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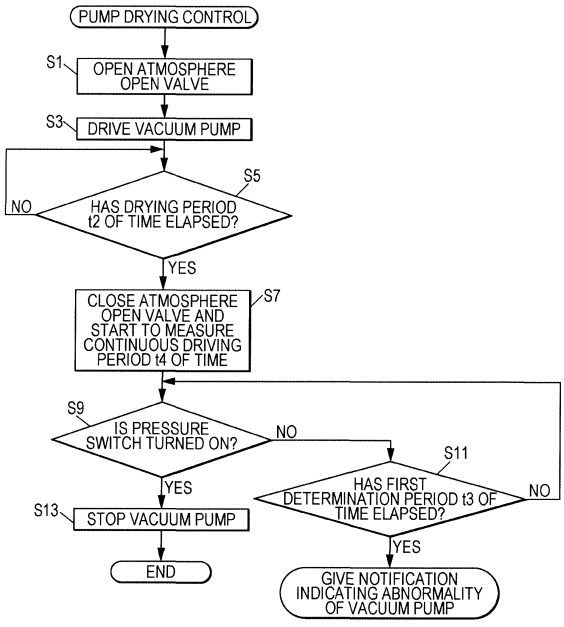
# (54) INKJET PRINTING APPARATUS AND CONTROL METHOD THEREFOR

(57) The inkjet printing apparatus is equipped with: a deaeration module (831) provided in the ink supply path; a vacuum pump (832) for reducing the pressure of the ink through a gas-permeable membrane of the deaeration module; an atmosphere access valve (834) provided between the deaeration module and the vacuum pump and capable of switching the vacuum pump between a deaera-tion module-connected state and a state that is open to the atmo - sphere; and a control device (9) for controlling a liquid delivery pump, the vacuum pump and the atmosphere access valve. The control device performs pump-drying control, which opens the atmo - sphere access valve to the atmosphere and operates the vacuum pump.

*FIG. 7*

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## Description

### Technical Field

**[0001]** The present invention relates to an inkjet printing apparatus equipped with a deaerator for ink to be supplied to a head and a method for controlling the inkjet printing apparatus.

### Background Art

**[0002]** In an inkjet printing apparatus that ejects ink from a nozzle by pressurizing the ink, if gas dissolved in the ink becomes air bubble and remains in the ink, it causes a trouble in that the ink is not ejected from the nozzle or the like.

**[0003]** For this reason, in an inkjet printing apparatus of a related art, a deaerator is installed in an ink path in which ink is supplied from an ink tank to an inkjet head, and removes gas dissolved in the ink (for example, Patent Literature 1).

**[0004]** The deaerator includes a vacuum module that allows the passage of the ink to be supplied to the inkjet head and has a sealed region separated by a hollow fiber membrane for the ink and a vacuum pump that produces a vacuum in the sealed region of the vacuum module. A diaphragm pump is used as the vacuum pump.

**[0005]** In the inkjet printing apparatus, when the ink is supplied at the time of image forming, the vacuum pump is driven to perform vacuum production for the ink passing through the deaerator through the hollow fiber membrane. As a result, the air bubbles in the ink are sucked out to the sealed region side through the hollow fiber membrane, and thus excellent ejection is performed.

### Citation List

### Patent Literature

**[0006]** Patent Literature 1: JP 11-42771 A

### Summary of Invention

### Technical Problem

**[0007]** However, in the inkjet printing apparatus of the related art disclosed in Patent Literature 1, it is necessary to increase a degree of vacuum for vacuum production according to a type of ink, and in this case, there are cases in which moisture in the ink is also sucked out through the hollow fiber membrane.

**[0008]** Further, when gas containing moisture is sucked by the vacuum pump configured with the diaphragm pump, the gas is attached to an internal valve, and movement of the valve gets worse, and suction force is reduced. Further, the gas is dried in a state in which it is attached to the diaphragm after an operation stop, and thus the diaphragm degrades, leading to a problem in that the lifespan of the apparatus is reduced.

**[0009]** It is an object of the present invention to reduce influence of the moisture of the ink.

### Solution to Problem

**[0010]** In order to solve the above problems, an invention of an inkjet printing apparatus is an inkjet printing apparatus including: a deaeration module that is installed in a middle of an ink supply path in which ink is supplied from an ink tank to an inkjet head; a vacuum pump that exposes ink to a vacuum through a gas permeable membrane of the deaeration module; an atmosphere open valve that is capable of switching an inside of a path connecting the deaeration module with the vacuum pump between an airtight state and an atmosphere open state; and a control apparatus that controls the vacuum pump and the atmosphere open valve, wherein the control apparatus causes the atmosphere open valve to enter the atmosphere open state, and performs pump drying control such that the vacuum pump is operated.

**[0011]** Further, in order to solve the above problems, an invention of a method for controlling an inkjet printing apparatus is a method for controlling an inkjet printing apparatus which includes a deaeration module that is installed in a middle of an ink supply path in which ink is supplied from an ink tank to an inkjet head, a vacuum pump that exposes ink to a vacuum through a gas permeable membrane of the deaeration module, an atmosphere open valve that is installed between the deaeration module and the vacuum pump and capable of switching the vacuum pump between a connection state with the deaeration module and an atmosphere open state, and a control apparatus that controls the vacuum pump and the atmosphere open valve, and the method includes causing, by the control apparatus, the atmosphere open valve to enter the atmosphere open state and performing pump drying control such that the vacuum pump is operated.

**[0012]** Further, according to the invention of the inkjet printing apparatus and the invention of the method for controlling an inkjet printing apparatus, the inkjet printing apparatus may be configured to include a liquid feeding pump that supplies the ink to the inkjet head side through the deaeration module.

**[0013]** Further, according to the invention of the inkjet printing apparatus and the invention of the method for controlling an inkjet printing apparatus, the control apparatus may be configured to perform the pump drying control in a stop state of the liquid feeding pump.

**[0014]** Further, according to the invention of the inkjet printing apparatus and the invention of the method for controlling an inkjet printing apparatus, the control apparatus may be configured to perform the pump drying control at the time of maintenance of the inkjet head or immediately after the maintenance.

**[0015]** Further, according to the invention of the inkjet printing apparatus and the invention of the method for

controlling an inkjet printing apparatus, the control apparatus may be configured to perform the pump drying control when the liquid feeding pump performs liquid feeding continuously during a predetermined period of time or more.

**[0016]** Further, according to the invention of the inkjet printing apparatus and the invention of the method for controlling an inkjet printing apparatus, the control apparatus may be configured to perform pressure maintaining control such that driving of the vacuum pump starts at an upper limit pressure and stops at a lower limit pressure, and the control apparatus may be configured to perform the pump drying control after the lower limit pressure is reached by the pressure maintaining control when [a deaerated ink consumption period of time obtained based on an ink capacity of the deaeration module and an ink consumption speed at a time of image forming] > ([a specified drying period of time in the pump drying control] + [a reduced pressure maintaining period of time in which a pressure equal to or lower than the upper limit pressure is maintained to deaerate the ink in the deaeration module] + [a first pump continuous driving period of time necessary for reducing a suction pressure from an atmosphere pressure to the lower limit pressure through the vacuum pump]).

**[0017]** Further, according to the invention of the inkjet printing apparatus and the invention of the method for controlling an inkjet printing apparatus, the control apparatus may be configured to perform pressure maintaining control such that driving of the vacuum pump starts at an upper limit pressure and stops at a lower limit pressure, and the control apparatus may be configured to execute the pump drying control at a time of power off in which a main power source of the inkjet printing apparatus is turned off when a second pump continuous driving period of time necessary for reducing a suction pressure from the upper limit pressure to the lower limit pressure through the vacuum pump exceeds a predetermined determination period of time.

**[0018]** Further, according to the invention of the inkjet printing apparatus and the invention of the method for controlling an inkjet printing apparatus, the control apparatus may be configured to perform a wiping process for the inkjet head with execution of the pump drying control at the time of power off.

**[0019]** Further, according to the invention of the inkjet printing apparatus and the invention of the method for controlling an inkjet printing apparatus, the control apparatus may be configured to give a notification indicating an abnormality of the vacuum pump when the second pump continuous driving period of time exceeds another determination period of time longer than the determination period of time.

**[0020]** Further, according to the invention of the inkjet printing apparatus and the invention of the method for controlling an inkjet printing apparatus, the control apparatus may be configured to give a notification indicating an abnormality of the vacuum pump when it is hard to perform pressure reduction to a desired lower limit pressure within a predetermined period of time through the vacuum pump after the pump drying control.

**[0021]** Further, according to the invention of the inkjet printing apparatus and the invention of the method for controlling an inkjet printing apparatus, the deaeration module, the vacuum pump, and the atmosphere open valve may be configured to be individually installed in association with ink of a plurality of colors, and the control apparatus may be configured to specify one or more colors that are not used from image data for performing image forming, and perform the pump drying control on the vacuum pump corresponding to the ink of the specified color at the time of the image forming.

**[0022]** Further, according to the invention of the inkjet printing apparatus and the invention of the method for controlling an inkjet printing apparatus, the deaeration module, the vacuum pump, and the atmosphere open valve may be configured to be individually installed in association with ink of a plurality of colors, and the control apparatus may be configured to specify one or more colors that are high in an amount of used ink from image data for performing image forming, and perform the pump drying control on the vacuum pump corresponding to the ink of the specified color after the image forming.

**[0023]** Further, according to the invention of the inkjet printing apparatus and the invention of the method for controlling an inkjet printing apparatus, the deaeration module, the vacuum pump, and the atmosphere open valve may be configured to be individually installed in association with a plurality of inkjet heads, and the control apparatus may be configured to specify one or more inkjet heads that are not used from image data for performing image forming, and perform the pump drying control on the vacuum pump corresponding to the specified inkjet head at the time of the image forming.

## Advantageous Effects of Invention

**[0024]** In order to solve the above problems, according to the present invention, the control apparatus causes the atmosphere open valve to enter the atmosphere open state and executes pump drying control of operating the vacuum pump, and thus outdoor air drier than in the deaeration module can be introduced into the pump, and humidity in the pump can be removed.

**[0025]** Accordingly, it is possible to excellently perform deaeration of the ink by the vacuum pump, suppress degradation of the vacuum pump, and thus increase the lifespan.

## Brief Description of Drawings

**[0026]**

Fig. 1 is a perspective view illustrating an inkjet printing apparatus.

Fig. 2 is a plane view illustrating an arrangement of

a head on a carriage.
Fig. 3 is a schematic view illustrating an overview of an ink supply apparatus.
Fig. 4 is a configuration view schematically illustrating a deaerator.
Fig. 5 is a diagrammatic view illustrating a relation between a path pressure and an elapsed time at the time of on-off control of a vacuum pump of a deaerator.
Fig. 6 is a block diagram illustrating a control system of an inkjet printing apparatus.
Fig. 7 is a flowchart illustrating pump drying control.
Fig. 8 is a flowchart illustrating a process of performing pump drying control at the time of power on.
Fig. 9 is a flowchart illustrating a process of pump drying control on standby.
Fig. 10 is a flowchart illustrating a process of pump drying control at the time of image forming.
Fig. 11 is a flowchart illustrating a process of pump drying control at the time of an extrusion process for the maintenance.
Fig. 12 is a flowchart illustrating a process of pump drying control at the time of a wiping process for the maintenance.
Fig. 13 is a flowchart illustrating a process of pump drying control at the time of a nozzle failure confirmation process.
Fig. 14 is a flowchart illustrating a process of pump drying control at the time of power off.
Fig. 15 is an explanatory diagram illustrating an effect test result when pump drying control is executed on a vacuum pump.
Fig. 16 is an explanatory diagram illustrating a result of a confirmation test of influence of moisture (vapor) on a vacuum pump.
Fig. 17 is an explanatory diagram illustrating a result of a confirmation test of influence of moisture (vapor) removal on a vacuum pump.

Description of Embodiments

**[0027]** An inkjet printing apparatus 1 equipped with an ink supply apparatus according to an embodiment of the present invention will be described with reference to Figs. 1 to 14. Fig. 1 is a perspective view illustrating the overall inkjet printing apparatus 1.

**[0028]** The inkjet printing apparatus 1 mainly includes a conveyance apparatus 20 that conveys a recording medium in a horizontal direction, a carriage 4 equipped with heads 3 (see Fig. 2) serving as a plurality of inkjet heads that eject ink onto the recording medium being conveyed downward, a main scanning apparatus 5 that conveys the carriage 4 in the horizontal direction orthogonal to a conveyance direction of the recording medium, a maintenance unit 7 that performs the maintenance of the heads 3 mounted in the carriage 4, a nozzle moisturizing unit 6 that moisturizes nozzles of the heads 3 mounted in the carriage 4, an ink supply apparatus 8 (see Fig. 3) that supplies the ink to the heads 3 mounted in the carriage 4, a control apparatus 9 (see Fig. 6) serving as a control unit that controls the respective components, and a frame 100 that supports the entire apparatus.

**[0029]** In the following description, a direction that is the horizontal direction and identical to the conveyance direction of the recording medium is a "Y-axis direction," a direction that is the horizontal direction and identical to the conveyance direction of the carriage 4 is referred to as an "X-axis direction" or a "main scanning direction," and a vertical direction is referred to as a "Z-axis direction."

[Conveyance apparatus]

**[0030]** The conveyance apparatus 20 includes a driving roller 21, a driven roller (not illustrated), a driving motor 22, and a conveying belt 23.

**[0031]** The driving roller 21 and the driven roller are rotatably shaft-supported, and the driving roller 21 is arranged to extend in the main scanning direction X. The driving motor 22 is a driving source for rotatably driving the driving roller 21 and attached to one end side of the driving roller 21.

**[0032]** The conveying belt 23 is formed in an endless form and suspended between the driving roller 21 and the driven roller. With the rotation of the driving roller 21, the conveying belt 23 revolves between the driving roller 21 and the driven roller, conveys the recording medium placed on the top surface of the conveying belt 23 in the conveyance direction F identical to the Y-axis direction, and stops the revolving between both rollers and the conveyance of the recording medium when the rotation of the driving roller 21 stops.

**[0033]** Under control of the control apparatus 9, when the head 3 ends single one-way scanning in the X-axis direction, the driving motor 22 rotates the driving roller 21 by a predetermined amount, and conveys the recording medium in the conveyance direction by a predetermined distance, and when the head 3 starts and ends opposite-direction scanning in the main scanning direction X, the driving motor 22 rotates the driving roller 21 by a predetermined amount again, conveys the recording medium by a predetermined distance in the conveyance direction F, and stops. Such an operation is repeated, and thus the recording medium is intermittently conveyed.

**[0034]** As the recording medium, for example, a resin film or metal may be used as in addition to paper or fabric.

**[0035]** The conveyance apparatus 20 is not limited to the intermittent conveyance. For example, a group of heads including a line of nozzles in the X-axis direction may be arranged above the carriage 4 across substantially the full width of the conveying belt 23 in the X-axis direction for each color, the groups of heads of respective colors may be sequentially lined up in the Y-axis direction, and image forming may be performed while conveying the recording medium in the Y-axis direction through the

conveyance apparatus 20 in a state in which the carriage 4 stops at a position directly above the conveying belt 23.

[Frame]

**[0036]** As illustrated in Fig. 1, the frame 100 is mainly configured with a rectangular body portion 101 that extends in the X-axis direction, a first base portion 102 that supports one end portion of the body portion 101 in the X-axis direction, and a second base portion 103 that supports the other end portion of the body portion 101 in the X-axis direction.

**[0037]** The first base portion 102 supports one end portion of the body portion 101 upward while storing and holding the nozzle moisturizing unit 6 therein. The second base portion 103 supports the end portion of the body portion 101 upward while storing and holding the maintenance unit 7 therein.

**[0038]** The body portion 101 stores and holds a pair of carriage rails 51 and 51 of the main scanning apparatus 5 which will be described later in a state in which the pair of carriage rails 51 and 51 is arranged in the X-axis direction, and the carriage 4 is conveyed in the body portion 101 in the X-axis direction.

**[0039]** The first base portion 102 and the second base portion 103 are arranged at both sides in the X-axis direction with the conveyance apparatus 20 interposed therebetween, and the body portion 101 is installed above the conveyance apparatus 20. Thus, the image forming can be performed such that the ink is ejected from the heads 3 mounted in the carriage 4 while the conveyance apparatus 20 conveys the carriage 4 in the direction orthogonal the conveyance direction of the recording medium.

[Main scanning apparatus and carriage]

**[0040]** The main scanning apparatus 5 includes a pair of rod-like carriage rails 51 and 51 that are supported to extend in the X-axis direction in the body portion 101 of the frame 100. The pair of carriage rails 51 and 51 is installed to straddle the conveying belt 23 of the conveyance apparatus 20. The box-like carriage 4 is supported on the carriage rails 51 and 51 to reciprocate in the X-axis direction.

