s) 341, and is ejected through the nozzles 311 to the ink tray 71. At this time, all the ink supply pressure acts on the ejection from the nozzles 311 and thereby foreign substance and the like can be pushed out of clogged nozzles 311, eliminating clogging.

[0147] At the completion of the third fluid supplying control, the control device 9 opens all the recording operation valves 874 for the heads 3 except the target head(s) 3 to be maintained (Step S37), opens the protecting valve 871, and switches the third three-way switching valve 848 to the state in which the sixth ink flow path 844 is connected to the seventh ink flow path 845 (Step S39).

[0148] The control device 9 then executes the control for adjustment of back pressure of the negative pressure forming unit (Step S41), further executes the wiping control of the heads 3, and ends the maintenance control (Step S43).

[0149] The control for adjustment of back pressure of the negative pressure forming unit is described in detail on the basis of the flowchart of FIG. 10.

[0150] First, the control device 9 performs switching to open the opening valve 868 and close the protecting valve 871 (Step S411).

[0151] The control device 9 then sets the current pressure of the pressure sensor 866 of the negative pressure forming unit 86 to the atmospheric pressure (Step S412).

[0152] The control device 9 then starts actuating the third fluid supplying pump 850 (Step S413) and determines whether the ink supplied to the body container 861 of the negative pressure forming unit 86 reaches the fluid level sensor 865 disposed at the upper end part of the body container 861 (Step S414).

[0153] If the ink does not reach the upper end part of the body container 861, the control device 9 continues the ink supply to the body container 861; and if the ink reaches the upper end part of the body container 861, the control device 9 stops the third fluid supplying pump 850 (Step S415).

[0154] After that, the control device 9 performs control to close the opening valve 868 (Step S416) and to switch the first and second three-way switching valves 846 and 847 to the connection state for return (i.e., the black arrow of FIG. 4) (Step S417). The control device 9 then actuates the third fluid supplying pump 850 again (Step

S418), and the ink in the body container 861 of the negative pressure forming unit 86 is discharged. As a result, the internal pressure of the body container 861 decreases.

[0155] The negative pressure value suitable for ink ejection from the heads is determined in advance. When the pressure sensor 866 detects that the pressure has reduced to the negative pressure value suitable for ink ejection (Step S419), the control device 9 stops the third fluid supplying pump 850 (Step S420).

[0156] The control device 9 then opens the protecting valve 871 (Step S421), thereby connecting the negative pressure forming unit 86 to the heads 3, with the eighth ink flow path 863 and the common flow path 87 in between. As a result, the interiors of the heads 3 have the same negative pressure as the interior of the negative pressure forming unit 86.

[0157] After that, the control device 9 performs control to switch the first and second three-way switching valves 846 and 847 to the connection state for supply (i.e., the white arrow of FIG. 4) (Step S422), and ends the control for adjustment of back pressure of the negative pressure forming unit.

[0158] The wiping control is described on the basis of the flowchart of FIG. 11. In the wiping control, the nozzles 311 and their periphery are wiped out for all the heads 3 on the carriage 4.

[0159] The nozzles 311 are wiped out in such a way that the wiping roller is driven to rotate around its axis extending in the X-axis direction so that the wiping roller is conveyed in the Y-axis direction on the lower faces of the nozzle plates 31.

[0160] Since the inkjet recording apparatus 10 is provided with nine heads 3 for each of the nine colors on the carriage 4, the area to be wiped is very large. If the wipe is to be done by a single one-way conveyance of the wiping roller, the wiping roller has to be long in the direction of its rotation axis. This may cause the roller to easily bend and may fail to perform effective wipe.

[0161] In view of this, the wiping roller has a width substantially identical to the width of the heads 3 for three adjacent colors with respect to the X-axis direction so that the wiping roller wipes the nozzles of all the heads 3 for the nine colors in three travels.

[0162] The control for the operation is described below.

[0163] First, the control device 9 makes a one-way (outward) conveyance of the wiping roller from its standby position while rotating the wiping roller (Step S431). The wiping roller thus wipes the heads 3 for three colors.

[0164] Next, the control device 9 moves the carriage 4 by the same distance as the width of the three-color heads 3 with respect to the X-axis direction (Step S433), and makes a one-way (homeward) conveyance of the wiping roller while rotating the wiping roller (Step S435). The wiping roller thus wipes the heads 3 for the next three colors.

[0165] The control device 9 further moves the carriage 4 by the same distance as the width of the three-color

heads 3 with respect to the X-axis direction (Step S437), and makes a one-way (outward) conveyance of the wiping roller while rotating the wiping roller (Step S439). The wiping roller thus wipes the heads 3 for the last three colors.

[0166] The wipes are repeated a predetermined number of times. When completing the wipes for the nine colors, the control device 9 compares the number of wipes which have been made currently with the predetermined repeat number (Step S441). If the current number of wipes has not reached the predetermined repeat number, the control device 9 returns the process to Step S431 and starts the wiping operation again.

[0167] If the current number of wipes coincides with the predetermined repeat number, the control device 9 ends the wiping control.

[0168] FIG. 12A is a chart illustrating the states of recovery from clogging of the nozzles 311 in the fluid supplying control at Step S35 of the maintenance control shown in FIG. 8. Specifically, the chart illustrates the states of recovery from clogging of the nozzles 311 obtained when a supply pressure for supplying fluid is changed in a stepwise fashion while the recording operation valve(s) 874 connected to the target head(s) 3 to be maintained is (are) open and the maintenance valve(s) 875 connected to the target head(s) 3 to be maintained is (are) closed. The ink supply pressure is controlled through PWM control for a motor, a drive source of the third fluid supplying pump 850.

[0169] As shown in the drawing, the supply pressure of 10 [kPa] does not cause poor ejection but fails to make a full recovery, the supply pressure of 20 [kPa] allows good ejection, and the supply pressures of 30 [kPa] and 40 [kPa] makes a recovery allowing better ejection. These results show that the ink supply pressure of 30 [kPa] or more is preferable for the maintenance of the nozzles 311 in order to allow the nozzles 311 to recover from clogging.

[0170] FIG. 12B is a chart illustrating the states of removal of air bubbles in the fluid supplying control at Step S31 of the maintenance control shown in FIG. 8. Specifically, the chart illustrates the states of removal of air bubbles obtained when a supply pressure for supplying fluid is changed in a stepwise fashion while both the recording operation valve(s) 874 and the maintenance valve(s) 875 connected to the target head(s) 3 to be maintained are open.

[0171] As shown in the drawing, the supply pressure of 3 [kPa] fails to fully discharge air bubbles from the heads 3, the supply pressures of 4 [kPa] and 5 [kPa] allow some of the air bubbles to be discharged but tolerate air bubbles remaining in the heads 3 to an unsatisfactory extent, the supply pressures of 7 [kPa] and 9 [kPa] allow satisfactory discharge of air bubbles from the heads 3, and the supply pressure of 10 [kPa] allows more satisfactory discharge of air bubbles from the heads 3. These results shows that the ink supply pressure of 7 [kPa] or more is preferable for the maintenance in order

to discharge air bubbles from the heads 3.

[Maintenance control (in the case in which all of the heads are to be maintained)]

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[0172] Next, the maintenance control for all the heads 3 to be performed by the control device 9 is described in detail on the basis of the flowchart of FIG. 13.

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[0173] The control device 9 brings the first and second three-way switching valves 846 and 847 into the connection state for supply (i.e., the connection indicated by the white arrow of FIG. 4) and connects the third three-way switching valve 848 to the bypass flow path 854, with the carriage 4 on standby above the maintenance unit 7 (Step S51).

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[0174] The control device 9 opens the waste fluid valve 873 for the common flow path 87, closes the protecting valve 871, and closes the recording operation valves 874 for all the heads 3 (Step S53).

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[0175] The control device 9 then executes the ink fluid supplying control (see FIG. 9) (Step S55) and discharges air bubbles from the common flow path 87 along with ink.

