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(71) Applicant: **Konica Minolta, Inc.**
Tokyo 100-7015 (JP)

(72) Inventors:

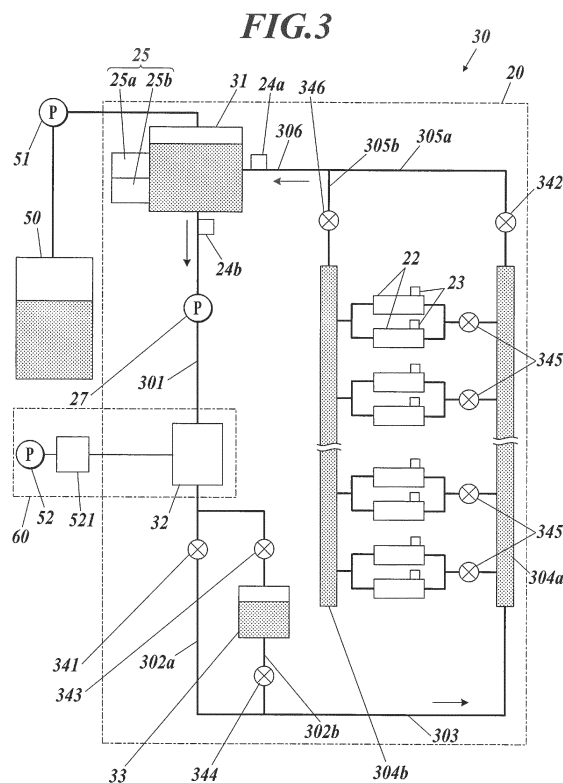
- **KOYAMA, Nobuhiko**
Tokyo 100-7015 (JP)
- **KOMADA, Naoya**
Tokyo 100-7015 (JP)

(30) Priority: 01.12.2015 JP 2015234881

(74) Representative: **Gille Hrabal**
Brucknerstrasse 20
40593 Düsseldorf (DE)

(54) **INKJET RECORDING DEVICE**

(57) Provided is an inkjet recording device that can better stabilize the temperature of ink that is supplied to recording heads (22). The inkjet recording device comprises: a plurality of recording heads (22) that each have a nozzle that discharges ink and an ink flow path part that communicates with the nozzle; an ink storage part (31) that stores ink that is supplied to the plurality of recording heads (22); an ink-temperature adjustment means that adjusts the temperature of the ink stored in the ink storage part (31) to within a prescribed temperature range; an ink circulation path that passes through the ink storage part (31) and through a common ink flow path part (304a), which communicates with the ink flow path parts of the plurality of recording heads (22), and that circulates the ink stored in the ink storage part (31); a liquid delivery means (27) that performs a liquid delivery operation that makes the ink inside the ink circulation path flow in a prescribed liquid delivery direction and thereby makes the ink in the ink storage part (31) circulate through the ink circulation path; and a liquid delivery control means that makes the liquid delivery means perform the liquid delivery operation such that the temperature of the ink inside the ink circulation path approaches a prescribed target temperature that is within the prescribed temperature range.



Description

TECHNICAL FIELD

5 [0001] The present invention relates to an inkjet recording device.

BACKGROUND ART

10 [0002] Conventionally, there have been inkjet recording devices which have recording heads provided with nozzles to discharge ink and record images by discharging ink on recording media from the nozzles of the recording heads, while moving the recording heads and the recording media relative to each other.

15 [0003] The viscosity of ink used in the inkjet recording devices varies according to the ink temperature. The amount and speed of ink discharged from the nozzles depend on the viscosity of ink, and an appropriate ink discharge may be prevented when the viscosity of ink is too high or too low. To avoid this, conventionally, there has been a technique in which an ink temperature adjuster which heats or cools ink in an ink flow path through which ink supplied to the recording heads passes is provided, and ink whose temperature and viscosity are adjusted by the ink temperature adjuster is supplied to the recording heads to execute a more appropriate ink discharge (for example, patent document 1).

PRIOR ART DOCUMENTS

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PATENT DOCUMENTS

[0004] Patent Document 1: Japanese Patent Application Laid Open Publication No. 2009-178996

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SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

30 [0005] However, it is not easy to accurately adjust the temperature of ink flowing through the ink flow path, and even if the ink temperature is accurately adjusted, the ink temperature fluctuates before ink flows into the recording heads when the temperature of the ink flow path is uneven. Thus, the conventional technique described above has a problem that the temperature of ink supplied to the recording heads is not stable and the ink at an inappropriate temperature is sometimes supplied to the recording heads.