**[0041]** The carriage 4 is a housing having substantially a rectangular shape whose upper portion is opened, and a plurality of heads 3 are mounted on a bottom plate thereof. As illustrated in Fig. 1, the carriage 4 includes arm portions 42 and 42 that extend toward both sides in the Y-axis direction in upper portions of both side surfaces in the Y-axis direction, and the arm portions 42 and 42 are placed above the carriage rails 51 and 51 through linear guides and arranged to be slidable on the carriage rails 51 and 51 in the X-axis direction.

**[0042]** A linear motor is installed between the carriage rails 51 and 51 and the arm portions 42 and 42 of the carriage 4. In other words, a stator of the linear motor is installed in each of the carriage rails 51 and 51, a rotor is installed in each of the arm portions 42 and 42 of the carriage 4, and the carriage 4 performs a conveyance operation in the X-axis direction through current control of a coil at the stator side.

**[0043]** Fig. 2 is a schematic explanatory view illustrating a bottom plate 41 of the carriage 4 which is viewed downward. In the inkjet printing apparatus 1, nine heads 3 are arranged for each of 9 colors, that is, Y (yellow), Lm (light magenta), Or (orange), M (magenta), Bk (black), Bl (blue), Lk (light black), C (cyan), and Lc (light cyan), and a total of 81 heads 3 are mounted on the bottom plate of the carriage 4.

**[0044]** A group of heads of each color is arranged in the order of Y, Lm, Or, M, Bk, Bl, Lk, C, and Lc in the X-axis direction as illustrated in Fig. 2, and the nine heads 3 of each group of heads are arranged in a zigzag form in the Y-axis direction.

**[0045]** The bottom plate 41 includes openings that are arranged at mounting positions of the heads 3 in a stripe form in the Y-axis direction, and the heads 3 mounted on the bottom plate 41 downward can eject droplets of the ink directly below the carriage 4 through the openings.

**[0046]** Since the nine heads 3 are arranged in the zigzag form for each color as described above, the ink of each color can be ejected to any position within the range across substantially the full width of the bottom plate 41 of the carriage 4 in the Y-axis direction.

[Head]

**[0047]** Fig. 3 is a cross-sectional view illustrating a schematic structure of the head 3. The head 3 is configured such that a plurality of lines of nozzles in the Y-axis direction are arranged in the X-axis direction on a nozzle plate facing the recording medium being conveyed on the bottom portion thereof. In the head 3, an ink flow channel in which the ink is guided to the nozzles and a plurality of piezoelectric elements installed for each nozzle are arranged. The ink flow channel communicates with a first port 341 and a second port 342 installed above the head 3, the ink is supplied from the first port 341 to the nozzles, and extra ink is discharged from the second port 342.

[Maintenance unit]

**[0048]** The maintenance unit 7 performs maintenance on the heads 3 during a non-recording operation. The maintenance unit 7 is installed on one end sides of the carriage rails 51 and 51 outside the conveyance apparatus 20. In other words, the maintenance is performed in a state in which the carriage 4 moves up to the opposite position to the maintenance unit 7 on one end portions of the carriage rails 51 and 51.

**[0049]** The maintenance unit 7 includes a wiping apparatus that wipes (performs a wiping process on) residual ink or impurities on the lower surface of the nozzle

plate of each head 3, an ink tray 71 (see Fig. 3) that serves as a tray when the head 3 ejects the ink, and a nozzle sensor 72 (see Fig. 6) that detects a nozzle in which a nozzle failure has occurred.

**[0050]** The wiping apparatus is configured with a cleaning roller that comes into sliding contact with the lower surface of the nozzle plate 31 and is rotatable around a rotation shaft in the X-axis direction and a roller conveyance mechanism that conveys the cleaning roller in the Y-axis direction. The width of the cleaning roller in the X-axis direction is set so that the cleaning roller wipes the groups of heads of three colors among the groups of heads of nine colors mounted on the carriage 4, and all the heads 3 are cleaned by one and half reciprocating movements. Thus, the nozzle is prevented from being clogged due to solidification of the residual ink.

**[0051]** The ejection of the ink to the ink tray 71 at the time of the maintenance is performed through an extrusion process performed by ink supply pressure of the ink supply apparatus 8 and a flushing process in which the ink is ejected by driving of the piezoelectric element.

**[0052]** In the extrusion process, a larger amount of ink than in a normal operation is ejected from the nozzles of the heads 3, and thus, for example, clogging of the ink flow channel in the head 3 is solved.

**[0053]** The flushing process is a process of ejecting a small amount of ink after the wiping process or at regular intervals and preventing a plugged state caused by the dried ink.

**[0054]** Even in a nozzle failure detection process, the ink is ejected to the ink tray 71. The nozzle failure is a process of detecting a nozzle in which non-ejection occurs against an ink ejection command. In this process, the ink ejection is performed from all or some nozzles of the heads 3 based on the ejection instruction two or more times, and at this time, the ejected droplets are detected by the nozzle sensor 72 installed along with the ink tray 71. The nozzle sensor 72 is, for example, a line-type light receiving sensor arranged in the Y-axis direction such that the ejected droplets traverse the light receiving surface of the nozzle sensor 72. When the droplets are ejected from the nozzles, the passage of the droplets change a quantity of received light of respective portions of the light receiving surface of the nozzle sensor 72, and ejection and non-ejection of the droplets can be determined based on the change in the quantity of received light.

[Nozzle moisturizing unit]

**[0055]** The nozzle moisturizing unit 6 is installed at the other end sides of the carriage rails 51 and 51 outside the conveyance apparatus 20. In other words, at the time of the non-recording operation, the carriage 4 moves up to the opposite position to the nozzle moisturizing unit 6 on the other end portions of the carriage rails 51 and 51, and the nozzles of the heads 3 are moisturized in this state.

**[0056]** In other words, the nozzle moisturizing unit 6 comes into close contact with the nozzles of the nozzle plate 31, and causes the insides of the nozzles to be connected to a moisturizing liquid storage and is configured with the moisturizing liquid storage and a lifting mechanism.

[Ink supply apparatus]

**[0057]** Fig. 3 is an explanatory diagram illustrating a schematic configuration of the ink supply apparatus 8. The inkjet printing apparatus 1 includes the ink supply apparatus 8 for each color.

**[0058]** The ink supply apparatus 8 mainly includes main tanks 81 and 81 that are two ink tanks that store the ink, a sub tank 82 serving as an ink tank to which the ink is supplied from the main tanks 81 and 81, a deaerator 83 installed at a downstream side of the sub tank 82 in the ink supply direction, an intermediate tank 84 serving as an ink tank that is installed at the downstream side of the deaerator 83 in the ink supply direction and temporarily stores the ink, a negative pressure forming portion 86 installed at the downstream side of the intermediate tank 84 in the ink supply direction, and a common flow channel 87 to which the first ports 341 of the heads 3 are connected in parallel to supply the ink to the heads 3.

**[0059]** The ink tray 71 of the maintenance unit 7 is also illustrated in Fig. 3.

**[0060]** The main tanks 81 and 81 are containers whose upper portion is opened to the atmosphere, and both of the two main tanks 81 and 81 are attachable to the inkjet printing apparatus 1 so that the two main tanks 81 and 81 can be replaced when they are empty. Since the two main tanks 81 and 81 are arranged, even when one main tank is employed and replaced, the ink can be supplied from the other main tank 81, and thus the interruption of the printing operation of the inkjet printing apparatus 1 can be prevented. The number of sold substances mounted in the main tank 81 may be larger.

**[0061]** In Fig. 3, a reference numeral 815 indicates a residue sensor that detects whether or not the ink of the main tanks 81 and 81 is empty.

**[0062]** A first ink flow channel 811 in which one end portion is bifurcated into the sides of the main tanks 81 and 81 and the other end portion merges into and reaches the sub tank 82 is installed between the main tanks 81 and 81 and the sub tank 82. Tank valves 812 and 812 are installed near the main tanks 81 and 81 in the first ink flow channel 811 as a connection switching portion serving as an electromagnetic valve capable of switching an on-off state of the flow channel.

**[0063]** A filter 813 for removing impurities such as waste or dust is installed in the middle of the flow channel at the sub tank 82 side in the first ink flow channel 811, and a first liquid feeding pump 814 serving as a first liquid feeding portion that feeds the ink to the sub tank side is installed at a position closer to the sub tank 82 than the filter 813.

**[0064]** The sub tank 82 has a funnel shape having a

sidewall portion 821 whose diameter decreases downward, and the upper portion of the sub tank 82 is blocked by a top panel 822.

**[0065]** The center of the bottom portion of the sub tank 82 is connected to a second ink flow channel 823, and the ink in the sub tank 82 can be supplied to the deaerator 83 side through the second ink flow channel 823.

**[0066]** An atmosphere open tube 824 that maintains the inside of the sub tank 82 to be the atmosphere pressure is attached to the top panel 822 of the sub tank 82. The atmosphere open tube 824 is equipped with a filter 825 that prevents the invasion of refuse or waste from the outside.

**[0067]** The first ink flow channel 811 is connected to the top panel 822 of the sub tank 82 such that a leading end portion of the first ink flow channel 811 penetrates the top panel 822 and enters the sub tank 82.

**[0068]** The leading end portion of the first ink flow channel 811 extends up to a position at which the leading end portion comes into contact with or almost comes into contact with the inner surface of the sidewall 821 of the sub tank 82, and the ink supplied from the first ink flow channel 811 is poured to the liquid level in the sub tank 82 along the sidewall 821.

**[0069]** An upper limit position of the liquid level of the ink of the sub tank 82 is decided by liquid level monitoring control which will be described later, and the leading end portion of the first ink flow channel 811 supplies the ink to the sidewall 821 at a higher position than the upper limit position of the liquid level of the ink.

**[0070]** In the sub tank 82, a first liquid level sensor 826 that specifies the upper limit position of the liquid level of the ink in the liquid level monitoring control which will be described later and a second liquid level sensor 827 that specifies a lower limit position of the liquid level of the ink are installed.

**[0071]** Both of the liquid level sensors 826 and 827 are floating type sensors having a float and can detect whether or not the liquid level is lower or higher than the upper limit position or the lower limit position based on the height of the float. The liquid level monitoring control will be described in detail.

**[0072]** The second ink flow channel 823 is installed between the sub tank 82 and the deaerator 83. In the middle of the second ink flow channel 823, a check valve 828 that prevents return of the ink from the deaerator 83 to the sub tank 82 and a second liquid feeding pump 829 serving as a second liquid feeding portion that feeds the ink from the sub tank 82 to the deaerator 83 are installed.

**[0073]** Fig. 4 is a configuration diagram illustrating the deaerator 83. As illustrated in Fig. 4, the deaerator 83 includes a deaeration module 831 configured with a film having gas permeability, a vacuum pump 832 that reduces the pressure in the deaeration module 831, a vacuum path 836 that connects the vacuum pump 832 with the deaeration module 831, a pressure switch 833 that is installed in a branch passage 837 branched from the vacuum path 836 and serves as a pressure detecting portion that performs an ON/OFF operation according to the pressure in the vacuum path 836, a trap 838 that traps the liquid in the vacuum path 836, and an atmosphere open valve 834 capable of switching the inside of the vacuum path 836 between an airtight state and an atmosphere open state.

**[0074]** A plurality of hollow fiber membranes 831a are bundled and accommodated in the deaeration module 831, and the inside of the deaeration module 831 is partitioned into two spaces, that is, the inner side and the outer side of the hollow fiber membranes 831a. An ink inlet 831b connected to the second ink flow channel 823 and an ink outlet 831c connected to a third ink flow channel 835 directed toward the inkjet head 3 side are installed on the outer side of the deaeration module 831. The ink inlet 831b and the ink outlet 831c communicate with an external space of each hollow fiber membrane 831a in the deaeration module 831, the ink fed from the sub tank 82 through the second liquid feeding pump 829 flows into the deaeration module 831 from the ink inlet 831b, passes through a gap of a bundle of a plurality of hollow fiber membranes 831a, and flows out from the ink outlet 831c.

**[0075]** On the other hand, the vacuum path 836 communicates with the internal space of each of hollow fiber membrane 831a in the deaeration module 831, and the vacuum pump 832 is driven to suck the internal space of each hollow fiber membrane 831a through the vacuum path 836 and reduce the pressure until the internal space of each hollow fiber membrane 831a has predetermined pressure. Through the pressure reduction, the ink in the external space coming into contact with the outer surface of each hollow fiber membrane 831a passes through the hollow fiber membrane 831a, and thus dissolved oxygen is deaerated and removed from the ink.

**[0076]** Any deaeration module capable of removing the dissolved oxygen in the ink by causing one surface of a film having gas permeability to come into contact with the ink and performing the pressure reduction in the other surface via the vacuum path 836 using the vacuum pump 832 can be used as the deaeration module 831, but it is desirable to use a deaeration module in which a plurality of hollow fiber membranes are bundled as a film.

**[0077]** The vacuum pump 832 is a diaphragm pump including a pump chamber equipped with an expandable diaphragm and a driving source that operates the diaphragm so that the volume of the pump chamber is expanded and contracted. The pump chamber is equipped with a suction port having a check valve that allows only inflow of a fluid from the outside and a discharge port having a check valve that allows only discharge of a grain from the inside.

**[0078]** In the diaphragm pump, when moisture is attached to the diaphragm or the check valve, the pump performance decreases and degrades, and a failure occurs.

**[0079]** Even when the ink or the moisture invades the vacuum path 836 from the deaeration module 831 side, the trap 838 can prevent the ink or the moisture from

reaching the vacuum pump 832 by dropping the ink or the moisture and store the trapped ink or moisture therein. Thus, it is possible to prevent the vacuum pump 832 from being broken, malfunctioning, or degradation due to ink or the moisture. However, since the trap 838 has a structure of trapping them by dropping down water droplets, the moisture that is vaporized and then reaches the vacuum pump 832 is hardly trapped by the trap 838.

**[0080]** The pressure switch 833 is a pressure detecting unit, and includes a cylindrical pressure chamber 833a in which the diameter of the leading end of the branch passage 837 is expanded and a piston-like rotor 833b that is slidable in the pressure chamber 833a. The outer circumferential surface of the rotor 833b is fitted into the inner circumferential surface of the pressure chamber 833a in the airtight state, and one end of the rotor 833b is urged by predetermined force in a direction away from the deaeration module 831 through an extension spring 833c fixed to a frame in the apparatus.

**[0081]** A switch operation unit 833d extending to the outside of the pressure chamber 833a is installed in the rotor 833b, and when the inside of the vacuum path 836 enters a reduced pressure state up to predetermined lower limit pressure by driving of the vacuum pump 832, the pressure of the inside of the pressure chamber 833a is also reduced through the branch passage 837, and when the rotor 833b moves to the deaeration module 831 side by a predetermined distance against the extension spring 833c, for example, the switch operation unit 833d comes into contact with a switch unit 833e attached to the frame in the apparatus, and thus an electric signal ON is transmitted to the control apparatus 9. Further, when the pressure of the inside of the vacuum path 836 is increased to an upper limit pressure higher than the lower limit pressure, the rotor 833b is pulled in the direction away from the deaeration module 831 due to an action of the extension spring 833c, the switch operation unit 833d is separated from the switch unit 833e, and electric signal OFF is transmitted to the control apparatus 9.

**[0082]** Thus, the pressure switch 833 operates to output ON when the pressure of the inside of the vacuum path 836 is detected to be the predetermined lower limit pressure by the driving of the vacuum pump 832 and output OFF when the vacuum pump 832 is stopped, the density of gas passing through the hollow fiber membranes 831a is increased, and the pressure is detected to be increased to be higher than the lower limit pressure and reach the upper limit pressure.

**[0083]** Fig. 5 is a graph illustrating a relation between a pressure value in the vacuum path 836 and an elapsed time when the control apparatus 9 performs pressure maintaining control on the vacuum pump 832 using the pressure switch 833 such that the pressure of the internal space of each hollow fiber membrane 831a in the deaeration module 831 is maintained to be between the upper limit pressure and the lower limit pressure. The pressure maintaining control to be described herein is a control example in which pump drying control which will be described later is not considered.

**[0084]** In Fig. 5, a reference numeral t4 indicates a period of time (referred to as a "first pump continuous driving period t4 of time) taken for reducing the suction pressure from the atmosphere pressure to the lower limit pressure through the driving of the vacuum pump 832.

**[0085]** In Fig. 5, a reference numeral t8 indicates a period of time (referred to as a "second pump continuous driving period t8 of time) taken for reducing the suction pressure from the upper limit pressure to the lower limit pressure through the driving of the vacuum pump 832.

**[0086]** In Fig. 5, a reference numeral t9 indicates a period of time taken for increasing the pressure from the lower limit pressure to the upper limit pressure through the deaeration in the stop state of the vacuum pump 832.