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[0176] At the completion of the fluid supplying control, the control device 9 closes the waste fluid valve 873 for the common flow path 87 (Step S57) and opens the recording operation valves 874 and the maintenance valves 875 for all the heads 3 (Step S59).

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[0177] The control device 9 then executes the second fluid supplying control (Step S61) and discharges air bubbles and impurity etc., if any, from the heads 3 to the outside through the nozzles 311 and the second ports 342.

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[0178] At the completion of the fluid supplying control, the control device 9 closes the maintenance valves 875 for all the heads 3 (Step S63).

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[0179] The control device 9 then executes the control for adjustment of back pressure of the negative pressure forming unit (see FIG. 10) (Step S65), further executes the wiping control for the heads 3 (see FIG. 11), and ends the maintenance control (Step S67).

[Technical effects of embodiments of invention]

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[0180] The inkjet recording apparatus 10 includes nine heads 3 for the same color. The manifold 34 of each head 3 has the first and second ports 341 and 342 each communicating with the inside of the manifold 34. The flow paths connected to the first and second ports 341 and 342 are provided with a recording operation valve 874 and a maintenance valve 875, respectively, for which opening/closing control is performed by the control device 9.

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[0181] The control device 9 thus can individually open and close each of the first ports 341 and second ports 342 for any head 3. This enables recovery from clogging by discharging impurity from the heads 3 and enables discharge of air bubbles for only one/some of the heads 3, i. e., target head (s) 3 to be maintained.

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[0182] As a result, ink consumption for maintenance can be reduced.

[0183] Since ink consumption is reduced without collecting the ink used for the maintenance, each head does not have to have a filter to collect ink and the need for inspecting filters is eliminated.

[0184] Further, maintaining only one/some target head(s) 3 largely shortens the required time compared to the case of maintaining all the heads connected in series.

[0185] Further, since the inkjet recording apparatus 10 includes the common flow path 87 to which the heads 3 are connected in parallel, air bubbles and impurity in a head 3 do not move to another head 3 unlike the case of a plurality of heads connected in series. The common flow path 87 also allows pressure adjustment of all the heads 3 collectively at one time, for example.

[0186] In the case in which the waste fluid flow path 872 is provided to discharge ink from the common flow path 87, air bubbles generated in the common flow path 87 can be easily discharged through the waste fluid flow path 872.

[0187] Further, providing the negative pressure forming unit 86 and the bypass flow path 854 can avoid the effects of a high pressure when a pressure higher than usual is applied to any of the heads 3 at the time of maintenance. Specifically, closing the protecting valve 871 and the third three-way switching valve 848 provided ahead of and behind the negative pressure forming unit 86, respectively, can avoid the effects of such a high pressure. This can protect the negative pressure forming unit 86.

[Others]

[0188] In the above-described embodiments, the common flow path 87 is like a flat plate having a substantially isosceles triangular shape when viewed from the front, but the shape is not limited thereto.

[0189] FIGS. 14A to 14C show modifications of the common flow path 87. A common flow path 87A of the modifications has the shape of a rectangle, when viewed from the front, whose long side is parallel with the Y-axis direction. The common flow path 87A, which is a hollow flow path, has the shape of a rectangular parallelepiped as a whole and the inner space of the common flow path 87A has the same shape as its external shape.

[0190] Unlike the above-described common flow path 87, the common flow path 87A has a flat uppermost face. The waste fluid flow path 872 is connected to the common flow path 87A to be substantially at the same level as the inner upper face of the common flow path 87A and allows discharge of air bubbles gathering at the uppermost part of the common flow path 87A at the time of maintenance.

[0191] FIGS. 14A to 14C show the cases in which the connection position of an eighth ink flow path 863 to supply ink to the common flow path 87 is the right end, the left end, and the center, respectively, of the common flow

path 87A. Such a common flow path 87A, having a rectangular shape when viewed from above, allows selection of any connection position of the eighth ink flow path 863.

INDUSTRIAL APPLICABILITY

[0192] The present invention has applicability in the field of inkjet recording apparatuses to eject ink with a plurality of heads for one color.

REFERENCE NUMERALS

[0193]

3	head
9	control device (control unit)
10	inkjet recording apparatus
34	manifold
341	first port
342	second port
8	ink supply device
81	main tank (first tank)
811	first ink flow path
812	tank valve (connection switching unit)
814	first fluid supplying pump (first fluid supplying unit)
82, 82A and 82B	sub-tank (second tank)
829	second fluid supplying pump (second fluid supplying unit)
83	deaeration device
84	intermediate tank (ink tank)
848	third three-way switching valve (valve)
850	third fluid supplying pump (fluid supplying unit)
854	bypass flow path
86	negative pressure forming unit
87	common flow path
871	protecting valve (valve)
872	waste fluid flow path (discharge flow path)
873	waste fluid valve (valve)
874	solenoid valve for recording operation (valve)
875	maintenance valve (valve)

Claims

1. An inkjet recording apparatus comprising:

a plurality of heads to eject ink of the same color onto a recording medium;
an ink tank to store ink to be supplied to the heads; and
a fluid supplying unit to supply ink from the ink

tank toward the heads, wherein
 each of the heads includes a manifold to be filled
 with ink, and a first port and a second port each
 communicating with the manifold;
 an ink flow path is connected to each of the first 5
 and second ports of each of the heads, the ink
 flow path being provided with an open/close
 switchable valve; and
 a control unit is provided to individually control
 opening and closing of the valve for each of the 10
 first and second ports of each of the heads.

2. The inkjet recording apparatus according to claim 1,
 further comprising a common flow path to which the
 first ports of all the heads are connected in parallel, 15
 with the valve between each of the first ports and the
 common flow path, wherein
 ink is supplied to the heads through the common flow
 path.

3. The inkjet recording apparatus according to claim 2,
 further comprising:

a discharge flow path connected to the common
 flow path to discharge ink from the common flow 25
 path; and
 an open/close switchable valve provided on the
 discharge flow path, wherein
 the control unit controls opening and closing of
 the valve on the discharge flow path. 30

4. The inkjet recording apparatus according to any one
 of claims 1 to 3, further comprising:

a negative pressure forming unit disposed on an 35
 ink flow path between the ink tank and the heads,
 the negative pressure forming unit keeping the
 heads at a negative pressure lower than an at-
 mospheric pressure;
 a bypass flow path to supply ink without using 40
 the negative pressure forming unit; and
 open/close switchable valves provided ahead of
 and behind the negative pressure forming unit,
 respectively, to shut off a pressure for the ink
 supply. 45