**[0087]** When the dissolved oxygen in the ink is removed by the deaeration module 831, if the vacuum pump 832 is driven to reduce the pressure of the inside of the vacuum path 836 up to the lower limit pressure as illustrated in Fig. 5, the pressure switch 833 is turned on, an operation of stopping the driving of the vacuum pump 832 is performed, and the deaeration is performed during the stop. Under the pressure maintaining control, a setting is performed such that, when the vacuum pump 832 is driven, and the pressure of the inside of the vacuum path 836 is steadily decreased up to the lower limit pressure (for example, about -70 kPa), the switch operation unit 833d and the switch unit 833e of the pressure switch 833 come into contact with each other, the electric signal ON is transmitted to the control apparatus 9, and the vacuum pump 832 stops its driving by a CPU 91 (see Fig. 6) of the control apparatus 9.

**[0088]** The value of the lower limit pressure of the inside of the vacuum path 836 at which the pressure switch 833 is turned on and the value of the lower limit pressure of the inside of the vacuum path 836 at which the pressure switch 833 is turned off can be changed by a spring pressure adjustment, a stroke adjustment of the switch unit 833e, or the like and can be appropriately set according to a type of used ink or an amount of dissolved oxygen in the ink.

**[0089]** After the pressure reduction is performed until the pressure of the inside of the vacuum path 836 becomes the lower limit pressure, and the driving of the vacuum pump 832 is stopped, if the oxygen in the ink gradually passes through the hollow fiber membrane 831a and enters the vacuum path 836, the pressure of the inside of the vacuum path 836 is steadily increased. Here, when the pressure of the inside of the vacuum path 836 exceeds the upper limit pressure, the switch operation unit 833d and the switch unit 833e of the pressure switch 833 are separated, and the electric signal OFF is set to be transmitted, and the CPU 91 of the control apparatus 9 repeats an operation of driving the vacuum pump 832 so that the pressure value of the inside of the vacuum path 836 becomes the lower limit pressure again according to the electric signal OFF and creating the reduced pressure state.

**[0090]** The atmosphere open valve 834 is an electromagnetic valve capable of switching the vacuum path 836 between the airtight state and the atmosphere open state according to an operation command given from the outside, and performs the switching under the operation control of the control apparatus 9.

**[0091]** The third ink flow channel 835 is formed between the deaeration module 831 and the intermediate tank 84. The ink is supplied to the intermediate tank 84 via the second and third ink flow channels 823 and 835 through supply pressure applied by the second liquid feeding pump 829.

**[0092]** The intermediate tank 84 is formed in a bag form having flexibility and expanded or contracted as an amount of stored ink varies.

**[0093]** A liquid measure sensor 841 that detects a state in which a regulated amount of ink is stored is installed along with the intermediate tank 84. When the ink is supplied from the sub tank 82, the ink is supplied by the second liquid feeding pump 829 until the liquid measure sensor 841 detects that the amount of ink reaches the regulated amount.

**[0094]** Fourth to seventh ink flow channels 842 to 845 are installed between the intermediate tank 84 and the negative pressure forming portion 86, and the ink is supplied through the fourth to seventh ink flow channels 842 to 845. A first three-way changeover valve 846 serving as an electromagnetic changeover valve is interposed between the fourth ink flow channel 842 and the fifth ink flow channel 843, a second three-way changeover valve 847 serving as an electromagnetic changeover valve is interposed between the fifth ink flow channel 843 and the sixth ink flow channel 844, and a third three-way changeover valve 848 serving as an electromagnetic changeover valve is interposed between the sixth ink flow channel 844 and the seventh ink flow channel 845.

**[0095]** A check valve 849 that allows only flow in a direction from the first three-way changeover valve 846 to the second three-way changeover valve 847, a third liquid feeding pump 850 serving as a liquid feeding portion that feeds a liquid in the same direction as the direction allowed by the check valve 849, and a relief valve 851 that returns the ink to the sub tank 82 when regulated pressure is exceeded at the downstream side of the third liquid feeding pump 850 are installed in the fifth ink flow channel 843.

**[0096]** One end portion of a branched flow channel 852 merges into and is connected with the sixth ink flow channel 844 in the middle, and the other end portion of the branched flow channel 852 is connected to the first three-way changeover valve 846. The first three-way changeover valve 846 can perform switching between a state in which the fifth ink flow channel 843 is connected to the fourth ink flow channel 842 and a state in which the fifth ink flow channel 843 is connected to the branched flow channel 852 under the control of the control apparatus 9.

**[0097]** The second three-way changeover valve 847 is also connected to a return flow channel 853 for returning the ink to the sub tank 82, and the second three-way changeover valve 847 can perform switching between a state in which the fifth ink flow channel 843 is connected to the sixth ink flow channel 844 and a state in which the fifth ink flow channel 843 is connected to the return flow channel 853 under the control of the control apparatus 9.

**[0098]** The control apparatus 9 performs switching control on the first and second three-way changeover valves 846 and 847 at the same time in combination with each other, and performs control such that switching between a supply connection state (a white arrow in Fig. 3) in which the ink is fed from the intermediate tank 84 to the negative pressure forming portion 86 side (or the head side) via the fourth to sixth ink flow channels 842, 843, and 844 and a return connection state (a black arrow in Fig. 3) in which the ink is fed from the negative pressure forming portion 86 side (or the head side) to the sub tank 82 side via the branched flow channel 852, the fifth ink flow channel 843, and the return flow channel 853 is performed.

**[0099]** In other words, supply of the ink to the negative pressure forming portion 86 side and recovery of the ink from the negative pressure forming portion 86 side can be freely selectively executed using feeding pressure of the third liquid feeding pump 850.

**[0100]** The third three-way changeover valve 848 is also connected with a bypass flow channel 854 in which the ink is supplied to the head side without intervention of the negative pressure forming portion 86, and can perform switching between a state in which the sixth ink flow channel 844 is connected with the seventh ink flow channel 845 and a state in which the sixth ink flow channel 844 is connected with the bypass flow channel 854 under the control of the control apparatus 9.

**[0101]** In other words, it is possible to perform switching between the state in which the supply and recovery of the ink to and from the negative pressure forming portion 86 are executable and the state in which the supply and recovery of the ink to and from the head 3 side (strictly, the common flow channel 87) are executable through this switching.

**[0102]** The negative pressure forming portion 86 mainly includes a rectangular main body container 861 in which a large opening is formed in a front surface, a film member 862 made of a flexible resin film that blocks the opening of the main body container 861, and a spring (not illustrated) that pressing the center of the film member 862 from the inside of the main body container 861 to the outside.

**[0103]** The main body container 861 is connected with the seventh ink flow channel 845 and an eighth ink flow channel 863 communicating with the common flow channel 87 to which all the first ports 341 of the nine heads 3 are connected in parallel.

**[0104]** Since the center of the film member 862 is pressed to the outside through the spring, the film member 862 is in a tension state in a shape in which it protrudes to the outside in a substantially conical form.

**[0105]** After the main body container 861 is fully filled with the ink through the same pressure as the atmosphere pressure, by causing the first and second three-way changeover valves 846 and 847 to enter the return connection state and recovering the ink from the main body container 861, it is possible to cause the insides of the heads 3 to enter the negative pressure state lower than the atmosphere pressure through the common flow channel 87. When the nozzle 3 has the atmosphere pressure, the ink is likely to leak from the nozzle, and the ink is likely to be attached to portions around the nozzle, leading to poor ejection or a variation in a dot diameter, and thus the inside of the head 3 is maintained to be the negative pressure as described above to prevent this problem.

**[0106]** Target pressure serving as the negative pressure can be controlled by adjusting an amount of recovered ink in the main body container 861.

**[0107]** A communication tube 864 extending upwards from the inside of the main body container 861 is installed above the main body container 861 of the negative pressure forming portion 86. A liquid level sensor 865 is attached to an end portion of the communication tube 864 at the main body container 861 side, and a pressure sensor 866 is attached to an upper end portion of the communication tube 864. A branched tube 867 that has one end opened in the air and extends horizontally is connected to a middle portion of the communication tube 864, and an open valve 868 that opens or closes the branched tube 867 and an air filter 869 that filters the air are installed in the middle of the branched tube 867.

**[0108]** This configuration is used when the ink is supplied to the inside of the main body container 861, and control is performed such that predetermined negative pressure is formed. In other words, in the state in which the open valve 868 is opened, the ink is supplied to the inside of the main body container 861 until the liquid level sensor 865 detects the liquid level, and then, the open valve 868 is closed, and the ink is recovered from the inside of the main body container 861 until the pressure sensor 866 shows the negative pressure of the target. As a result, it is possible to cause the inside of each head 3 to have a predetermined negative pressure state through the negative pressure forming portion 86.

**[0109]** The eighth ink flow channel 863 extending from the negative pressure forming portion 86 merges with the bypass flow channel 854 and is connected to the common flow channel 87. A protection valve 871 serving as a normally opened electromagnetic valve is installed at a position closer to the negative pressure forming portion 86 than a merging point with the bypass flow channel 854 in the eighth ink flow channel 863.

**[0110]** The common flow channel 87 is mounted on the carriage 4, the eighth ink flow channel 863 is connected to an upper portion of the common flow channel 87, and the first ports 341 of the nine heads 3 for the same color are connected to a bottom portion of the common flow channel 87 in parallel.

**[0111]** A waste liquid flow channel 872 serving as a discharge flow channel communicating with a waste liquid tank (not illustrated) is connected to the upper portion of the common flow channel 87. In the waste liquid flow channel 872, a waste liquid valve 873 serving as a normally closed electromagnetic valve is installed, and when the common flow channel 87 is fully filled with the ink, the waste liquid valve 873 is opened, and air bubbles are discharged.

**[0112]** The common flow channel 87 is connected to the first ports 341 of the heads 3 via a recording operation valve 874 serving as a normally opened electromagnetic valve. The second ports 342 of the heads 3 are connected to a common waste liquid flow channel 876 in parallel via normally closed maintenance valves 875.

**[0113]** At the time of image forming or maintenance, the ink is supplied from the common flow channel 87 to the heads 3 via the first ports 341. At the time of image forming, the maintenance valve 875 of the second port 342 is closed, and when a maintenance process (air bubble discharging or the like) in which no ink is ejected is performed, the ink supply is performed such that the maintenance valve 875 is opened, the ink flows into the first port 341, and the ink is discharged from the second port 342.

[Control apparatus]

**[0114]** Fig. 6 is a block diagram illustrating a control system of the ink supply apparatus 8. The control apparatus 9 illustrated in Fig. 6 controls the whole inkjet printing apparatus 1, but only a configuration of the ink supply apparatus 8 is illustrated herein, and the remaining configuration is not illustrated. For a plurality of components, only one component is illustrated.

**[0115]** The control apparatus 9 controls not only the ink supply apparatus 8, for example, such that image data of an image to be recorded on the recording medium which is input from an external apparatus is converted into data corresponding to the nozzles of the heads 3 but also driving of the respective portions of the inkjet printing apparatus 1.

**[0116]** As illustrated in Fig. 6, the control apparatus 9 is configured with a general-purpose computer in which the CPU 91, a ROM 92, a RAM 93, an input/output interface (not illustrated), and the like are connected to a bus.

**[0117]** The control apparatus 9 is connected to the first to third liquid feeding pumps 814, 829, and 850, the vacuum pump 832, the tank valve 812, the atmosphere open valve 834, the first to third three-way changeover valves 846, 847, ad 848, the open valve 868, the protection valve 871, the waste liquid valve 873, the recording operation valve 874, and the maintenance valve 875 which are control targets of the control apparatus 9.

**[0118]** The control apparatus 9 is further connected to the residue sensor 815, the first and second liquid level sensors 826 and 827, the liquid measure sensor 841, the liquid level sensor 865, the pressure switch 833, the pres-

sure sensor 866, and the nozzle sensor 72, and various kinds of detection signals are input from the sensors to the control apparatus 9.

**[0119]** The control apparatus 9 is further connected to a power switch 96, and the control apparatus 9 receives a power-on signal and performs a process of turning on a main power source, and receives an input of a power-off signal and performs a process of turning off the main power source.

**[0120]** The control apparatus 9 is further connected to an input operation portion 94 that receives, for example, a support of execution of various kinds of operations from an operator, a display portion 95 that displays various kinds of information such as error information, and the like.

**[0121]** The control apparatus 9 executes various kinds of control on the control targets according to detection information, but in the present embodiment, particularly, the description will proceed focusing on control related to a deaeration process of removing the dissolved oxygen in the ink centering on the components around the deaerator 83.

[Pump drying control]

**[0122]** As described above, the vacuum pump 832 of the deaerator 83 has the structure that is adversely affected by attachment of internal moisture, and thus pump drying control for removing the moisture by introducing the air into the vacuum pump 832 at various kinds of timings which will be described later is performed.

**[0123]** The pump drying control will be described with reference to a flowchart of Fig. 7.

**[0124]** In the pump drying control, the CPU 91 opens the atmosphere open valve 834 (step S1), starts driving of the vacuum pump 832 (step S3), and introduces the air into the vacuum pump 832. As a result, even when the moisture invaded from the deaeration module 831 reaches vacuum pump 832, the moisture is removed by the air having low humidity, and the inside of the vacuum pump 832 is dried.

**[0125]** Then, the air is continuously introduced during a predetermined drying period t2 of time (step S5). The drying period t2 of time can be appropriately changed by an input from the input operation portion 94.

**[0126]** Then, when the drying period t2 of time elapses, the CPU 91 closes the atmosphere open valve 834 (step S7), and the pressure of the inside of the vacuum path 836 that becomes the atmosphere pressure is reduced by the vacuum pump 832. At this time, in order to determine the occurrence of an abnormality in the vacuum pump 832, the CPU 91 starts to measure the first pump continuous driving period t4 of time necessary for reducing the suction pressure from the atmosphere pressure to the lower limit pressure through the vacuum pump 832.

**[0127]** Then, the CPU 91 determines whether or not the electric signal ON is input from the pressure switch 833 (step S9), and when no electric signal ON is input, the CPU 91 determines whether or not the current first pump continuous driving period t4 of time exceeds a first determination period t3 of time for determining the occurrence of an abnormality in the vacuum pump 832 (step S11). Then, when the first pump continuous driving period t4 of time does not exceed the first determination period t3 of time, the process returns to the determination of step S9.

**[0128]** When t4 > t3, a suction capability of the vacuum pump 832 is determined to have drastically decreased, and control is performed such that a notification indicating the abnormality of the vacuum pump 832 is given. As the notification control, for example, an abnormality notification screen is displayed on the display portion 95 installed along with the control apparatus 9, a lamp is turned on, or a buzzer is sounded. In this case, the pump drying control is suspended until the vacuum pump 832 is restored.

**[0129]** When the electric signal ON of the pressure switch 833 is detected in step S9, the pressure of the inside of the vacuum path 836 is regarded as reaching the lower limit pressure, the vacuum pump 832 is stopped (step S13), and the pump drying control ends.

**[0130]** The CPU 92 decides a measurement value of the first pump continuous driving period t4 of time until the electric signal ON of the pressure switch 833 is detected, and records the measurement value in the RAM 93.

**[0131]** The control apparatus 9 executes the pump drying control according to various situations until the inkjet printing apparatus 1 is powered off after it is powered on.

**[0132]** Next, the pump drying control in various kinds of situations will be described.

[At time of power on]

**[0133]** The pump drying control is executed when the inkjet printing apparatus 1 is powered on. Fig. 8 is a flowchart when the power switch 96 is turned on, and the CPU 91 performs the process at the time of power on on the deaerator 83. In the case in which the pump drying control is executed at the time of power on, the second liquid feeding pump 829 is in the state in which driving is stopped, and it is the state in which the supply of the ink from the deaeration module 831 to the downstream side is stopped.

**[0134]** When the ON state of the power switch 96 is detected, the CPU 91 executes the pump drying control illustrated in Fig. 7 (step S21).

**[0135]** When the pump drying control is completed, the vacuum path 836 and the internal space of the hollow fiber membrane 831a of the deaeration module 831 enter the state in which the pressures is reduced to the lower limit pressure. The CPU 91 maintains this state until a predetermined reduced pressure maintaining period t1 of time elapses (step S23). The reduced pressure maintaining period t1 of time is a period of time in which the dissolved oxygen in the ink in the deaeration module 831

can be sufficiently removed under the pressure equal to or lower than the upper limit pressure, and the reduced pressure maintaining period t1 of time can be appropriately changed by an input from the input operation portion 94.

**[0136]** Until the reduced pressure maintaining period t1 of time elapses, the CPU 91 maintains a standby state (a set-up state), for example, even when an image forming instruction or a maintenance instruction is received.

**[0137]** Then, when the reduced pressure maintaining period t1 of time elapses, the CPU 91 releases the standby state and enters a state in which the image forming instruction or the maintenance instruction can be received (step S25).

[At time of standby]

**[0138]** The pump drying control is also executed at the time of standby in which the image forming instruction or the maintenance instruction is not received. Fig. 9 is a flowchart when the CPU 91 executes the pump drying control on the deaerator 83 at the time of standby. In the case where the pump drying control is executed at the time of standby, the second liquid feeding pump 829 is in the state in which driving is stopped, and it is the state in which the supply of the ink from the deaeration module 831 to the downstream side is stopped.

**[0139]** In the standby state, the CPU 91 determines whether or not the electric signal ON is input from the pressure switch 833 (step S31), and when no electric signal ON is input, the CPU 91 drives the vacuum pump 832, and reduces the pressure of the inside of the vacuum path 836 to the lower limit pressure (step S33).

**[0140]** When the input of the electric signal ON of the pressure switch 833 is detected, the pressure of the inside of the vacuum path 836 is regarded as reaching the lower limit pressure, and the driving of the vacuum pump 832 is stopped (step S35).

**[0141]** Then, the pump drying control illustrated in Fig. 7 is executed, and thereafter, the process ends.

**[0142]** The process in the standby state is repeatedly performed periodically.

[At time of image forming]

**[0143]** The pump drying control is executed even when the image forming instruction is received, and the image forming is performed. Fig. 10 is a flowchart when the CPU 91 performs the pump drying control on the deaerator 83 at the time of image forming.

**[0144]** At the time of image forming, the third liquid feeding pump 850 supplies the ink in the intermediate tank 84 to the head 3 side by a predetermined amount at regular intervals. Then, after the ink of the intermediate tank 84 is reduced accordingly, the second liquid feeding pump 829 supplies the ink from the sub tank 82 to the downstream side through the deaeration module 831 based on the detection of the liquid measure sensor 841. In other words, when the ejection of the ink from the heads 3 starts by the image forming, the second liquid feeding pump 829 is intermittently driven according to the consumption of the ink and supplies the ink, and thus in the execution of the pump drying control at the time of image forming, consideration is made so that the ink that is insufficiently deaerated is not fed from the deaeration module 831 to the downstream side. Based on this, the pump drying control at the time of image forming will be described below.

**[0145]** Upon receiving image data together with the image forming instruction (step S41), the CPU 91 executes the pump drying control illustrated in Fig. 7 using a period of time necessary for processing and storage of the image data before driving of the heads 3 is started (step S43). In other words, initial pump drying control is executed in the state in which the ink supply by the liquid feeding pumps 829 and 850 is not performed since the heads 3 are not being driven.

**[0146]** When the initial pump drying control is completed, the carriage 4 moves to an image forming position, the heads 3 are driven to eject the ink, and the image forming starts (step S45). Thereafter, the liquid feeding pumps 829 and 850 are driven according to the amount of consumed ink, and the supply of the ink is intermittently performed (step S47).

**[0147]** In the deaerator 83, since the initial pump drying control has been already executed, the pressures of the vacuum path 836 and the internal space of the hollow fiber membrane 831a of the deaerator 83 are reduced to be at least lower than the upper limit pressure.

**[0148]** Then, the CPU 91 determines whether or not the electric signal ON is input from the pressure switch 833 (step S49), and when no electric signal ON is input, the CPU 91 starts the driving of the vacuum pump 832. At this time, the CPU 91 starts to measure the second pump continuous driving period t8 of time necessary for reducing the suction pressure from the upper limit pressure to the lower limit pressure through the vacuum pump 832 (step S51). Then, the process returns to step S49 again.

**[0149]** On the other hand, when the input of the electric signal ON from the pressure switch 833 is detected in step S49, the CPU 91 stops the driving of the vacuum pump 832 (step S53), and decides the measured value of the second pump continuous driving period t8 of time (step S55).

**[0150]** Then, it is determined whether or not the second pump continuous driving period t8 of time exceeds a second determination period t5 of time (step S57). The second determination period t5 of time is a value obtained by adding a marginal delay time to an average required time necessary for reducing the suction pressure from the upper limit pressure to the lower limit pressure through the vacuum pump 832, and when the second determination period t5 of time is not exceeded, it indicates that the vacuum pump 832 is in a good state, whereas when the second determination period t5 of time is

exceeded, it indicates that the vacuum pump 832 is slightly in a malfunction state.

**[0151]** The second determination period t5 of time can be appropriately changed by an input from the input operation portion 94.

**[0152]** The measurement value of the second pump continuous driving period t8 of time started immediately after the image forming starts to be measured in the state in which the pressure of the vacuum path 836 does not increase up to the upper limit pressure, and thus the measured second pump continuous driving period t8 of time is shorter than an actual one, but, for the second pump continuous driving period t8 of time measured for the second time or later, it is possible to accurately acquire a period of time necessary for reducing the suction pressure from the upper limit pressure to the lower limit pressure through the vacuum pump 832.

**[0153]** Then, when the second pump continuous driving period t8 of time does not exceed the second determination period t5 of time, the vacuum pump 832 is regarded as being in the good state, and the process proceeds to step S63.

**[0154]** On the other hand, when the second pump continuous driving period t8 of time exceeds the second determination period t5 of time, the vacuum pump 832 further determines whether or not the second pump continuous driving period t8 of time exceeds the third determination period t6 of time (step S59).

**[0155]** The third determination period t6 of time is longer than the second determination period t5 of time, and when the third determination period t6 of time is exceeded, it indicates that the vacuum pump 832 is suspected to be in a state in which a failure occurred. The third determination period t6 of time can be appropriately changed by an input from the input operation portion 94 as well.

**[0156]** Then, when the second pump continuous driving period t8 of time exceeds the third determination period t6 of time, an abnormality is regarded as occurring in the vacuum pump 832, and control is performed such that a notification indicating the abnormality of the vacuum pump 832 is given. As the notification control, similarly to the pump drying control, for example, an abnormality notification screen is displayed on the display portion 95, a lamp is turned on, or a buzzer is sounded. In this case, the process is suspended until the vacuum pump 832 is restored.

**[0157]** On the other hand, when the second pump continuous driving period t8 of time is determined not to exceed the third determination period t6 of time in step S59, the vacuum pump 832 is regarded as being in the malfunction state, and a power-off drying execution flag for executing the pump drying control at the time of power off is set to an ON state and recorded in the RAM 93 (step S61).

**[0158]** Then, the CPU 91 calculates a deaerated ink consumption period t7 of time that is obtained based on an ink capacity of the deaeration module 831 and an ink consumption speed at the time of image forming (step S63).

**[0159]** The deaerated ink consumption period t7 of time is a predicted period of time taken until the deaerated ink stored in the deaeration module 831 is all consumed at the time of image forming. The deaerated ink consumption period t7 of time is calculated by dividing the ink amount storable in the deaeration module 831 by the ink consumption speed at the time of image forming.

**[0160]** The ink amount of the deaeration module 831 is measured in advance and stored in a memory (not illustrated). For example, the ink consumption speed at the time of image forming is acquired based on the image data received together with the image forming instruction with reference to table data that indicates a correspondence relation between the number of dots to be ejected that is obtained based on the image data and an amounted of consumed ink per unit time and is stored in a memory (not illustrated).

**[0161]** Then, the CPU 91 performs a comparison process using the following Equation based on the following parameters (step S65) :

$$t7 > t2 + t4 + t1$$

t7: the deaerated ink consumption period of time calculated in step S63

t2: the drying period of time for the vacuum pump 832 in the pump drying control

t4: the first pump continuous driving period of time that is necessary for reducing the suction pressure from the atmosphere pressure to the lower limit pressure and acquired by measurement in the pump drying control

t1: the reduced pressure maintaining period of time necessary for sufficiently reducing the dissolved oxygen in the ink in the deaeration module 831 at the pressure equal to or lower than the upper limit pressure

**[0162]** In other words, the CPU 91 determines whether or not the period of time in which the deaerated ink in the deaeration module 831 is all consumed by the image forming that is currently being performed is enough as the period of time in which the vacuum pump is dried in the pump drying control, the period of time in which the pressure reduction from the atmosphere pressure to the lower limit pressure after the drying is performed, and the period of time in which the deaeration is performed at the reduced pressure.

**[0163]** Then, when the period of time is not enough ($t7 \leq t2 + t4 + t1$), the process proceeds to step S69 without performing the pump drying control.

**[0164]** However, when the period of time is enough ($t7 > t2 + t4 + t1$), the pump drying control illustrated in Fig. 7 is executed (step S67).

**[0165]** Even while the pump drying control is being executed, the ink can be fed by the second liquid feeding pump 829, but the pump drying control ends, and new ink deaeration is also completed until the deaerated ink is all fed, and thus insufficient supply of the deaerated ink can be prevented.

**[0166]** Then, the CPU 91 determines whether or not the image forming has ended (step S69). When the image forming is continuously performed, the process returns to step S49 again, and the output of the pressure switch 833 is monitored.

**[0167]** Further, when the image forming is completed, the ink supply control is also completed (step S71), and the entire process ends.

[At time of maintenance (extrusion process)]

**[0168]** The pump drying control is also executed at the time of maintenance accompanied by the ink supply. For example, when a relative large amount of ink is ejected from the nozzles of the heads 3 as in the extrusion process, the ink supply by the second and third liquid feeding pumps 829 and 850 is performed according to the above-described ink supply control, similarly to the time of image forming. Thus, in this case, the pump drying control is executed so that the ink that is insufficiently deaerated is not fed from the deaeration module 831 to the downstream side.

**[0169]** Fig. 11 is a flowchart when the CPU 91 performs the pump drying control on the deaerator 83 at the time of maintenance of the extrusion process.

**[0170]** In the pump drying control at the time of maintenance and the pump drying control at the time of image forming, many processes are common, and the reduced pressure maintaining period t1 of time, the drying period t2 of time, the first pump continuous driving period t4 of time, the second determination period t5 of time, the third determination period t6 of time, the deaerated ink consumption period t7 of time, and the second pump continuous driving period t8 of time are similarly applied, and thus a description thereof is omitted.

**[0171]** First, the CPU 91 starts the same ink supply control as that at the time of image forming through the liquid feeding pumps 829 and 850 according to the amount of consumed ink (step S81), and starts ink ejection from the nozzles of the heads 3 (step S83).

**[0172]** Then, the CPU 91 determines whether or not the electric signal ON is input from the pressure switch 833 (step S85), and when no electric signal ON is input, the CPU 91 starts the driving of the vacuum pump 832. At this time, the CPU 91 starts to measure the second pump continuous driving period t8 of time (step S87). Then, the process returns to step S85 again.

**[0173]** On the other hand, when the input of the electric signal ON of the pressure switch 833 is detected in step S85, the CPU 91 stops the driving of the vacuum pump 832 (step S89), and decides the measured value of the second pump continuous driving period t8 of time (step S91).

**[0174]** Then, it is determined whether or not the second pump continuous driving period t8 of time exceeds the second determination period t5 of time (step S93).

**[0175]** Then, when the second pump continuous driving period t8 of time does not exceed the second determination period t5 of time, the vacuum pump 832 causes the process to proceed to step S99.

**[0176]** On the other hand, when the second pump continuous driving period t8 of time exceeds the second determination period t5 of time, the vacuum pump 832 further determines whether or not the second pump continuous driving period t8 of time exceeds the third determination period t6 of time (step S95).

**[0177]** Then, when the second pump continuous driving period t8 of time exceeds the third determination period t6 of time, control is performed such that a notification indicating the abnormality of the vacuum pump 832 is given. Content of the notification control is the same as that at the time of image forming.

**[0178]** On the other hand, when the second pump continuous driving period t8 of time is determined not to exceed the third determination period t6 of time in step S95, the power-off drying execution flag is set to the ON state and recorded in the RAM 93 (step S97).

**[0179]** Then, the CPU 91 calculates the deaerated ink consumption period t7 of time (step S99), and performs a comparison process using the following Formula (step S101):

$$t7 > t2 + t4 + t1$$

**[0180]** Then, when $t7 \leq t2 + t4 + t1$, the process proceeds to step S105 without performing the pump drying control.

**[0181]** When $t7 > t2 + t4 + t1$, the pump drying control illustrated in Fig. 7 is executed (step S103).

**[0182]** As a result, even when the ink is supplied through the second liquid feeding pump 829 while the pump drying control is being executed, the supply of the ink that is insufficiently deaerated can be prevented.

**[0183]** Then, the CPU 91 determines whether or not a specified period of time in which the ejection of the extrusion process is continuously performed has elapsed (step S105). When the specified period of time has not elapsed, the process returns to step S85 again, and the output of the pressure switch 833 is monitored.

**[0184]** When the specified period of time has elapsed, the ink supply control is completed (step S107), the ejection of the ink from the nozzles of the heads 3 is also stopped (step S109), and the whole process ends.

[At time of maintenance (wiping process)]

**[0185]** The pump drying control is also executed at the time of maintenance not accompanied by the ink supply,

that is, at the time of the wiping process. Fig. 12 is a flowchart when the CPU 91 performs the pump drying control on the deaerator 83 at the time of maintenance, that is, at the time of the wiping process.

**[0186]** At the time of maintenance, since a small amount of ink is ejected, the second and third liquid feeding pumps 829 and 850 stop their driving.

**[0187]** First, the CPU 91 moves the carriage 4 to the maintenance unit 7, and starts a wiping operation on the nozzle surfaces of a group of heads of each color through the cleaning roller of the wiping apparatus (step S111).

**[0188]** Then, as the wipe operation starts, the pump drying control illustrated in Fig. 7 is executed (step S113).

**[0189]** After the pump drying control is completed, it is on standby until the wipe operation is completed (step S115), and the process ends.

**[0190]** In the wiping process, when the wiping operation ends, flushing by the heads 3 is performed, but since the flushing is small in the number of ejections, the ink supply is not performed.

[Nozzle failure confirmation process]

**[0191]** The pump drying control is also executed at the time of a nozzle failure confirmation process not accompanied with the ink supply. Fig. 13 is a flowchart when the CPU 91 performs the pump drying control on the deaerator 83 at the time of the nozzle failure confirmation process.

**[0192]** In the nozzle failure confirmation process, since a small amount of ink is ejected, the second and third liquid feeding pumps 829 and 850 stop their driving.

**[0193]** First, the CPU 91 moves the carriage 4 to a position above the ink tray 71 of the maintenance unit 7, and repeatedly executes the ejection operation through the heads 3 twice or more. Then, the nozzle sensor 72 detects the nozzle in which the ejection is not performed (step S121).

**[0194]** Then, as the ejection operations of the heads 3 start, the pump drying control illustrated in Fig. 7 is executed (step S123).

**[0195]** After the pump drying control is completed, it is on standby until the nozzle failure detection process is completed for all the heads 3 (step S125), and the process ends.

**[0196]** In the nozzle failure confirmation process, the ejection by the heads 3 is performed twice or more, but since an amounted of consumed ink is small, the ink supply is not performed.

[At time of power off]

**[0197]** The pump drying control is executed when the inkjet printing apparatus 1 is powered off. Fig. 14 is a flowchart when the power switch 96 is turned off, and the CPU 91 performs the process at the time of power off on the deaerator 83. In the case in which the pump drying control is executed at the time of power off, the second liquid feeding pump 829 is in the state in which driving is stopped, and it is the state in which the supply of the ink from the deaeration module 831 to the downstream side is stopped.

**[0198]** When the OFF state of the power switch 96 is detected (step S131), the CPU 91 reads the power-off drying execution flag stored in the RAM 93, and determines whether or not the flag is set to the ON state (step S133).

**[0199]** Then, when the flag is set to the OFF state, the process ends without change, and the power is turned off.

**[0200]** When the flag is set to the ON state, the pump drying control illustrated in Fig. 7 is executed (step S135), then the process ends, and the power is turned off.

**[0201]** When the pump drying control in step S135 is completed or being executed, the wiping process (and flushing) may be executed on the heads 3.

[Technical effects in embodiment of invention]

**[0202]** In the inkjet printing apparatus 1, the control apparatus 90 causes the atmosphere open valve 834 of the deaerator 83 to enter the atmosphere open state, and executes the pump drying control of operating the vacuum pump 832, and thus the outdoor air dryer than in the deaeration module 831 can be introduced into the pump 832, and thus the humidity of the pump 832 can be removed.

**[0203]** As a result, the deaeration of the ink by the vacuum pump 832 is excellently performed, and the degradation of the vacuum pump is suppressed, and the lifespan can be increased.

**[0204]** Particularly, when the pump drying control is executed in the stop state of the second liquid feeding pump 829, for example, at the time of power on, at the time of power off, in the standby state in which none of the image forming and the maintenance is executed, at the time of the wiping process, and at the time of the nozzle failure confirmation process, it is possible to dry the inside of the vacuum pump 832 with no specific process for preventing the supply of the ink that is insufficiently deaerated.

**[0205]** Further, even when it is accompanied by the supply of the ink by the second liquid feeding pump 829 as at the time of image forming or at the time of the extrusion process for the maintenance, the control apparatus 9 of the inkjet printing apparatus 1 performs the comparison determination using the deaerated ink consumption period t7 of time, the drying period t2 of time, the first pump continuous driving period t4 of time, and the reduced pressure maintaining period t1 of time as a parameter. Thus, since the pump drying control is executed after it is determined whether or not there is a period of time in which the pump drying control ends, and new ink deaeration is also completed until the deaerated ink is all fed from the deaeration module 831, it is possible to dry the inside of the vacuum pump 832 without supplying the ink that is insufficiently deaerated.