50

55

FIG.1

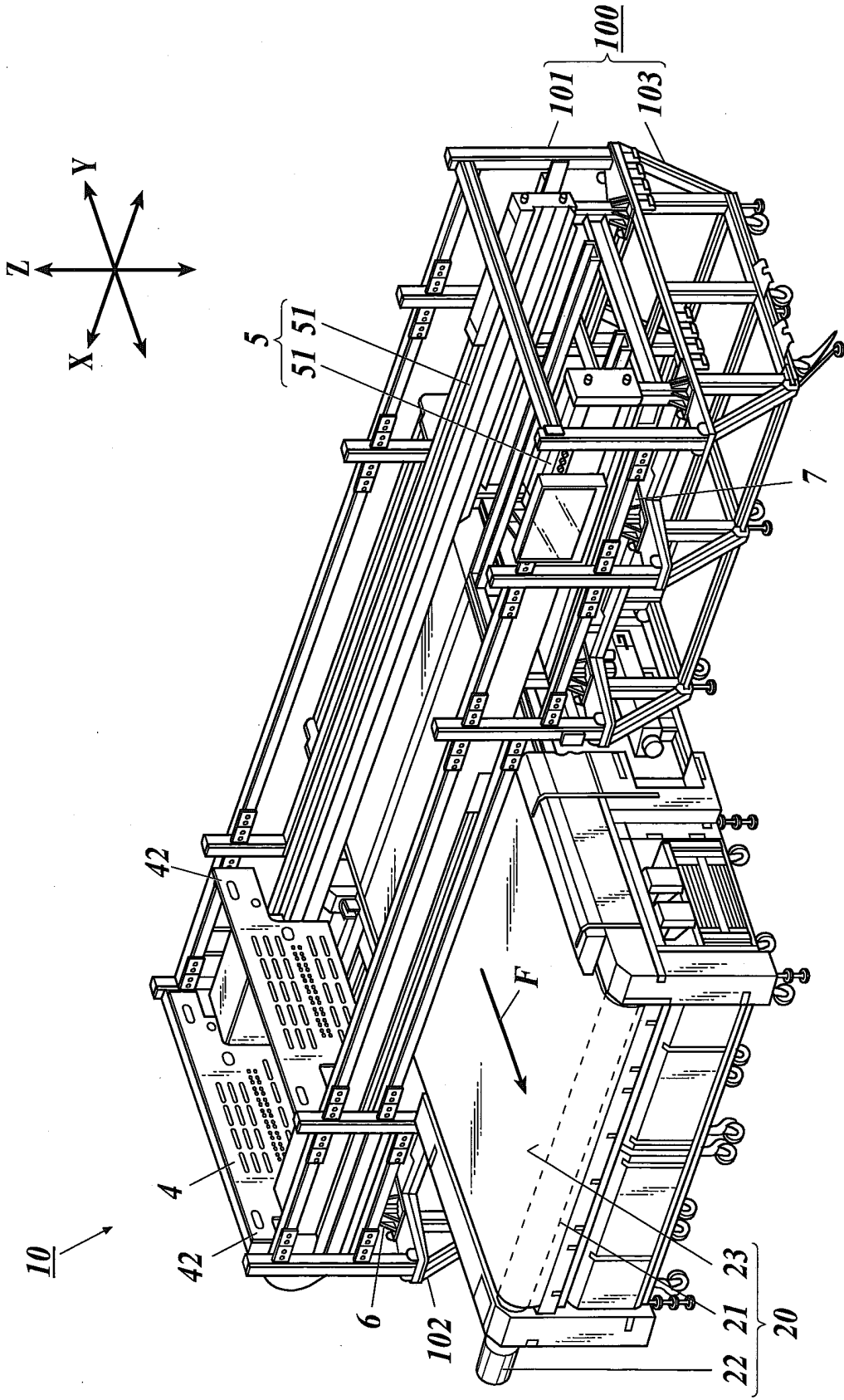


FIG.2

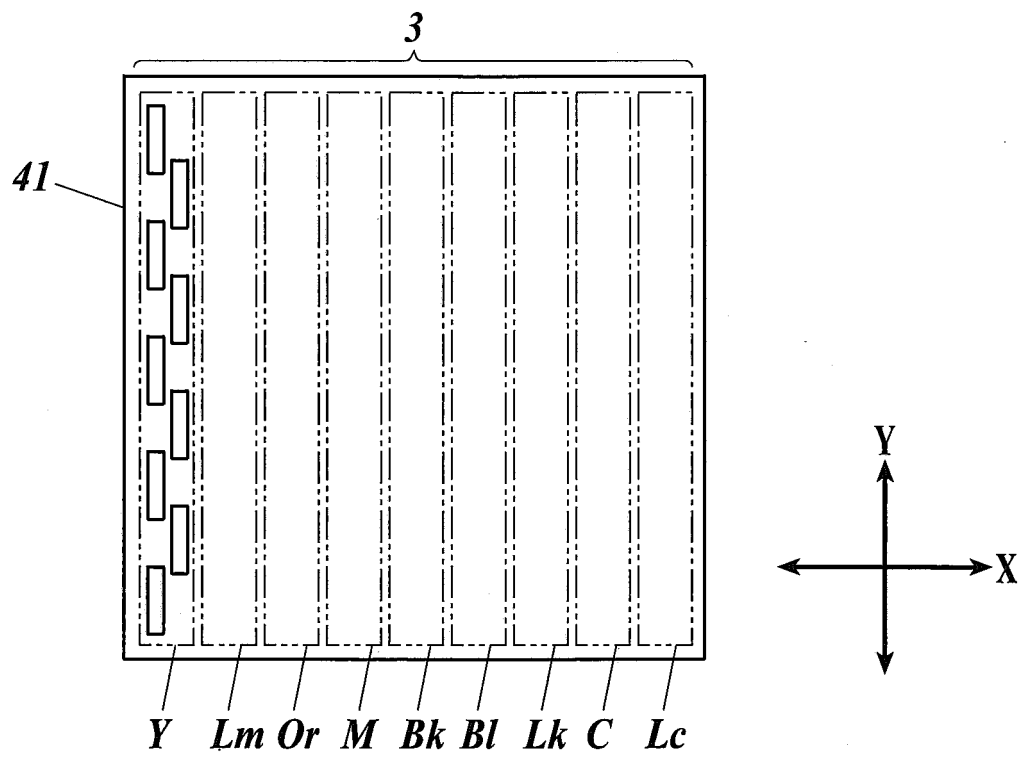


FIG.3

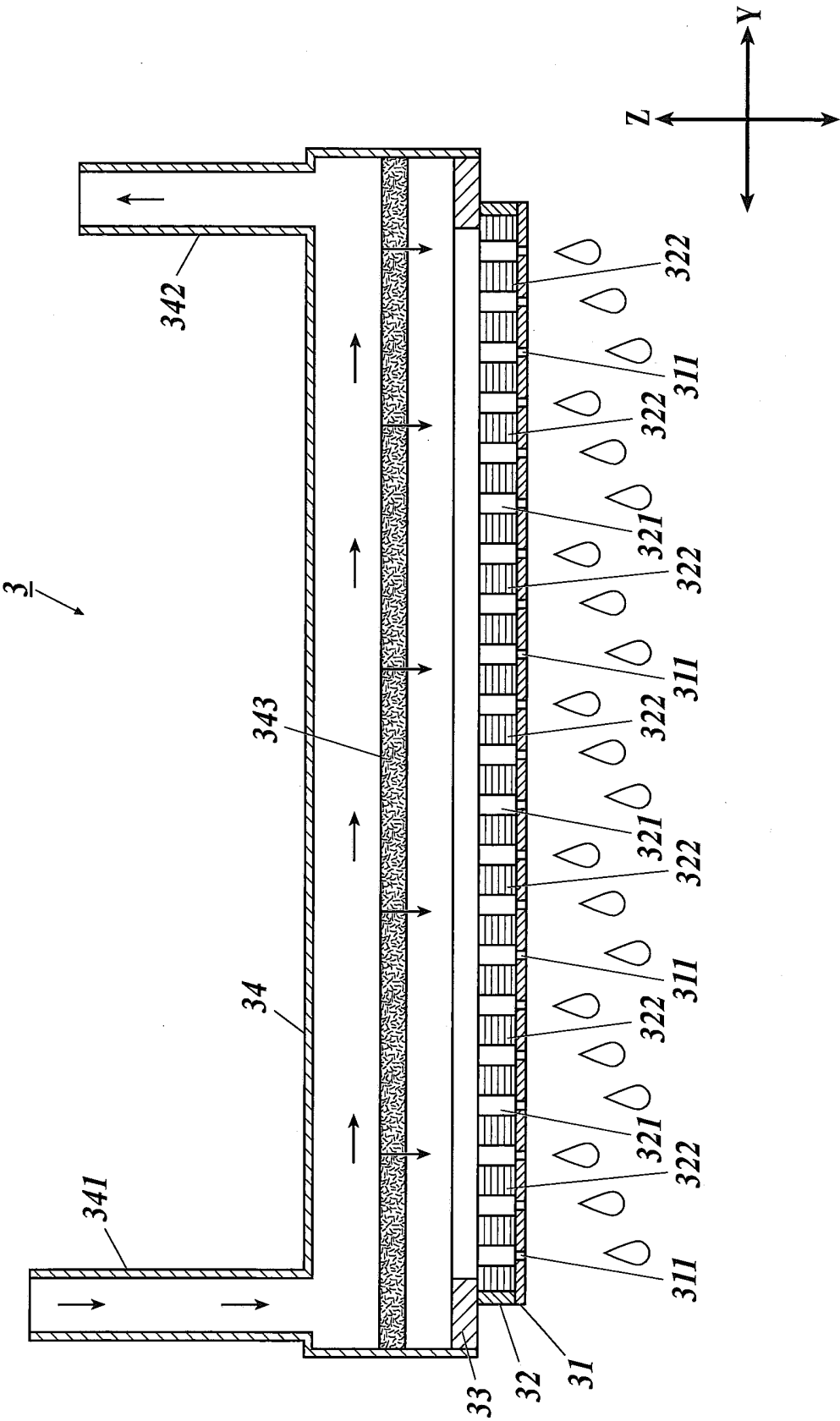


FIG. 4

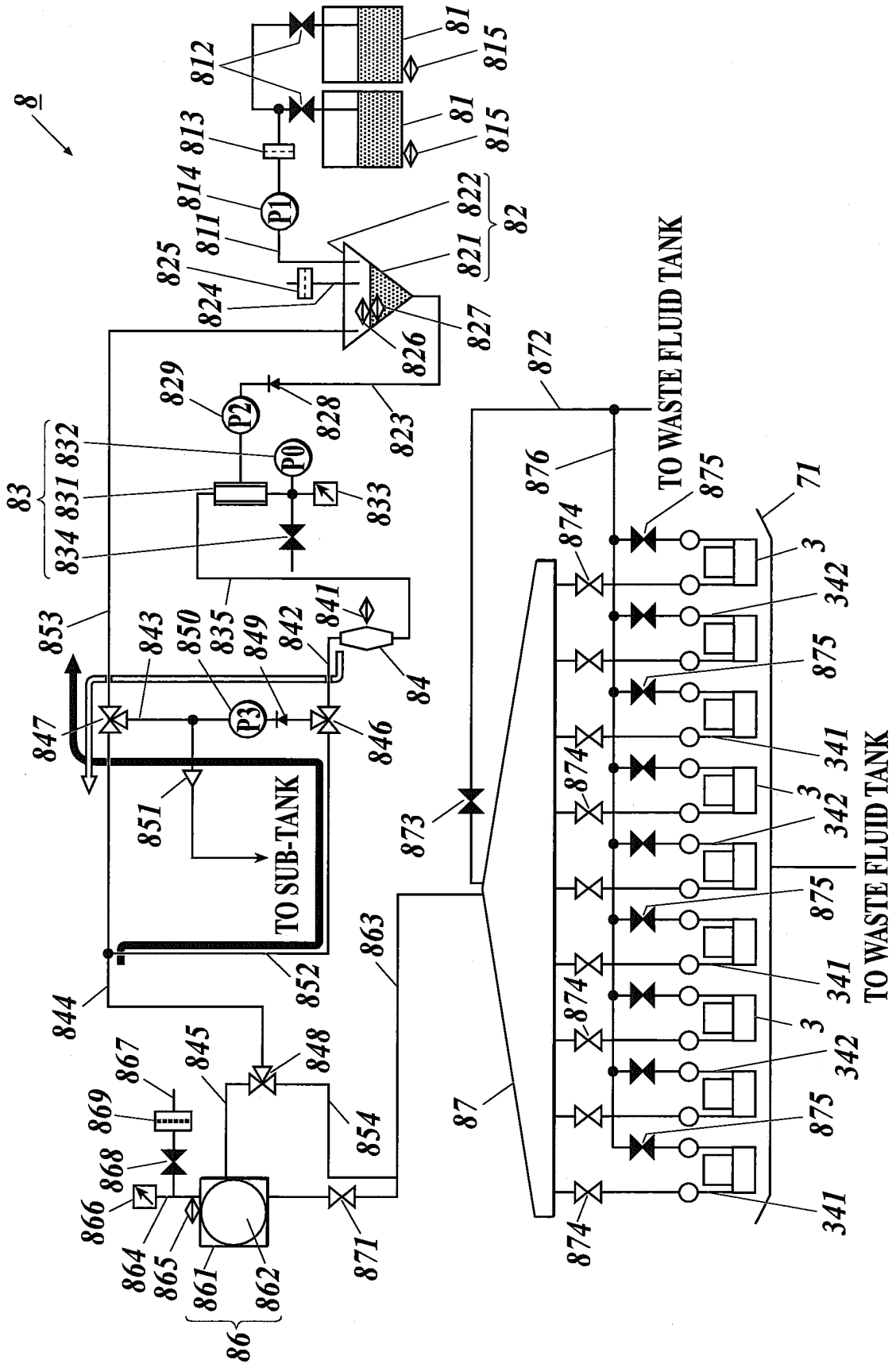


FIG. 5

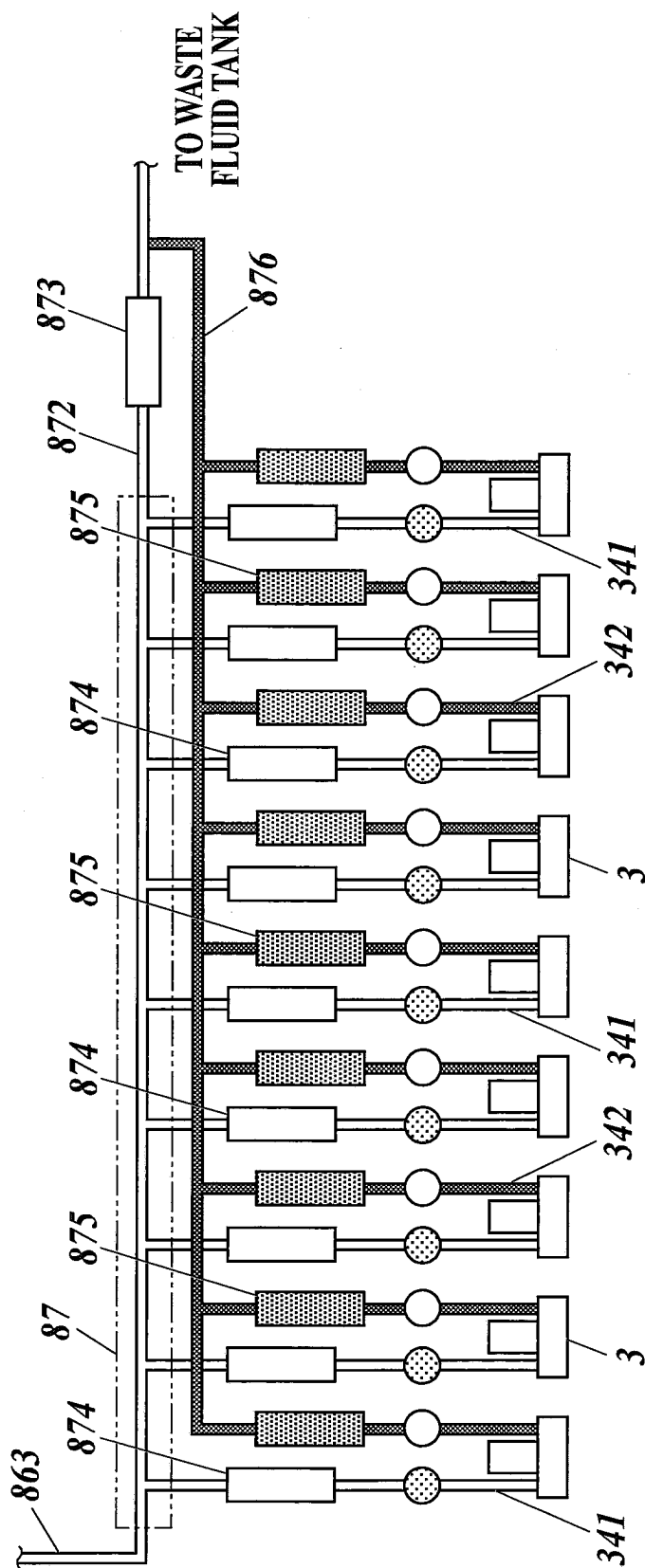


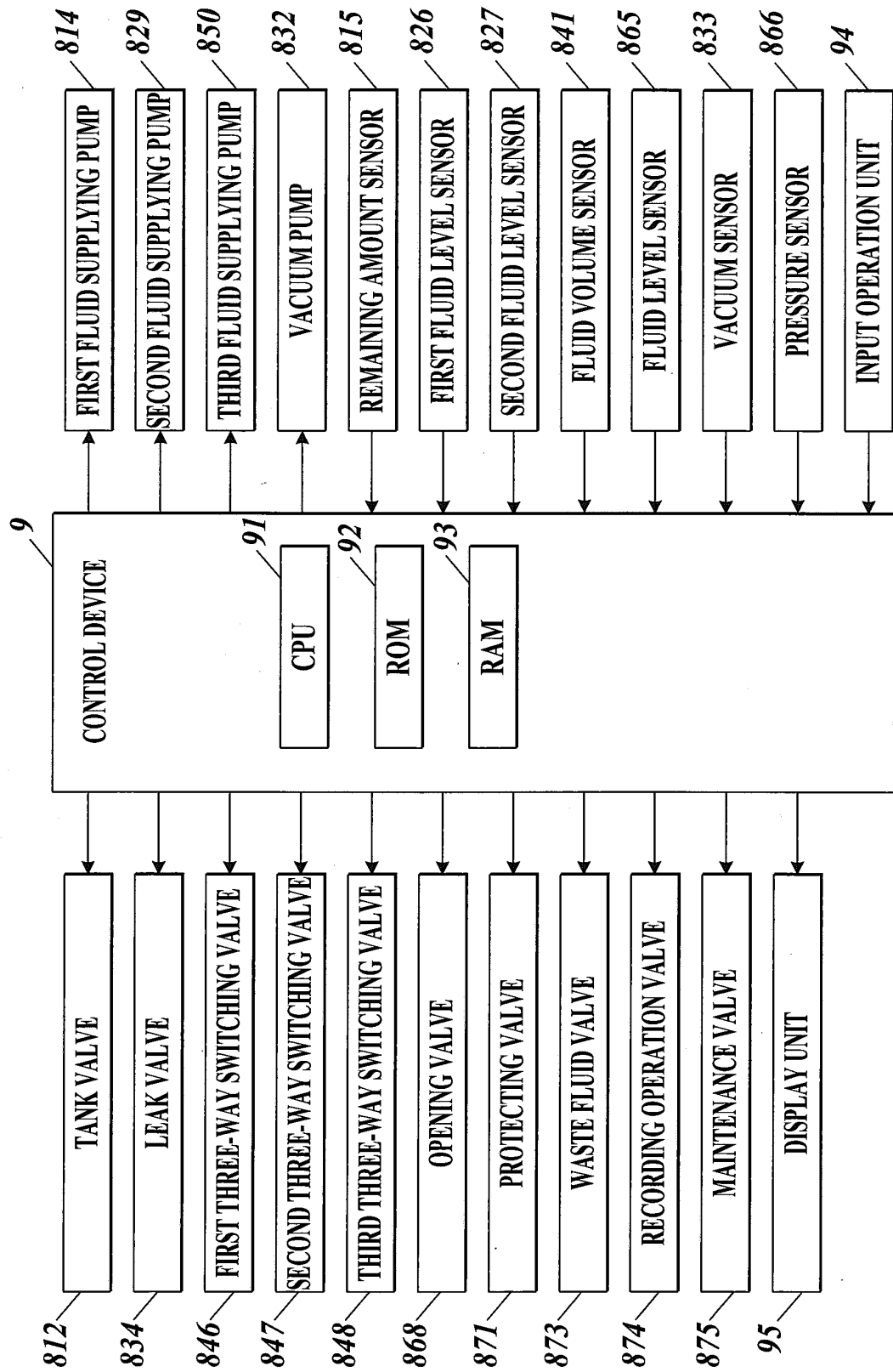
FIG. 6

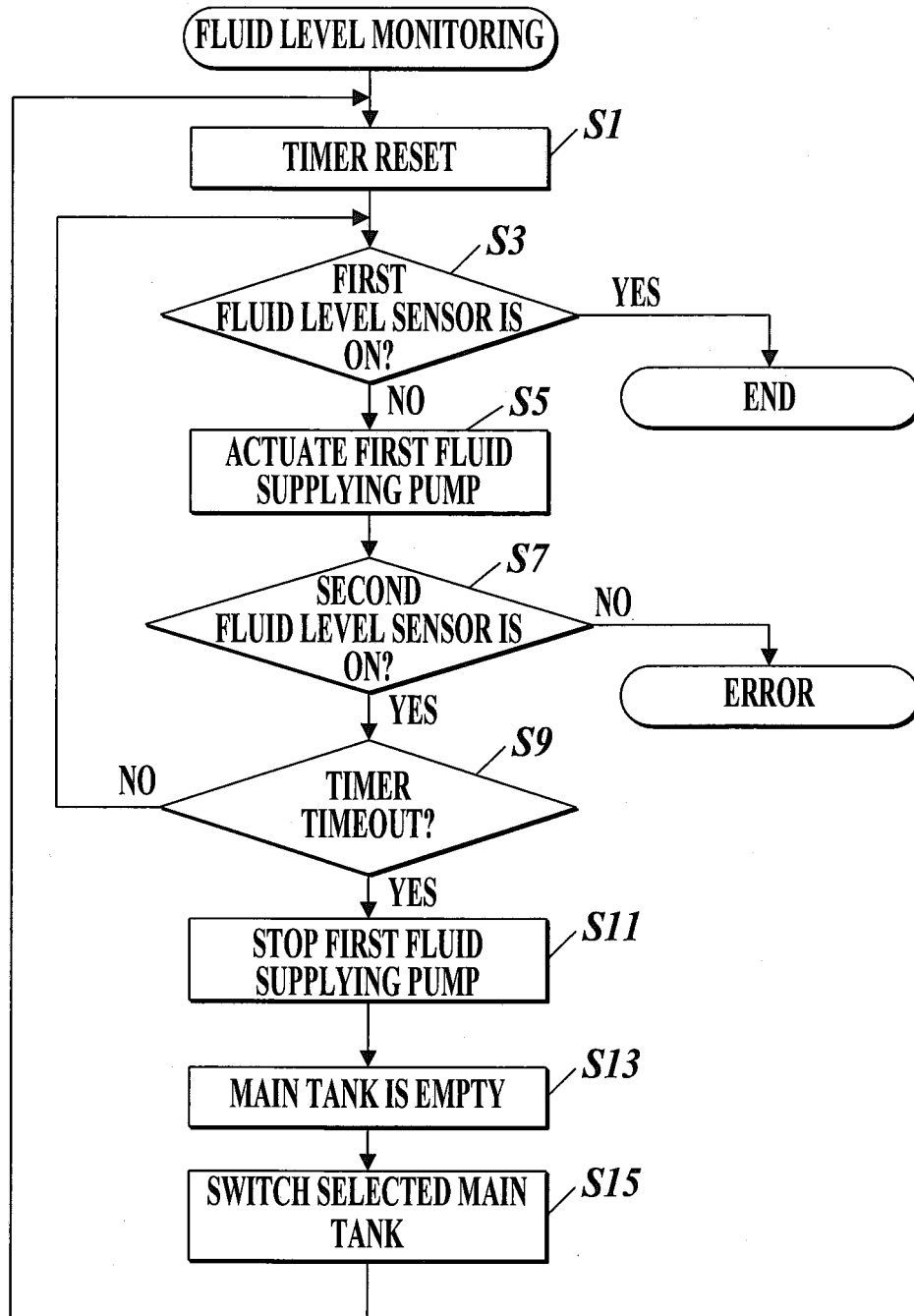
FIG. 7

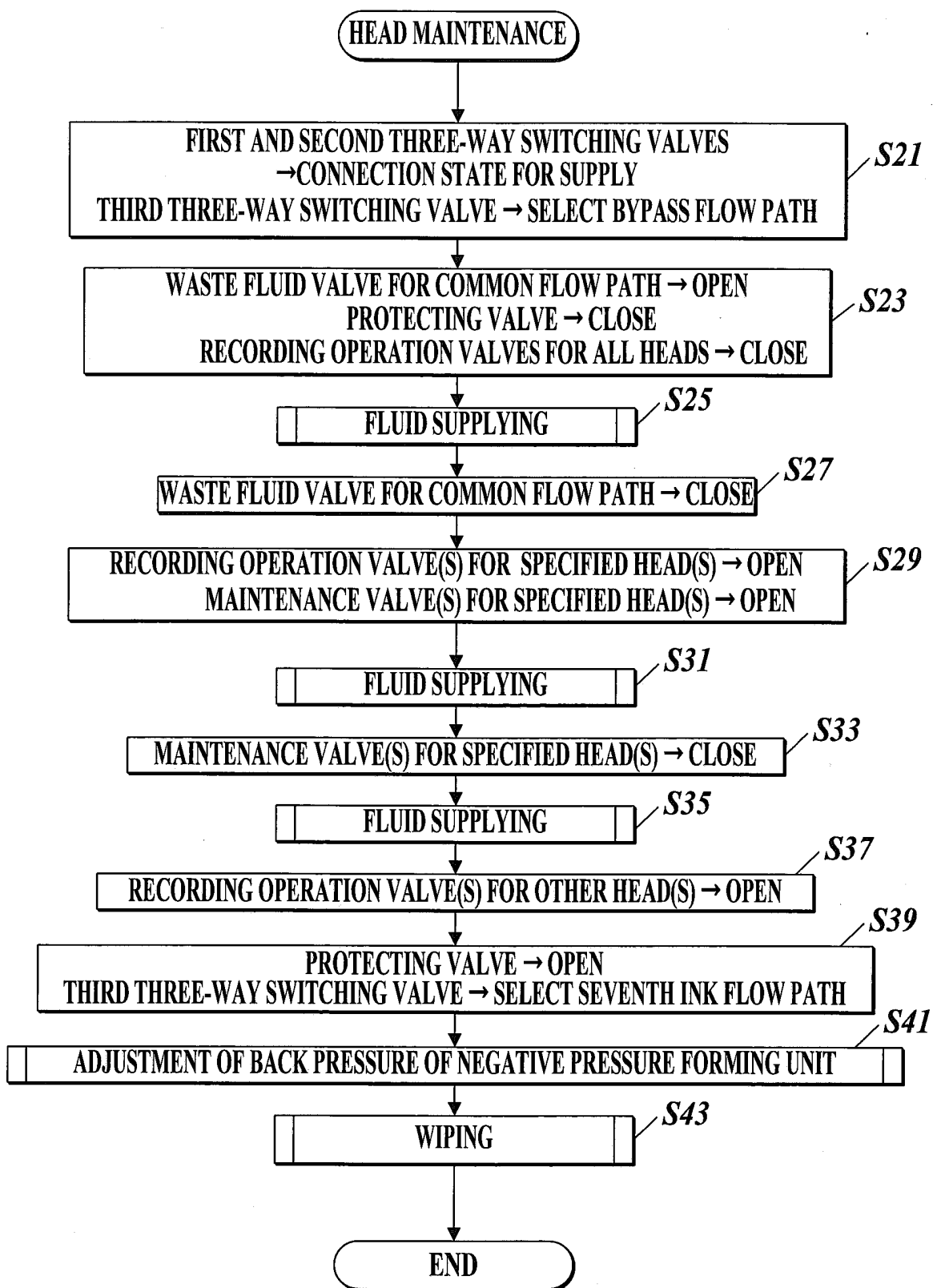
FIG. 8

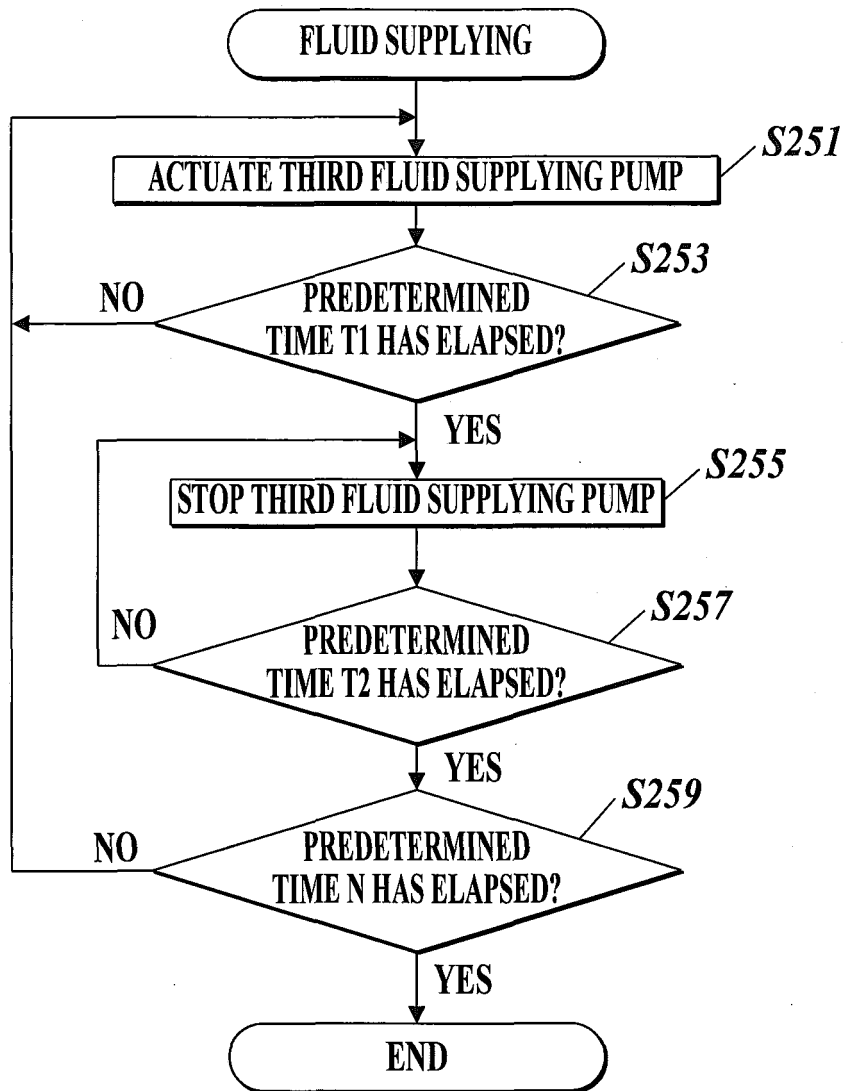
FIG. 9

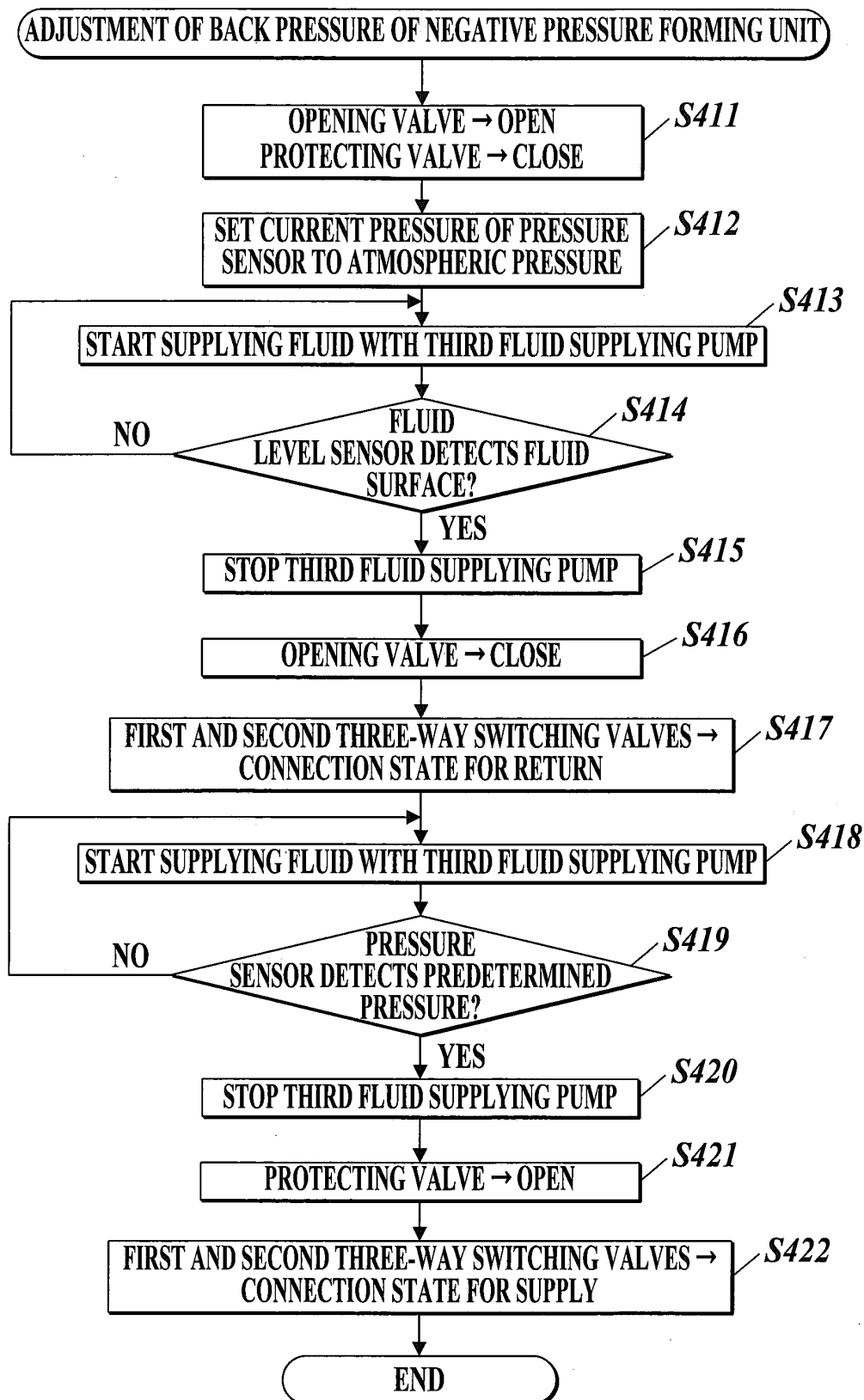
FIG.10

FIG. 11

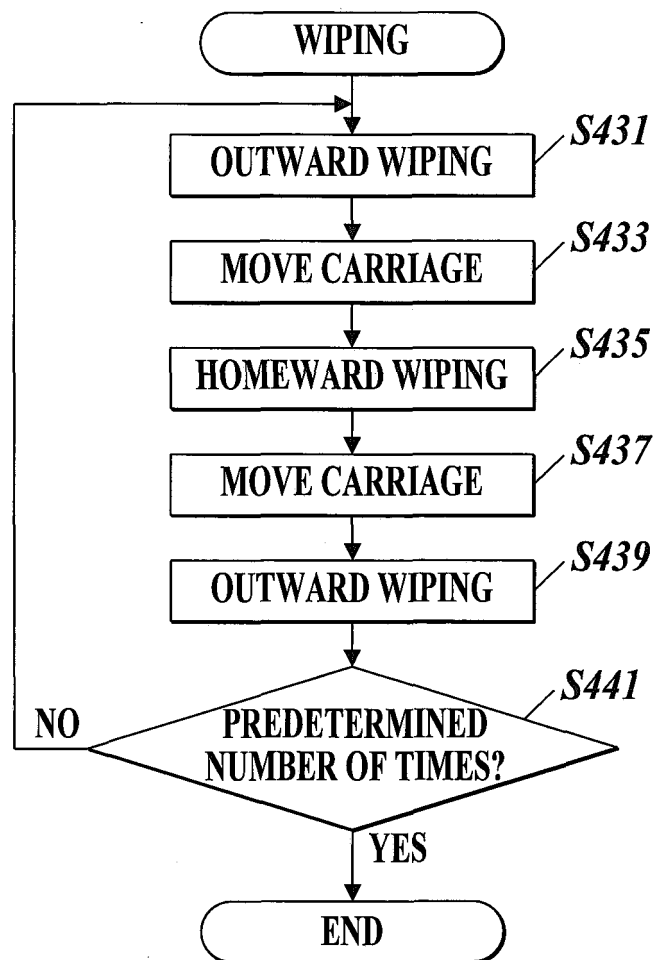


FIG.12A

PRESSURE FOR MAINTENANCE	DEGREE OF RECOVERY OF HEAD NOZZLES
10kPa	△
20kPa	○
30kPa	◎
40kPa	◎

◎: VERY GOOD、○: GOOD、△: NOT SO GOOD、×: POOR

FIG.12B

PRESSURE FOR MAINTENANCE	RATE OF DISCHARGE OF AIR BUBBLES FROM HEADS
3kPa	×
4kPa	△
5kPa	△
7kPa	○
9kPa	○
10kPa	◎

◎: VERY GOOD、○: GOOD、△: NOT SO GOOD、×: POOR