**[0206]** Further, the control apparatus 9 of the inkjet printing apparatus 1 measures the second pump continuous driving period t8 of time, determines whether or not the second pump continuous driving period t8 of time exceeds the second determination period t5 of time, and executes the pump drying control at the time of power off when the second pump continuous driving period t8 of time exceeds the second determination period t5 of time, and thus it is possible to dry, particularly, the inside of the vacuum pump 832 in which a malfunction occurred, and it is possible to improve the condition of the vacuum pump 832.

**[0207]** The control apparatus 9 of the inkjet printing apparatus 1 further determines whether or not the second pump continuous driving period t8 of time exceeds the third determination period t6 of time, and executes control such that a notification indicating the abnormality of the vacuum pump 832 is given when the second pump continuous driving period t8 of time exceeds the third determination period t6 of time, and thus it is possible to let the user recognize the abnormality of the vacuum pump 832 promptly, and it is possible to restore it rapidly.

**[0208]** Further, when it is hard to reduce the pressure from the atmosphere pressure to the lower limit pressure of the target within a predetermined period of time (the first determination period t3 of time) through the vacuum pump after the pump drying control, control is performed such that a notification indicating the abnormality of the vacuum pump 832 is given, and thus it is possible to let the user recognize the abnormality of the vacuum pump 832 promptly, and it is possible to restore it rapidly.

[Effect test]

**[0209]** Fig. 15 illustrates an effect test result when the pump drying control is executed on the vacuum pump.

**[0210]** The effect test was conducted using a diaphragm pump (NF-85.3DC (a 24V specification)) available from KNF Neuberger Inc. under an environment in which a room temperature is 25°C, and humidity is 38.0% to 40.0%.

**[0211]** As a test method, water of 0.11 [ml] was dropped on the vacuum path connected to the diaphragm pump. It is 10 times an amount of saturated water vapor of the volume of the vacuum path 836 of the inkjet printing apparatus 1.

**[0212]** In this state, the diaphragm pump was driven to suck the air, and after a specific period of time (15 seconds, 30 seconds, and 45 seconds) elapses, the diaphragm pump was disassembled, and the presence of moisture remaining on the inside was confirmed.

**[0213]** As a result, the moisture remained on the entire inside of the diaphragm pump when the pump was driven for 15 seconds, and the moisture remained in the vicinity of the outlet of the diaphragm pump and on the diaphragm when the pump was driven for 30 seconds.

**[0214]** On the other hand, the moisture was almost removed from the entire inside of the diaphragm pump when the pump was driven for 45 seconds.

**[0215]** Based on the above results, preferably, the drying period t2 of time is 45 seconds or more, and more preferably, the drying period t2 of time is set to 90 seconds by taking a double margin.

[Confirmation test of influence of moisture]

**[0216]** Figs. 16 and 17 illustrate a result of a confirmation test of influence of moisture (vapor) on the vacuum pump.

**[0217]** This test was conducted using a diaphragm pump (NF-85.3DC (a 24V specification)) available from KNF Neuberger Inc. under an environment in which a room temperature is 25°C, and humidity is 38.0% to 40.0%.

**[0218]** As a test method, vapor of tap water for humidification was sucked into the vacuum path (in which the deaeration module is removed) connected to the diaphragm pump for three minutes.

**[0219]** Thereafter, the deaeration module was connected again, and a period of time taken until the pressure reaches the lower limit pressure (-92 kPa (the differential pressure of the atmosphere pressure)) from the atmosphere pressure and a period of time taken until the pressure reaches the lower limit pressure (-92 kPa (the differential pressure of the atmosphere pressure)) from the upper limit pressure (-90 kPa (the differential pressure of the atmosphere pressure)) were measured three times. The measurement results are illustrated in Fig. 16.

**[0220]** Then, after the measurement, the pump drying control was executed for 90 seconds, and a period of time taken until the pressure reaches the lower limit pressure (-92 kPa (the differential pressure of the atmosphere pressure)) from the atmosphere pressure and a period of time taken until the pressure reaches the lower limit pressure (-92 kPa (the differential pressure of the atmosphere pressure)) from the upper limit pressure (-90 kPa (the differential pressure of the atmosphere pressure)) were measured three times. The measurement results are illustrated in Fig. 17.

**[0221]** As a result, an average period of time taken until the pressure reaches the lower limit pressure from the atmosphere pressure immediately after the vapor was sucked was 52 seconds, and an average period of time taken until the pressure reaches the lower limit pressure from the upper limit pressure immediately after the vapor was sucked was 31 seconds.

**[0222]** An average period of time taken until the pressure reaches the lower limit pressure from the atmosphere pressure after the pump drying control was executed was 23.6 seconds, an average period of time taken until the pressure reaches the lower limit pressure from the upper limit pressure immediately after the vapor was sucked was 9 seconds, and it is apparent that influence in which the moisture caused by the vapor is attached to the inside is remarkable in the diaphragm pump, and the pressure reduction is significantly delayed.

**[0223]** Based on the result, when a time out until the pressure of the vacuum pump reaches the lower limit pressure from the atmosphere pressure under the assumption that the pump drying control is not performed is set, 240 seconds that is about four time the average value of Fig. 16 is desirable, and when a time out until the pressure of the vacuum pump reaches the lower limit pressure from the upper limit pressure under the assumption that the pump drying control is not performed is set, 120 seconds that is about four time the average value of Fig. 16 is desirable.

[Others]

**[0224]** The present invention is not limited to the above embodiment, and various improvements and design changes may be performed within the scope not departing from the gist of the present invention.

**[0225]** For example, the example in which the pump drying control is performed in parallel with the maintenance process in various kinds of maintenance processes described above has been described, but the present invention is not limited thereto, and the pump drying control may be executed after the maintenance process is completed.

**[0226]** It may be determined whether or not the pump drying control according to a driving period of time of the second liquid feeding pump 829. In other words, it may be determined whether or not the second liquid feeding pump 829 has continuously performed liquid feeding during a predetermined period of time, and when the liquid feeding has been performed during more than the predetermined period of time, the deaerator 83 may be controlled such that the pump drying control is performed.

**[0227]** Further, the predetermined period of time in which the second liquid feeding pump 829 has continuously performed liquid feeding indicates a duration of the ink supply control in which the second liquid feeding pump 829 intermittently performs the liquid feeding.

**[0228]** In this case, there is no limitation to a timing at which the pump drying control is executed. For example, the pump drying control may start during the liquid feeding at a timing at which a predetermined period elapses after the liquid feeding starts, or the power-off drying execution flag may be set to the ON state at a timing at which a predetermined period elapses after the liquid feeding starts, and the pump drying control may be executed at the time of power off.

**[0229]** In the inkjet printing apparatus 1 of the above embodiment, the example in which the deaerator 83 and the second liquid feeding pump 829 are installed for each group of heads corresponding to the ink of each color, and the pump drying control is independently performed for each color with no mutual interference has been described, but the present invention is not limited to this example.

**[0230]** In other words, the pump drying control may be performed such that the deaerators 83 corresponding to the ink of the respective colors are associated with one another. For example, when the pump drying control is performed at the time of image forming, control may be performed such that one or more colors that are not used in the image forming are specified from image data in advance, and only the deaerator 83 corresponding to the corresponding color performs the pump drying control during the image forming. In this case, the comparison determination using the deaerated ink consumption period t7 of time, the drying period t2 of time, the first pump continuous driving period t4 of time, and the reduced pressure maintaining period t1 of time as the parameter may be omitted.

**[0231]** On the contrary, control may be performed such that one or more colors that are high in the amount of used ink in the image forming are selected from image data in advance, and only the deaerator 83 corresponding to the corresponding color performs the pump drying control after the image forming. In this case, the pump drying control during the image forming may not be performed.

**[0232]** In the inkjet printing apparatus 1 of the above embodiment, the example in which the deaerator 83 and the second liquid feeding pump 829 are installed for each group of heads corresponding to the ink of each color has been described, but the present invention is not limited to this example.

**[0233]** For example, the deaerator 83 and the second liquid feeding pump 829 may be installed for every two or more heads 3.

**[0234]** In this case, each deaerator 83 of the heads 3 may perform the pump drying control independently.

**[0235]** Further, control may be performed such that one or more colors that are not used in the image forming are specified from image data for each head 3 in advance, and only the deaerator 83 corresponding to each head 3 performs the pump drying control during the image forming. In this case, the comparison determination using the deaerated ink consumption period t7 of time, the drying period t2 of time, the first pump continuous driving period t4 of time, and the reduced pressure maintaining period t1 of time as the parameter may be omitted.

**[0236]** The embodiments disclosed herein are examples in all respects and not restrictive. The scope of the present invention is defined by the claims other than the above description and intended to include any modification within the meaning and scope equivalent to the claims.

Industrial Applicability

**[0237]** As described above, the present invention is suitable to provision of an inkjet printing apparatus and a method for controlling the inkjet printing apparatus, which are capable of reducing influence of moisture of ink.

Reference Signs List

**[0238]**

| | |
|---|---|
| 1 | inkjet printing apparatus |
| 3 | head (inkjet head) |
| 4 | carriage |
| 5 | main scanning apparatus |
| 6 | nozzle moisturizing unit |
| 7 | maintenance unit |
| 8 | ink supply apparatus |
| 9 | control apparatus |
| 20 | conveyance apparatus |
| 82 | sub tank (ink tank) |
| 83 | deaerator |
| 84 | intermediate tank |
| 86 | negative pressure forming portion |
| 9 | control apparatus |
| 96 | power switch |
| 100 | frame |
| 811 | ink flow channel |
| 814 | first liquid feeding pump |
| 829 | second liquid feeding pump |
| 850 | third liquid feeding pump |
| 823, 835 | ink flow channel |
| 831 | deaeration module |
| 831a | hollow fiber membrane |
| 832 | vacuum pump |
| 833 | pressure switch |
| 834 | atmosphere open valve |
| 835 | ink flow channel |
| 836 | vacuum path |
| 837 | branch passage |
| 842, 843, 844 | ink flow channel |
| 845 | ink flow channel |

## Claims

**1.** An inkjet printing apparatus comprising:

a deaeration module that is installed in a middle of an ink supply path in which ink is supplied from an ink tank to an inkjet head;
a vacuum pump that exposes ink to a vacuum through a gas permeable membrane of the deaeration module;
an atmosphere open valve that is capable of switching an inside of a path connecting the deaeration module with the vacuum pump between an airtight state and an atmosphere open state; and
a control apparatus that controls the vacuum pump and the atmosphere open valve,

wherein the control apparatus causes the atmosphere open valve to enter the atmosphere open state, and performs pump drying control such that the vacuum pump is operated.

**2.** The inkjet printing apparatus according to claim 1, further comprising
a liquid feeding pump that supplies the ink to the inkjet head side through the deaeration module.

**3.** The inkjet printing apparatus according to claim 2, wherein the control apparatus performs the pump drying control in a stop state of the liquid feeding pump.

**4.** The inkjet printing apparatus according to claim 3, wherein the control apparatus performs the pump drying control at the time of maintenance of the inkjet head or immediately after the maintenance.

**5.** The inkjet printing apparatus according to claim 3, wherein the control apparatus performs the pump drying control when the liquid feeding pump performs liquid feeding continuously during a predetermined period of time or more.

**6.** The inkjet printing apparatus according to claim 2, wherein the control apparatus performs pressure maintaining control such that driving of the vacuum pump starts at an upper limit pressure and stops at a lower limit pressure, and
the control apparatus performs the pump drying control after the lower limit pressure is reached by the pressure maintaining control when [a deaerated ink consumption period of time obtained based on an ink capacity of the deaeration module and an ink consumption speed at a time of image forming] > ([a specified drying period of time in the pump drying control] + [a reduced pressure maintaining period of time in which a pressure equal to or lower than the upper limit pressure is maintained to deaerate the ink in the deaeration module] + [a first pump continuous driving period of time necessary for reducing a suction pressure from an atmosphere pressure to the lower limit pressure through the vacuum pump]).

**7.** The inkjet printing apparatus according to any one of claims 1 to 6,
wherein the control apparatus performs pressure maintaining control such that driving of the vacuum pump starts at an upper limit pressure and stops at a lower limit pressure, and
the control apparatus executes the pump drying control at a time of power off in which a main power source of the inkjet printing apparatus is turned off when a second pump continuous driving period of time necessary for reducing a suction pressure from the upper limit pressure to the lower limit pressure through the vacuum pump exceeds a predetermined determination period of time.

**8.** The inkjet printing apparatus according to claim 7, wherein the control apparatus performs a wiping process for the inkjet head with execution of the pump drying control at the time of power off.

**9.** The inkjet printing apparatus according to claim 7 or 8,
wherein the control apparatus gives a notification indicating an abnormality of the vacuum pump when the second pump continuous driving period of time exceeds another determination period of time longer than the determination period of time.

**10.** The inkjet printing apparatus according to any one of claims 1 to 9,
wherein the control apparatus gives a notification indicating an abnormality of the vacuum pump when it is hard to perform pressure reduction to a desired lower limit pressure within a predetermined period of time through the vacuum pump after the pump drying control.

**11.** The inkjet printing apparatus according to claim 2,
wherein the deaeration module, the vacuum pump, and the atmosphere open valve are individually installed in association with ink of a plurality of colors, and
the control apparatus specifies one or more colors that are not used from image data for performing image forming, and performs the pump drying control on the vacuum pump corresponding to the ink of the specified color at the time of the image forming.

**12.** The inkjet printing apparatus according to claim 2,
wherein the deaeration module, the vacuum pump, and the atmosphere open valve are individually installed in association with ink of a plurality of colors, and
the control apparatus specifies one or more colors that are high in an amount of used ink from image data for performing image forming, and performs the pump drying control on the vacuum pump corresponding to the ink of the specified color after the image forming.

**13.** The inkjet printing apparatus according to claim 2,
wherein the deaeration module, the vacuum pump, and the atmosphere open valve are individually installed in association with a plurality of inkjet heads, and
the control apparatus specifies one or more inkjet heads that are not used from image data for performing image forming, and performs the pump drying control on the vacuum pump corresponding to the specified inkjet head at the time of the image forming.

**14.** A method for controlling an inkjet printing apparatus including
a deaeration module that is installed in a middle of an ink supply path in which ink is supplied from an ink tank to an inkjet head,
a vacuum pump that exposes ink to a vacuum through a gas permeable membrane of the deaeration module,
an atmosphere open valve that is capable of switching an inside of a path connecting the deaeration module with the vacuum pump between an airtight state and an atmosphere open state, and
a control apparatus that controls the vacuum pump and the atmosphere open valve, the method comprising
causing, by the control apparatus, the atmosphere open valve to enter the atmosphere open state and performing pump drying control such that the vacuum pump is operated.

**15.** The method for controlling an inkjet printing apparatus according to claim 14,
wherein the inkjet printing apparatus further includes a liquid feeding pump that supplies the ink to the inkjet head side through the deaeration module.

**16.** The method for controlling an inkjet printing apparatus according to claim 15,
wherein the control apparatus performs the pump drying control in a stop state of the liquid feeding pump.

**17.** The method for controlling an inkjet printing apparatus according to claim 16,
wherein the control apparatus performs the pump drying control at the time of maintenance of the inkjet head or immediately after the maintenance.

**18.** The method for controlling an inkjet printing apparatus according to claim 16,
wherein the control apparatus performs the pump drying control when the liquid feeding pump performs liquid feeding continuously during a predetermined period of time or more.

**19.** The method for controlling an inkjet printing apparatus according to claim 15,
wherein the control apparatus performs pressure maintaining control such that driving of the vacuum pump starts at an upper limit pressure and stops at a lower limit pressure, and
the control apparatus performs the pump drying control after the lower limit pressure is reached by the pressure maintaining control when [a deaerated ink consumption period of time obtained based on an ink capacity of the deaeration module and an ink consumption speed at a time of image forming] > ([a specified drying period of time in the pump drying control] + [a reduced pressure maintaining period of time in which a pressure equal to or lower than the

upper limit pressure is maintained to deaerate the ink in the deaeration module] + [a first pump continuous driving period of time necessary for reducing a suction pressure from an atmosphere pressure to the lower limit pressure through the vacuum pump]).

**20.** The method for controlling an inkjet printing apparatus according to any one of claims 14 to 19,
wherein the control apparatus performs pressure maintaining control such that driving of the vacuum pump starts at an upper limit pressure and stops at a lower limit pressure, and
the control apparatus executes the pump drying control at a time of power off in which a main power source of the inkjet printing apparatus is turned off when a second pump continuous driving period of time necessary for reducing a suction pressure from the upper limit pressure to the lower limit pressure through the vacuum pump exceeds a predetermined determination period of time.

**21.** The method for controlling an inkjet printing apparatus according to claim 20,
wherein the control apparatus performs a wiping process for the inkjet head with execution of the pump drying control at the time of power off.

**22.** The method for controlling an inkjet printing apparatus according to claim 20 or 21,
wherein the control apparatus gives a notification indicating an abnormality of the vacuum pump when the second pump continuous driving period of time exceeds another determination period of time longer than the determination period of time.

**23.** The method for controlling an inkjet printing apparatus according to any one of claims 14 to 22,
wherein the control apparatus gives a notification indicating an abnormality of the vacuum pump when it is hard to perform pressure reduction to a desired lower limit pressure within a predetermined period of time through the vacuum pump after the pump drying control.

**24.** The method for controlling an inkjet printing apparatus according to claim 14 or 15,
wherein the deaeration module, the vacuum pump, and the atmosphere open valve are individually installed in association with ink of a plurality of colors, and
the control apparatus specifies one or more colors that are not used from image data for performing image forming, and performs the pump drying control on the vacuum pump corresponding to the ink of the specified color at the time of the image forming.

**25.** The method for controlling an inkjet printing apparatus according to claim 14 or 15,
wherein the deaeration module, the vacuum pump, and the atmosphere open valve are individually installed in association with ink of a plurality of colors, and
the control apparatus specifies one or more colors that are high in an amount of used ink from image data for performing image forming, and performs the pump drying control on the vacuum pump corresponding to the ink of the specified color after the image forming.

**26.** The method for controlling an inkjet printing apparatus according to claim 14 or 15,
wherein the deaeration module, the vacuum pump, and the atmosphere open valve are individually installed in association with a plurality of inkjet heads, and
the control apparatus specifies one or more inkjet heads that are not used from image data for performing image forming, and performs the pump drying control on the vacuum pump corresponding to the specified inkjet head at the time of the image forming.

FIG. 1

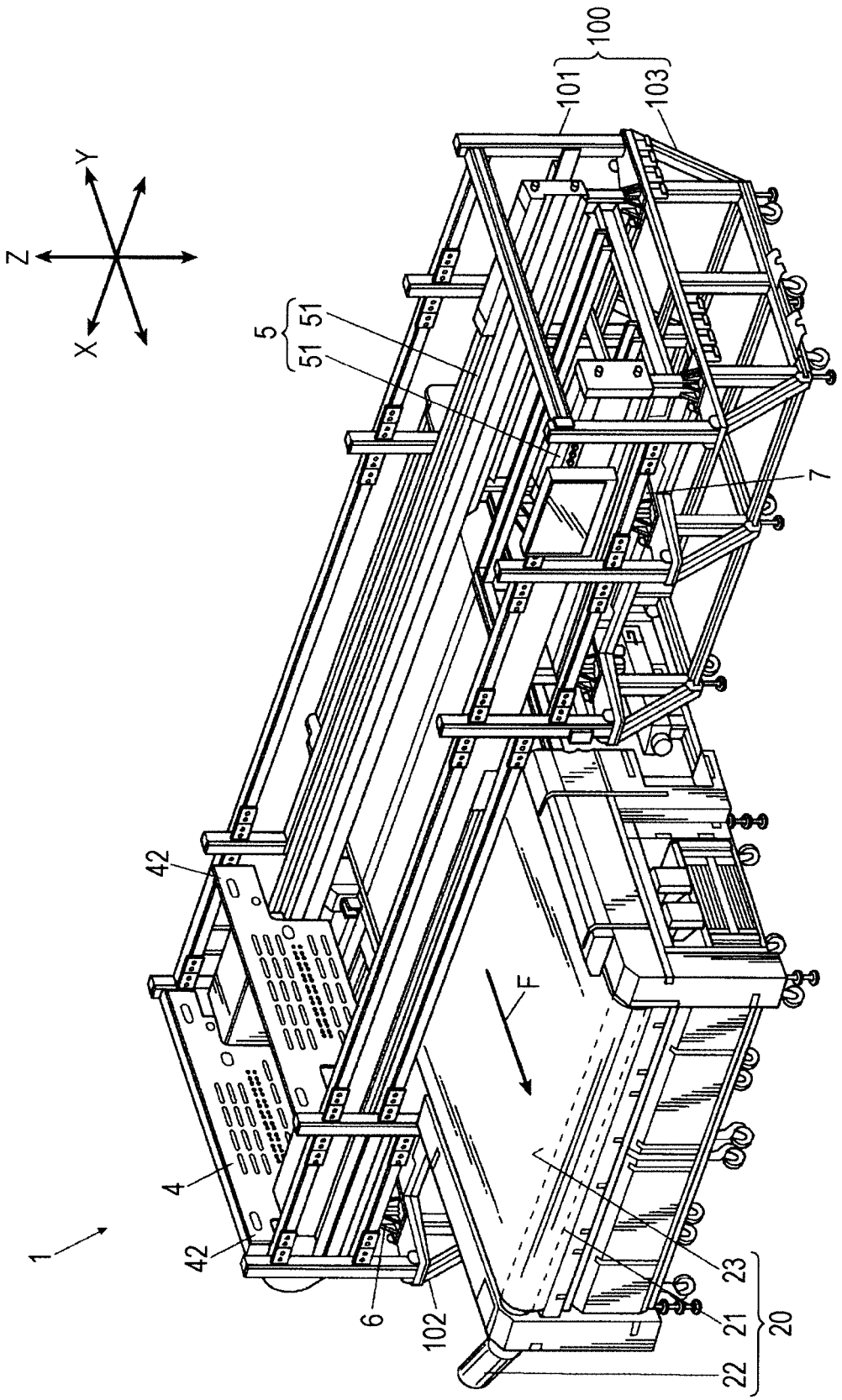


FIG. 2

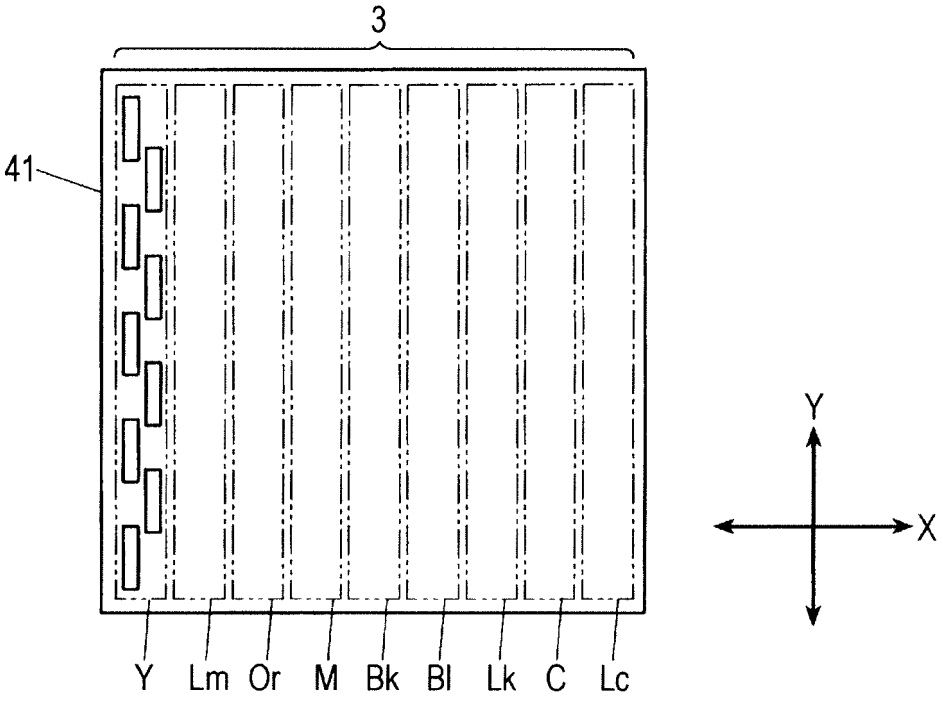
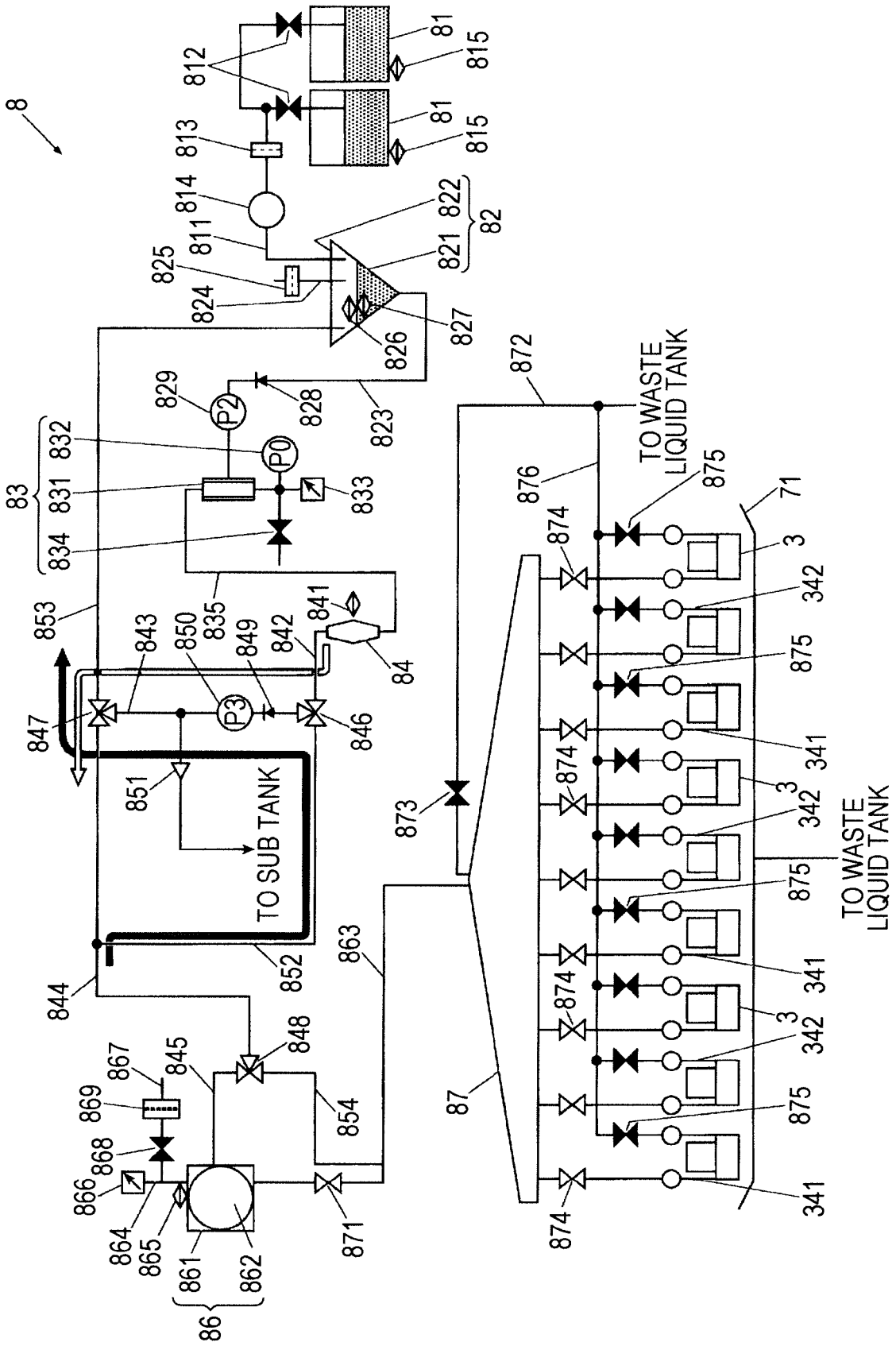


FIG. 3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P3
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TO SUB TANK
852
844
848
845
867
869
868
866
864
865
861
862
86
854
871
863
872
TO WASTE LIQUID TANK
876
875
71
874
3
342
341
873
87

FIG. 4

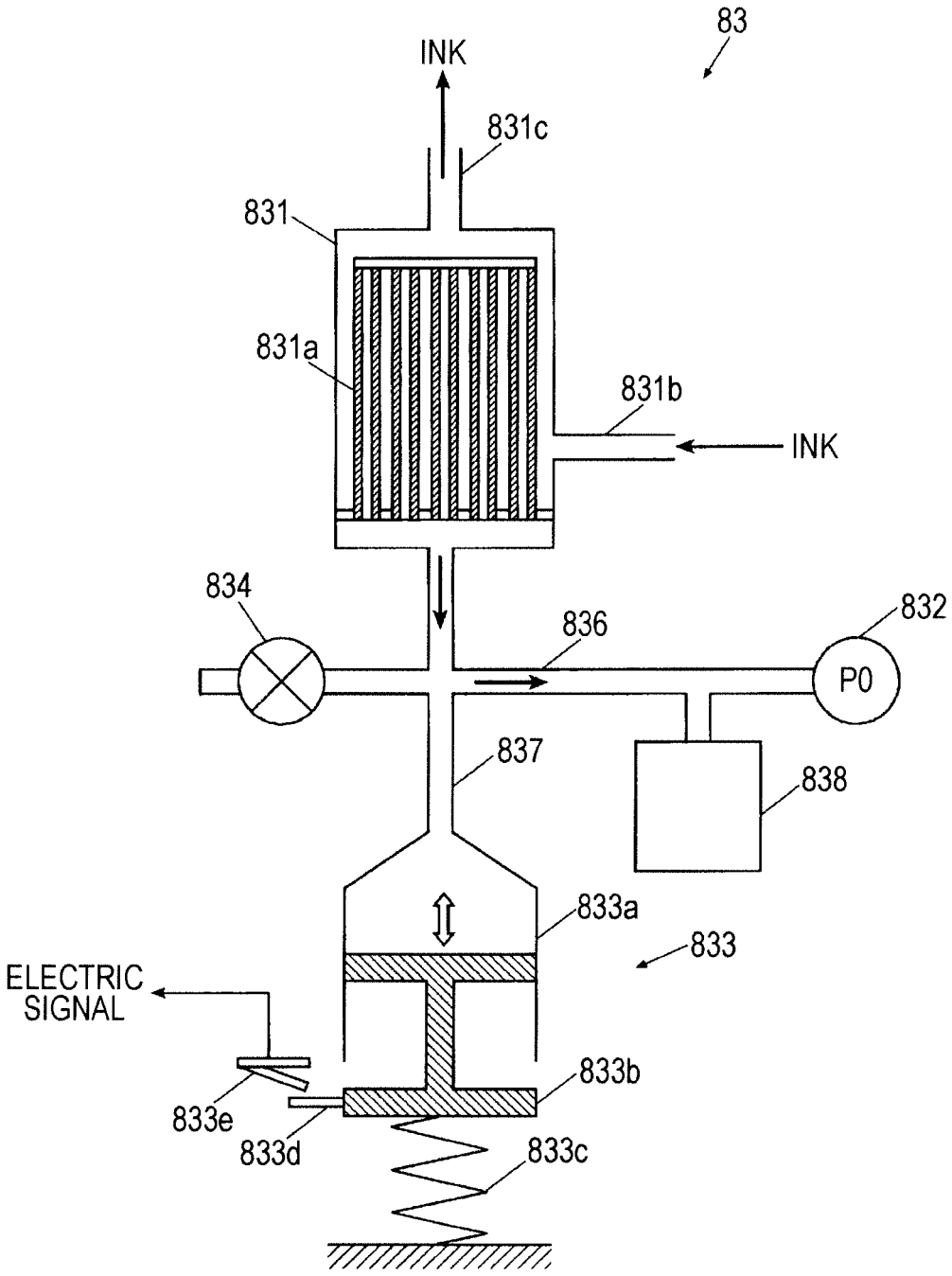
83
INK
831c
831
831a
831b
INK
834
836
832
P0
837
838
833a
833
ELECTRIC SIGNAL
833b
833e
833d
833c

FIG. 5

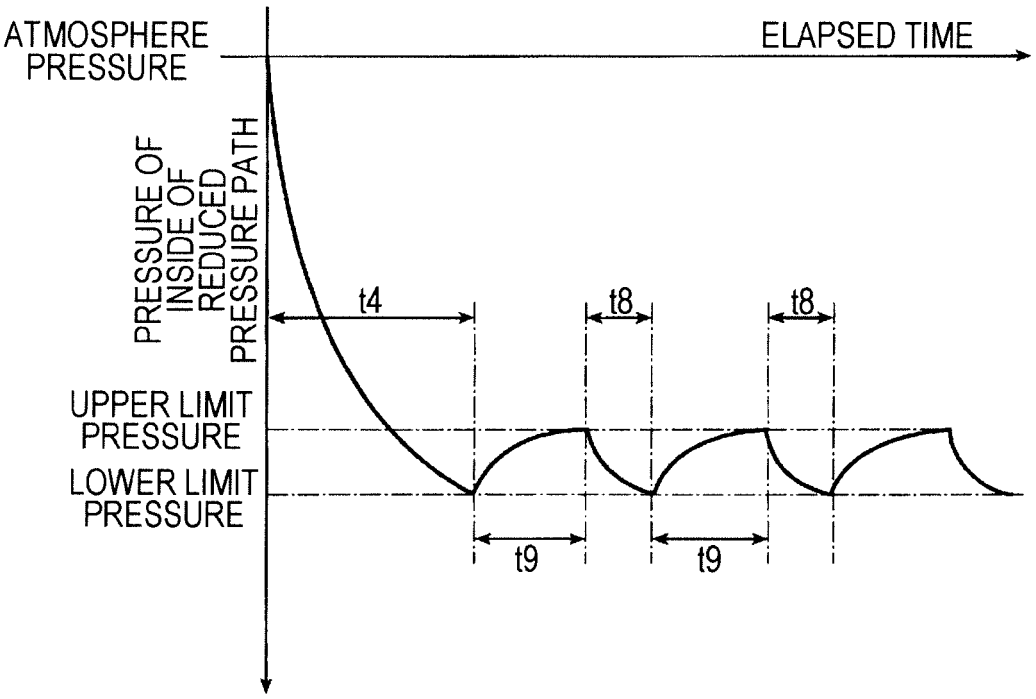
ATMOSPHERE PRESSURE
ELAPSED TIME
PRESSURE OF INSIDE OF REDUCED PRESSURE PATH
t4
t8
t8
UPPER LIMIT PRESSURE
LOWER LIMIT PRESSURE
t9
t9