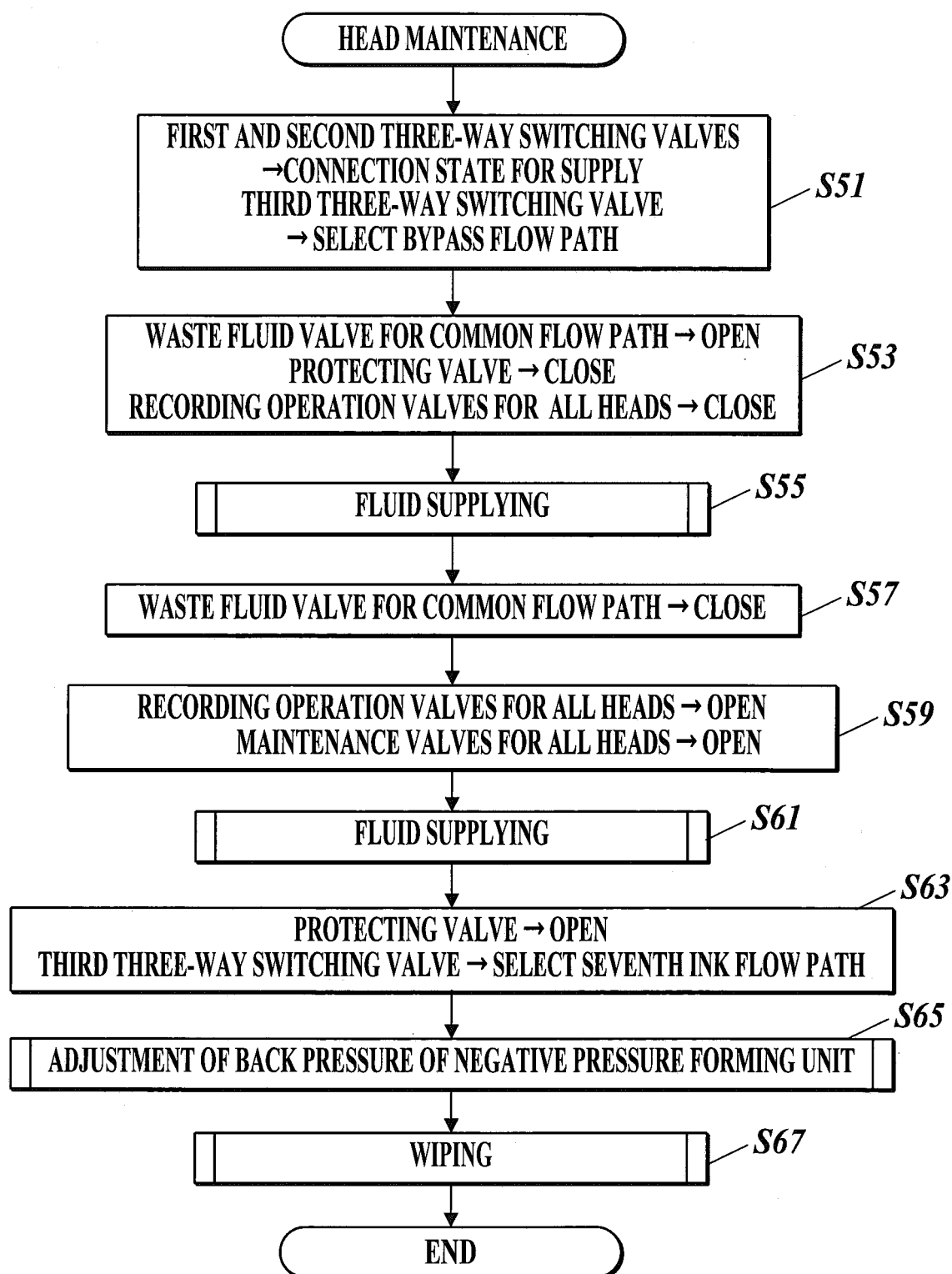
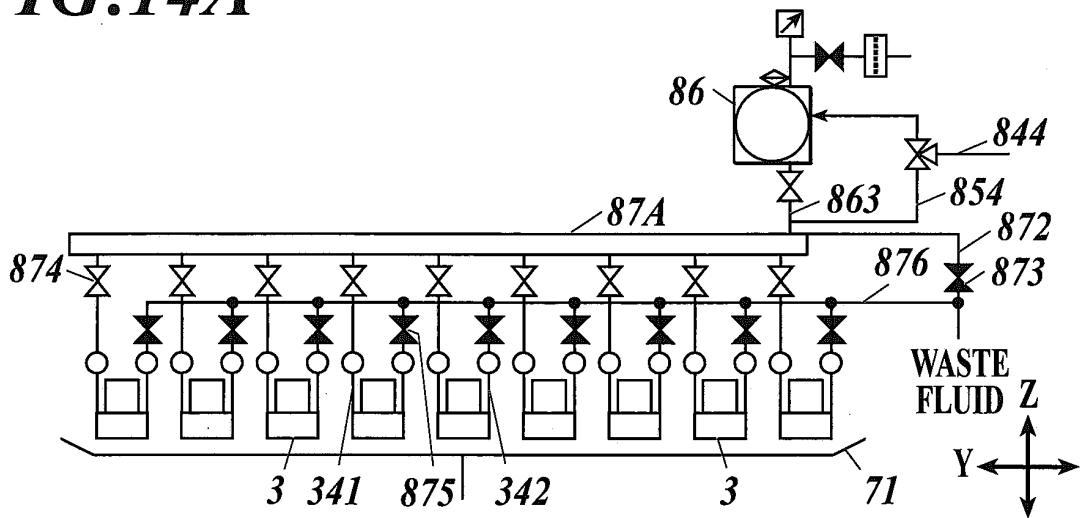
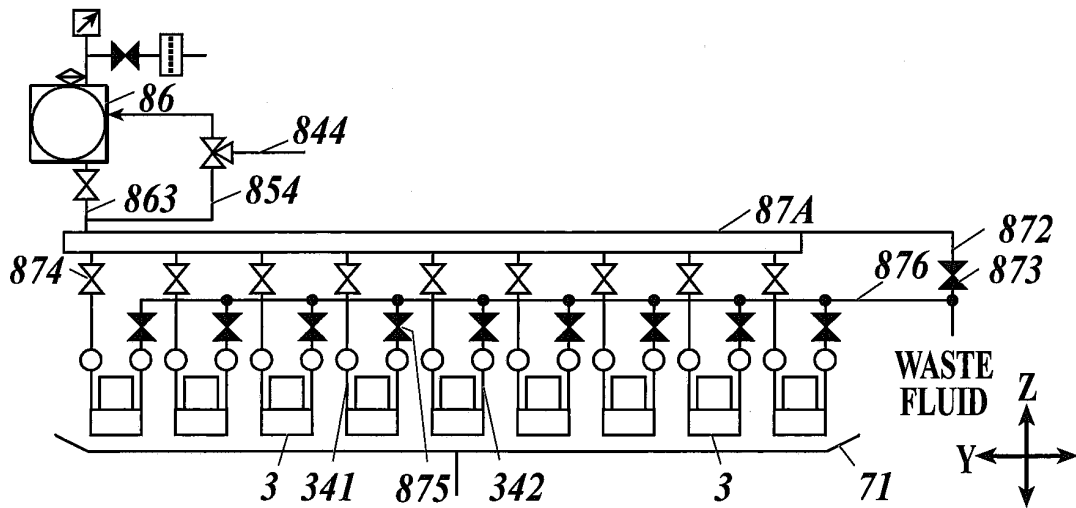
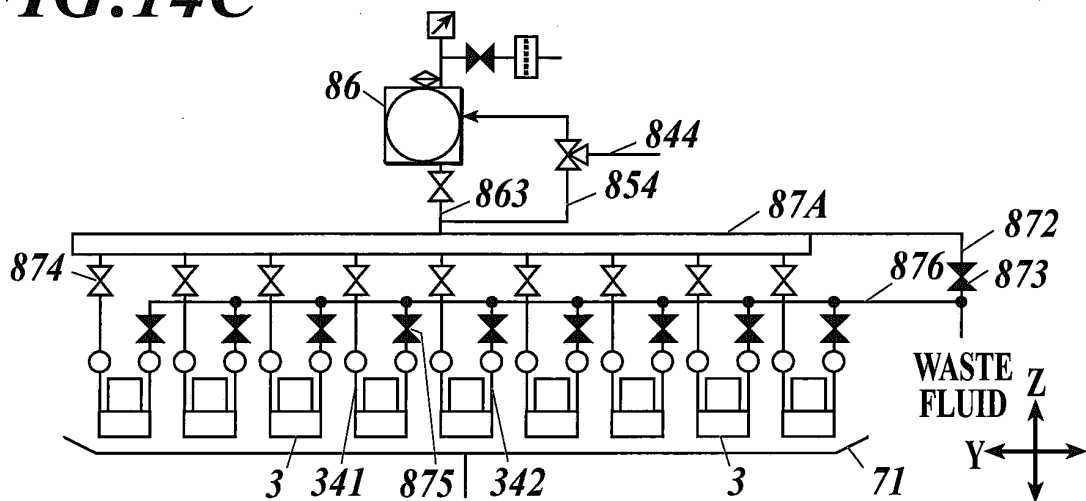
FIG.13

FIG.14A**FIG.14B****FIG.14C**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/069383

A. CLASSIFICATION OF SUBJECT MATTER

B41J2/175(2006.01)i, B41J2/18(2006.01)i, B41J2/185(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)

B41J2/175, B41J2/18, B41J2/185

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	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

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.
X Y	JP 2011-68033 A (Fujifilm Corp.), 07 April 2011 (07.04.2011), paragraphs [0081] to [0116]; fig. 5 (Family: none)	1, 2 3, 4
Y	JP 2007-245615 A (Konica Minolta Holdings, Inc.), 27 September 2007 (27.09.2007), paragraph [0043]; fig. 1 (Family: none)	3, 4
Y	JP 2010-64389 A (Fuji Xerox Co., Ltd.), 25 March 2010 (25.03.2010), paragraphs [0046] to [0067]; fig. 4 to 5 (Family: none)	4

☐ 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

"I" 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
22 August, 2012 (22.08.12)Date of mailing of the international search report
04 September, 2012 (04.09.12)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/069383

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

The document 1, which is cited in this international search report, discloses the inventions of claims 1 and 2, and the inventions of claims 1-4 have no common single inventive concept.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☒ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2001113726 A [0009]
- JP 2007261234 A [0009]
- JP 2009285900 JP [0009]