FIG. 6

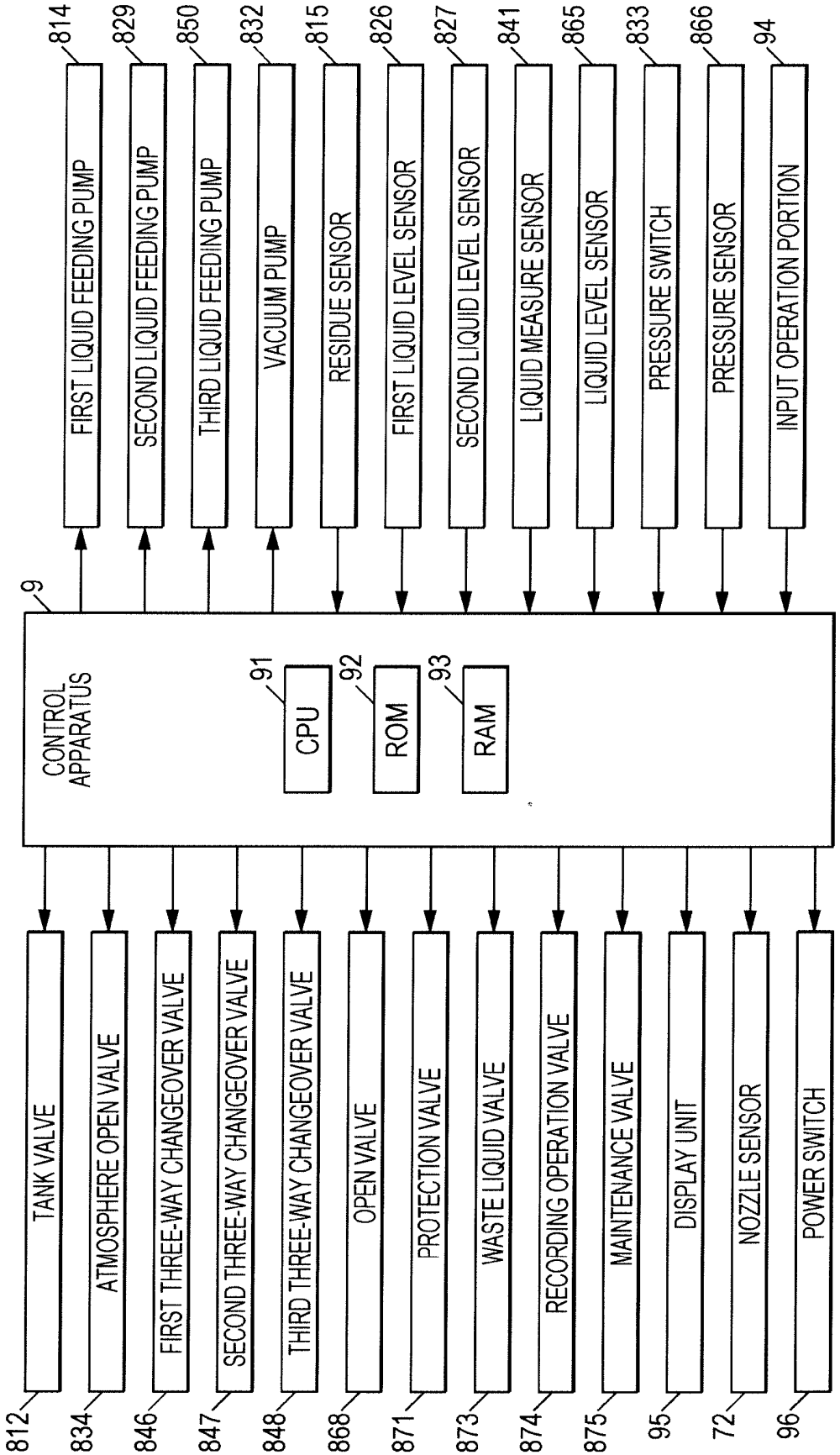
814
FIRST LIQUID FEEDING PUMP
829
SECOND LIQUID FEEDING PUMP
850
THIRD LIQUID FEEDING PUMP
832
VACUUM PUMP
815
RESIDUE SENSOR
826
FIRST LIQUID LEVEL SENSOR
827
SECOND LIQUID LEVEL SENSOR
841
LIQUID MEASURE SENSOR
865
LIQUID LEVEL SENSOR
833
PRESSURE SWITCH
866
PRESSURE SENSOR
94
INPUT OPERATION PORTION
9
CONTROL APPARATUS
91
CPU
92
ROM
93
RAM
812
TANK VALVE
834
ATMOSPHERE OPEN VALVE
846
FIRST THREE-WAY CHANGEOVER VALVE
847
SECOND THREE-WAY CHANGEOVER VALVE
848
THIRD THREE-WAY CHANGEOVER VALVE
868
OPEN VALVE
871
PROTECTION VALVE
873
WASTE LIQUID VALVE
874
RECORDING OPERATION VALVE
875
MAINTENANCE VALVE
95
DISPLAY UNIT
72
NOZZLE SENSOR
96
POWER SWITCH

FIG. 7

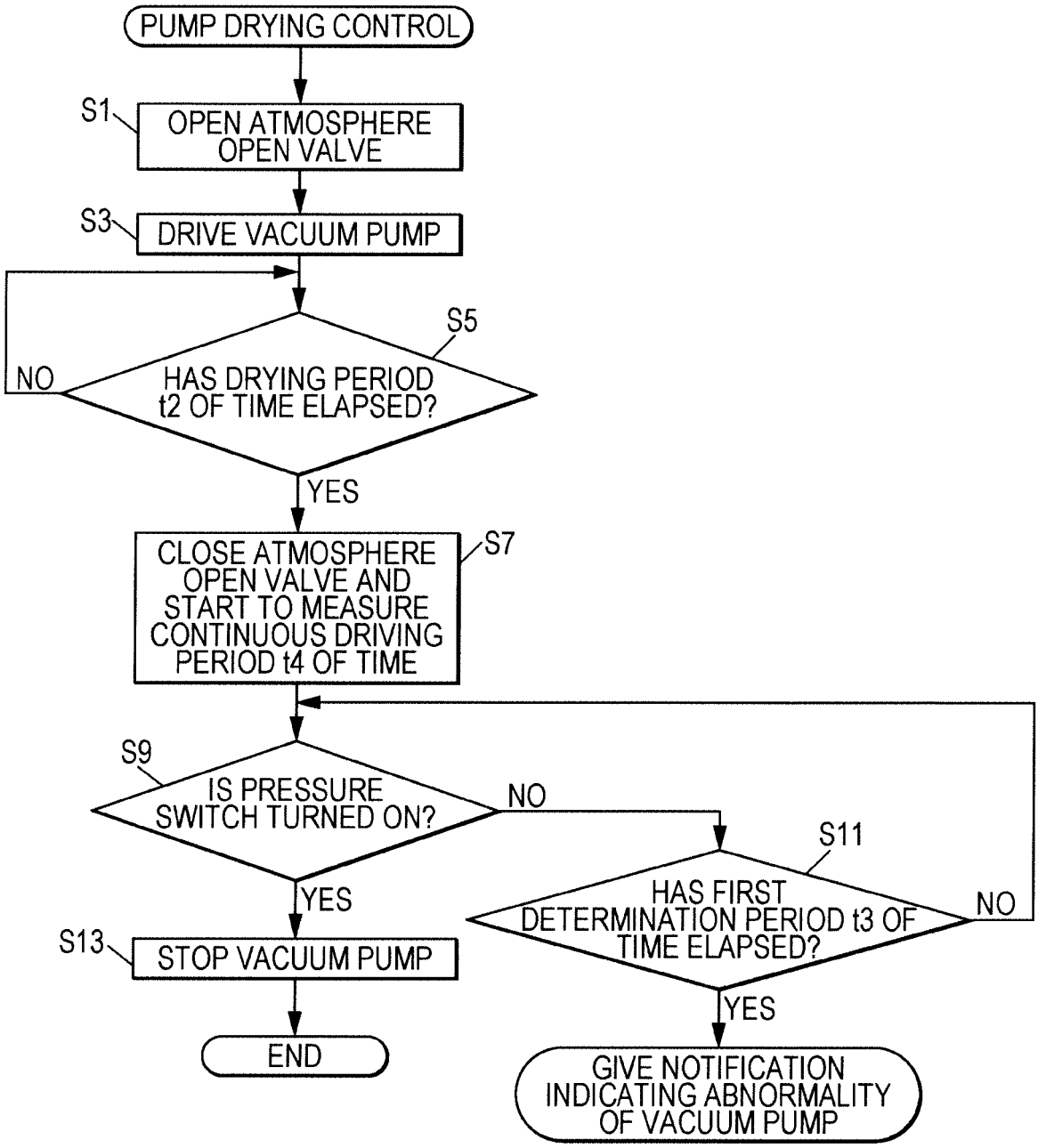
PUMP DRYING CONTROL
S1
OPEN ATMOSPHERE OPEN VALVE
S3
DRIVE VACUUM PUMP
S5
NO
HAS DRYING PERIOD t2 OF TIME ELAPSED?
YES
S7
CLOSE ATMOSPHERE OPEN VALVE AND START TO MEASURE CONTINUOUS DRIVING PERIOD t4 OF TIME
S9
IS PRESSURE SWITCH TURNED ON?
NO
S11
HAS FIRST DETERMINATION PERIOD t3 OF TIME ELAPSED?
NO
YES
S13
STOP VACUUM PUMP
YES
END
GIVE NOTIFICATION INDICATING ABNORMALITY OF VACUUM PUMP

FIG. 8

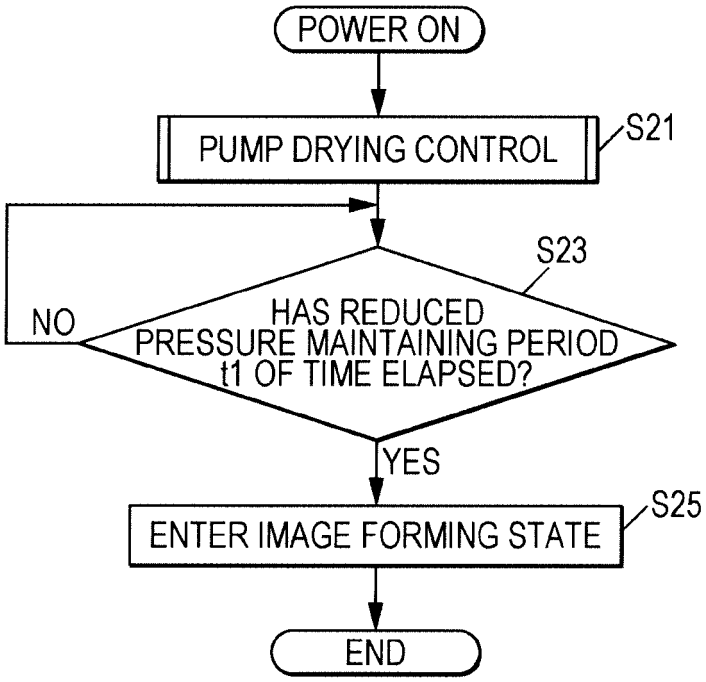
POWER ON
PUMP DRYING CONTROL
S21
S23
HAS REDUCED PRESSURE MAINTAINING PERIOD t1 OF TIME ELAPSED?
NO
YES
ENTER IMAGE FORMING STATE
S25
END

FIG. 9

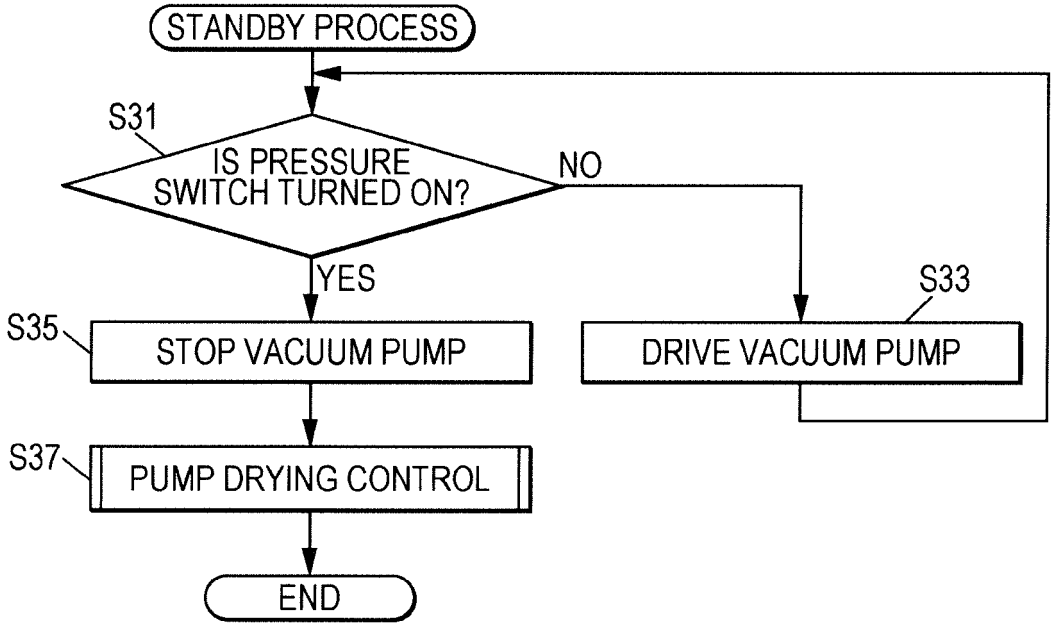
STANDBY PROCESS
S31
IS PRESSURE SWITCH TURNED ON?
NO
YES
S33
S35
STOP VACUUM PUMP
DRIVE VACUUM PUMP
S37
PUMP DRYING CONTROL
END

FIG. 10

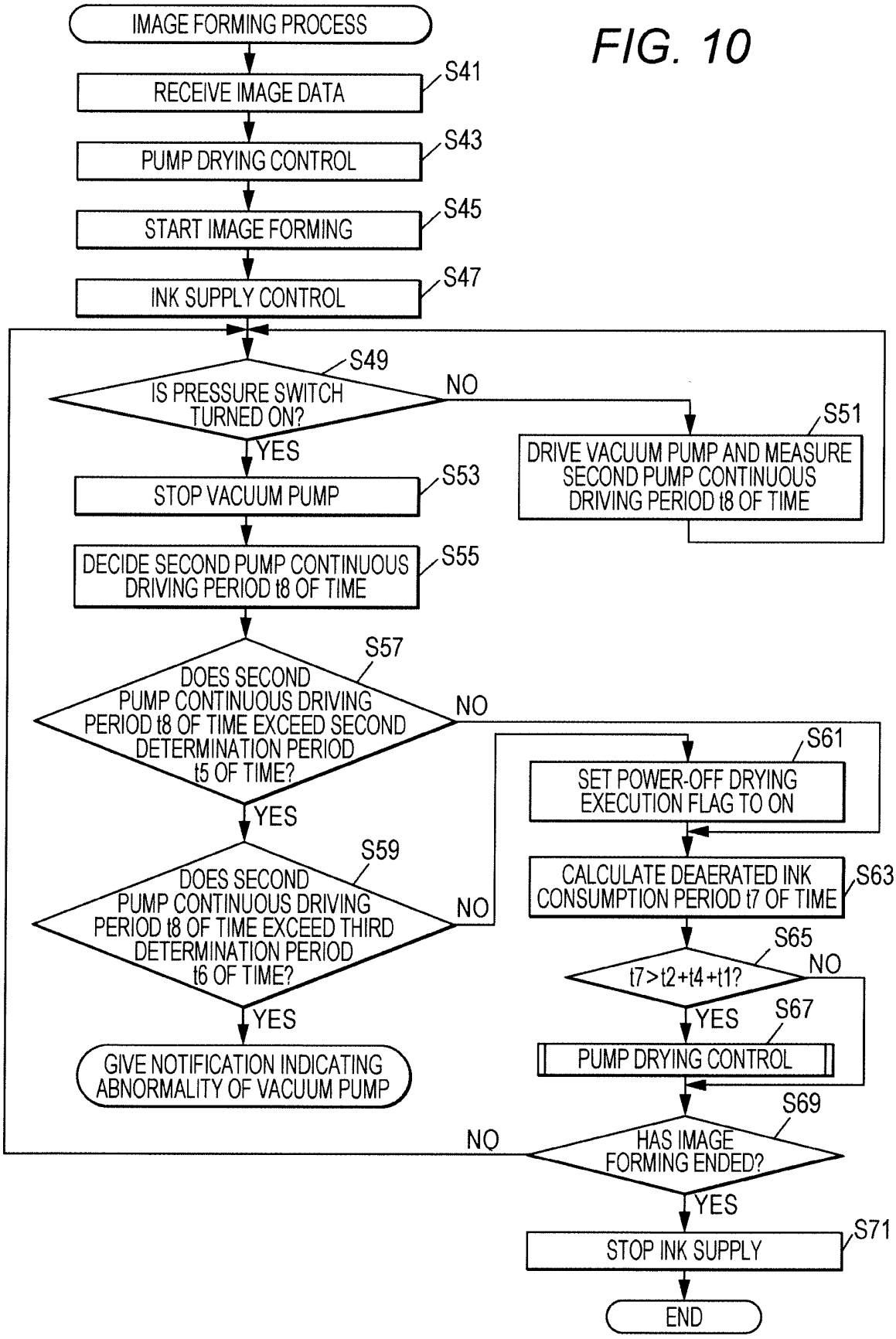
IMAGE FORMING PROCESS
RECEIVE IMAGE DATA
S41
PUMP DRYING CONTROL
S43
START IMAGE FORMING
S45
INK SUPPLY CONTROL
S47
S49
IS PRESSURE SWITCH TURNED ON?
NO
YES
S51
DRIVE VACUUM PUMP AND MEASURE SECOND PUMP CONTINUOUS DRIVING PERIOD t8 OF TIME
STOP VACUUM PUMP
S53
DECIDE SECOND PUMP CONTINUOUS DRIVING PERIOD t8 OF TIME
S55
S57
DOES SECOND PUMP CONTINUOUS DRIVING PERIOD t8 OF TIME EXCEED SECOND DETERMINATION PERIOD t5 OF TIME?
NO
YES
S59
DOES SECOND PUMP CONTINUOUS DRIVING PERIOD t8 OF TIME EXCEED THIRD DETERMINATION PERIOD t6 OF TIME?
NO
YES
GIVE NOTIFICATION INDICATING ABNORMALITY OF VACUUM PUMP
S61
SET POWER-OFF DRYING EXECUTION FLAG TO ON
CALCULATE DEAERATED INK CONSUMPTION PERIOD t7 OF TIME
S63
S65
t7>t2+t4+t1?
NO
YES
S67
PUMP DRYING CONTROL
S69
HAS IMAGE FORMING ENDED?
NO
YES
S71
STOP INK SUPPLY
END

FIG. 11

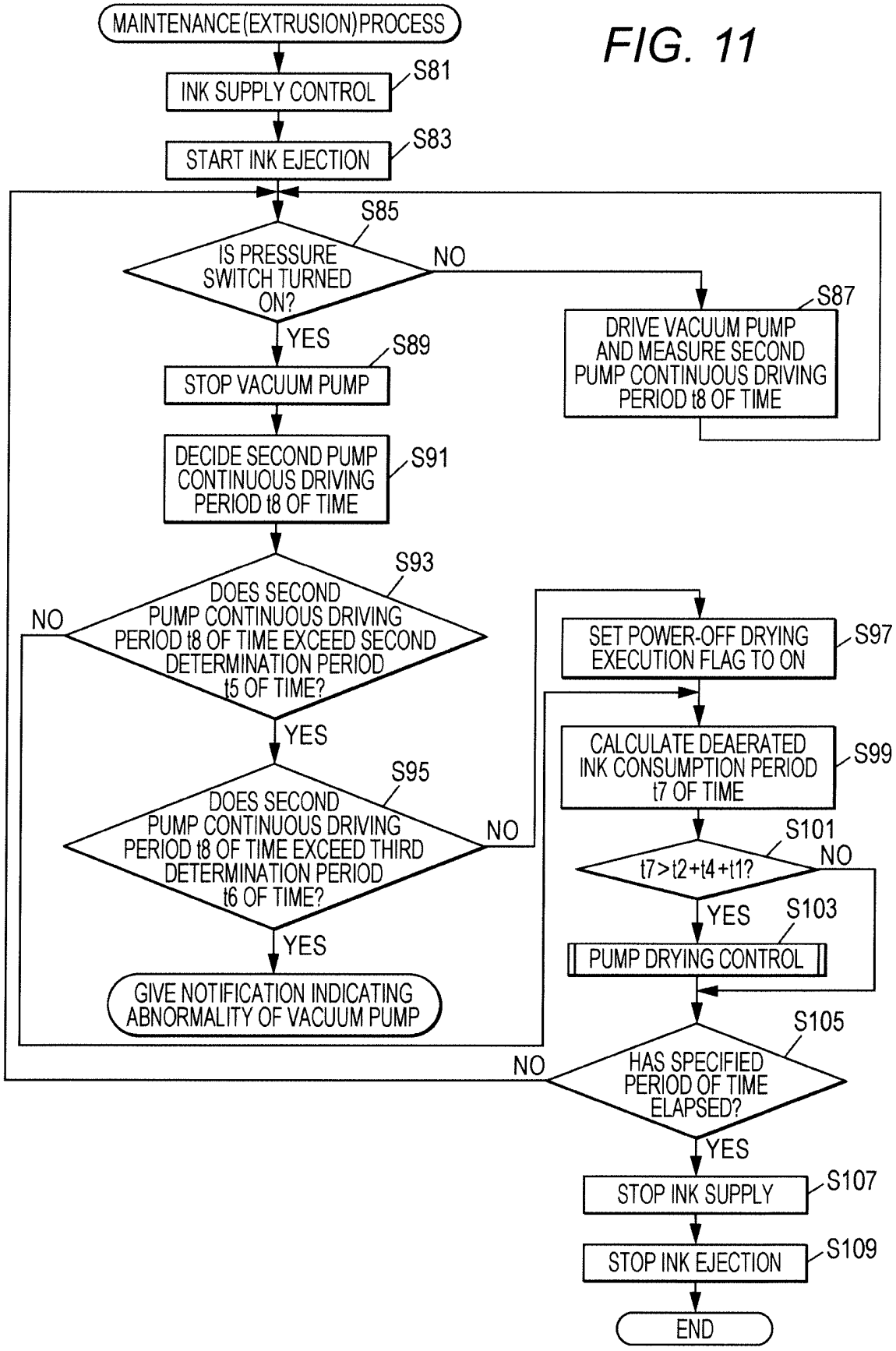
MAINTENANCE(EXTRUSION)PROCESS
INK SUPPLY CONTROL
S81
START INK EJECTION
S83
S85
IS PRESSURE SWITCH TURNED ON?
NO
S87
DRIVE VACUUM PUMP AND MEASURE SECOND PUMP CONTINUOUS DRIVING PERIOD t8 OF TIME
YES
S89
STOP VACUUM PUMP
DECIDE SECOND PUMP CONTINUOUS DRIVING PERIOD t8 OF TIME
S91
S93
DOES SECOND PUMP CONTINUOUS DRIVING PERIOD t8 OF TIME EXCEED SECOND DETERMINATION PERIOD t5 OF TIME?
NO
YES
S95
DOES SECOND PUMP CONTINUOUS DRIVING PERIOD t8 OF TIME EXCEED THIRD DETERMINATION PERIOD t6 OF TIME?
NO
YES
GIVE NOTIFICATION INDICATING ABNORMALITY OF VACUUM PUMP
SET POWER-OFF DRYING EXECUTION FLAG TO ON
S97
CALCULATE DEAERATED INK CONSUMPTION PERIOD t7 OF TIME
S99
S101
t7>t2+t4+t1?
NO
YES
S103
PUMP DRYING CONTROL
S105
HAS SPECIFIED PERIOD OF TIME ELAPSED?
NO
YES
STOP INK SUPPLY
S107
STOP INK EJECTION
S109
END

FIG. 12

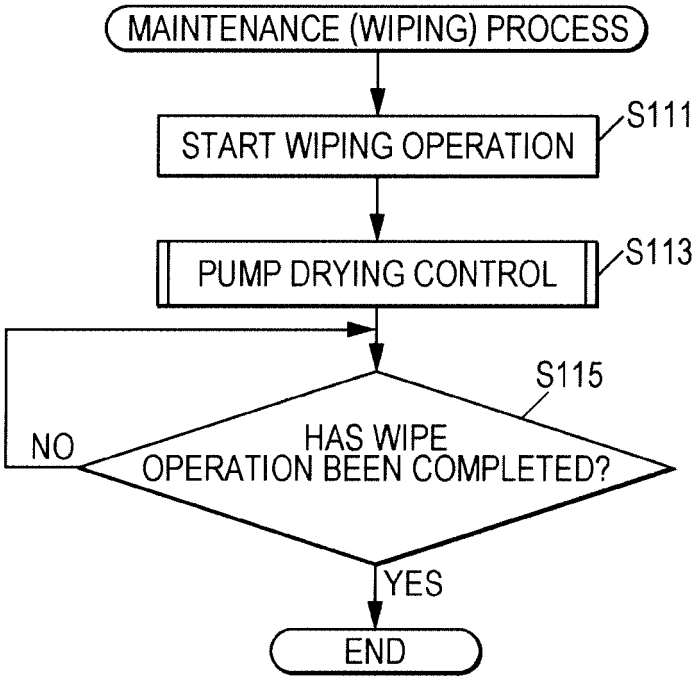
MAINTENANCE (WIPING) PROCESS
START WIPING OPERATION
S111
PUMP DRYING CONTROL
S113
S115
HAS WIPE OPERATION BEEN COMPLETED?
NO
YES
END

FIG. 13

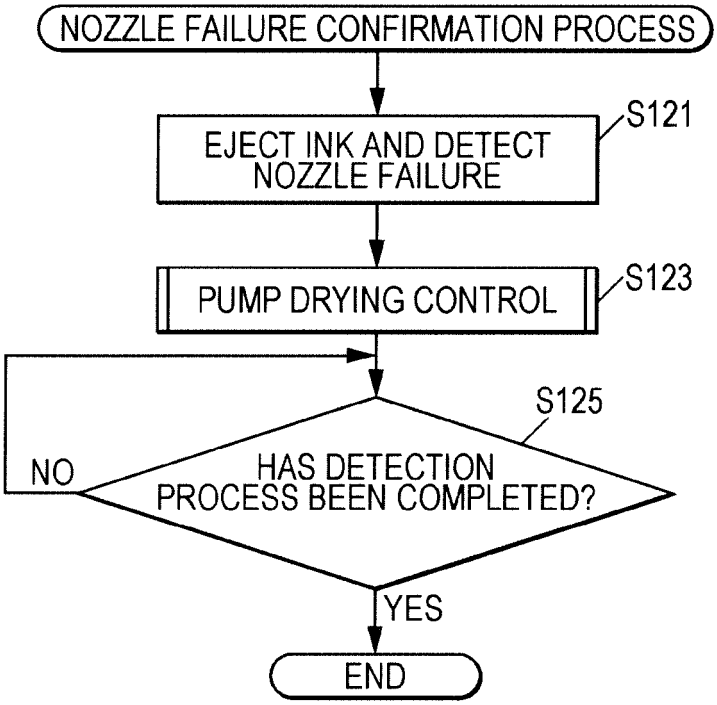
NOZZLE FAILURE CONFIRMATION PROCESS
EJECT INK AND DETECT NOZZLE FAILURE
S121
PUMP DRYING CONTROL
S123
S125
HAS DETECTION PROCESS BEEN COMPLETED?
NO
YES
END

FIG. 14

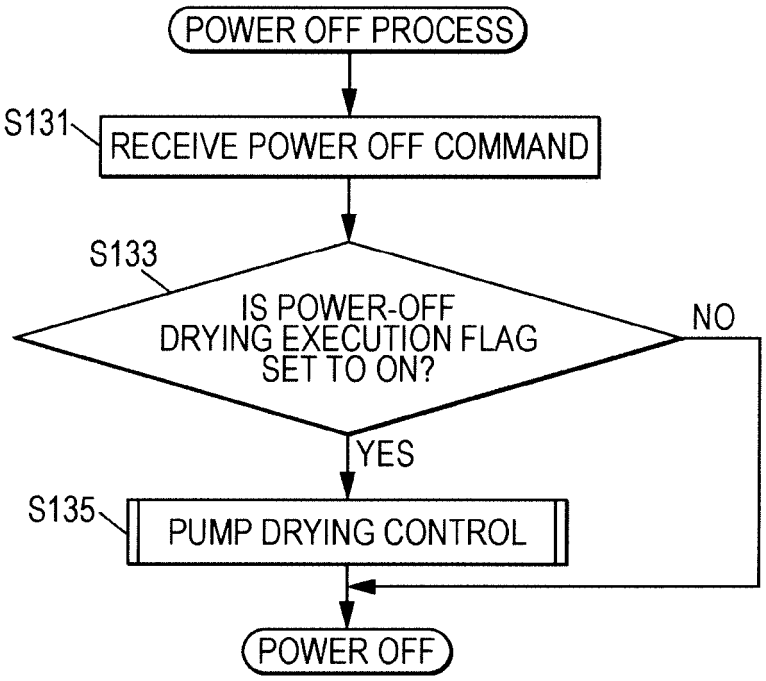
POWER OFF PROCESS
S131
RECEIVE POWER OFF COMMAND
S133
IS POWER-OFF DRYING EXECUTION FLAG SET TO ON?
NO
YES
S135
PUMP DRYING CONTROL
POWER OFF

FIG. 15

| OPERATION PERIOD OF TIME OF PUMP | 15 SECONDS | 30 SECONDS | 45 SECONDS |
|---|---|---|---|
| PUMP INSIDE OBSERVATION | × MOISTURE REMAINS ON ENTIRE INSIDE OF PUMP | △ SMALL MOISTURE REMAINS ON PORTIONS AROUND OUTLET AND DIAPHRAGM | ○ INSIDE IS ALMOST DRIED |

FIG. 16

| | FIRST TIME | SECOND TIME | THIRD TIME | AVERAGE |
|---|---|---|---|---|
| A 0kPa→−92kPa | 45sec | 55sec | 56sec | 52sec |
| B −90kPa→−92kPa | 27sec | 32sec | 36sec | 31sec |

FIG. 17

| | FIRST TIME | SECOND TIME | THIRD TIME | AVERAGE |
|---|---|---|---|---|
| A 0kPa→−92kPa | 45sec→22sec | 55sec→25sec | 56sec→24sec | 23.6sec |
| B −90kPa→−92kPa | 27sec→10sec | 32sec→7sec | 36sec→10sec | 9sec |

**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2014/075808

A. CLASSIFICATION OF SUBJECT MATTER
*B41J2/19*(2006.01)i, *B41J2/165*(2006.01)i, *B41J2/175*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B41J2/19, B41J2/165, B41J2/175

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 1996-2014
Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

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. |
|---|---|---|
| Y<br>A | JP 2013-67032 A (Konica Minolta IJ Technologies, Inc.),<br>18 April 2013 (18.04.2013),<br>paragraphs [0037] to [0038]; fig. 4<br>& EP 2572886 A1 & CN 103057272 A | 1-4,10,<br>14-17,23<br>5-9,11-13,<br>18-22,24-26 |
| Y<br>A | JP 10-156104 A (Organo Corp.),<br>16 June 1998 (16.06.1998),<br>paragraphs [0031] to [0032]; fig. 1<br>(Family: none) | 1-4,10,<br>14-17,23<br>5-9,11-13,<br>18-22,24-26 |
| Y | JP 2009-66977 A (Brother Industries, Ltd.),<br>02 April 2009 (02.04.2009),<br>paragraph [0035]<br>(Family: none) | 4,17 |

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

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 25 December 2014 (25.12.14) | 13 January 2015 (13.01.15) |
| Name and mailing address of the ISA/<br>Japan Patent Office<br><br>Facsimile No. | Authorized officer<br><br>Telephone No. |

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**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2014/075808

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | JP 2010-58413 A (Konica Minolta IJ Technologies, Inc.), 18 March 2010 (18.03.2010), paragraphs [0056], [0057] (Family: none) | 10,23 |
| A | JP 2012-101366 A (Fujifilm Corp.), 31 May 2012 (31.05.2012), entire text; all drawings (Family: none) | 1-26 |
| A | Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 85153/1984(Laid-open No. 195982/1985) (Eruma Kogaku Kabushiki Kaisha), 27 December 1985 (27.12.1985), entire text; all drawings (Family: none) | 1-26 |

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## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description


- JP 11042771 A **[0006]**