35 [0006] An object of the present invention is to provide the inkjet recording device which can stabilize more the temperature of the ink supplied to the recording heads.

MEANS FOR SOLVING THE PROBLEM

40 [0007] To achieve the above object, the invention of an inkjet recording device according to claim 1 includes:

a plurality of recording heads which respectively have a nozzle discharging ink and an ink flow path portion communicating with the nozzle;
 an ink storage which stores ink to be supplied to the plurality of recording heads;
 an ink temperature adjusting means which adjusts a temperature of ink stored in the ink storage to within a prescribed temperature range;
 45 an ink circulation path which passes through the ink storage and a common ink flow path portion communicating with the ink flow path portion of the plurality of the recording heads and circulates ink stored in the ink storage;
 a liquid delivery means which performs a liquid delivery operation to cause ink in the ink circulation path to flow in a prescribed liquid delivery direction and to circulate ink in the ink storage in the ink circulation path; and
 50 a liquid delivery control means which causes the liquid delivery means to perform the liquid delivery operation so that a temperature of ink in the ink circulation path approaches a prescribed target temperature which is within the prescribed temperature range.

55 [0008] The invention according to claim 2 includes, in the inkjet recording device according to claim 1,

a first ink temperature detecting means which detects a temperature of ink right before flowing into the ink storage from ink in the ink circulation path; and
 a determining means which determines whether a temperature detected by the first ink temperature detecting means

is within the prescribed temperature range or not, and
the liquid delivery control means causes the liquid delivery means to perform the liquid delivery operation when the determining means determines that the temperature is out of the prescribed temperature range.

5 **[0009]** The invention according to claim 3, in the inkjet recording device according to claim 2, includes a second ink temperature detecting means which detects a temperature of ink in the ink storage or a temperature of ink right after flowing out of the ink storage in the ink circulation path, and

10 the determining means determines whether a difference between a temperature detected by the first ink temperature detecting means and a temperature detected by the second ink temperature detecting means is equal to or smaller than a prescribed reference difference or not, and
the liquid delivery control means causes the liquid delivery means to perform the liquid delivery operation when the determining means determines that the difference is larger than the reference difference.

15 **[0010]** The invention according to claim 4, in the inkjet recording device according to claim 2, includes a recording control means which causes the plurality of recording heads to perform a recording operation to record an image on a recording medium by discharging ink to the recording medium when the determining means determines that the temperature is within the prescribed temperature range.

20 **[0011]** The invention according to claim 5, in the inkjet recording device according to claim 4, includes a second ink temperature detecting means which detects a temperature of ink in the ink storage or a temperature of ink right after flowing out of the ink storage in the ink circulation path, and

25 the determining means determines whether a difference between a temperature detected by the first ink temperature detecting means and a temperature detected by the second ink temperature detecting means is equal to or smaller than a prescribed reference difference or not, and
the recording control means causes the plurality of recording heads to perform the recording operation when the determining means determines that the temperature is within the prescribed temperature range and that the difference is equal to or smaller than the reference difference.

30 **[0012]** The invention according to claim 6, in the inkjet recording device according to claim 4 or 5, includes a plurality of head temperature detecting means which respectively detect a temperature of a section of each of the plurality of recording heads, the temperature of the section corresponding to a temperature of ink in the ink flow path portion, and the recording control means causes the plurality of the recording heads to perform the recording operation by a driving signal of which at least one of voltage amplitude and voltage application duration is corrected according to a temperature detected by each of the plurality of the head temperature detecting means.

35 **[0013]** The invention according to claim 7, in the inkjet recording device according to any one of claims 2 to 6, the liquid delivery control means causes the liquid delivery means to perform the liquid delivery operation so that an amount of liquid delivery of ink per prescribed unit of time gradually increases as the difference between a temperature detected by the first ink temperature detecting means and the prescribed target temperature gets larger.

40 **[0014]** The invention according to claim 8, in the inkjet recording device according to any one of claims 1 to 7,

45 the ink circulation path has a first branching flow path portion which is disposed between the common ink flow path portion and the ink storage in the liquid delivery direction and causes the common ink flow path portion and the ink storage to communicate with each other through the ink flow path portion of the plurality of the recording heads, and a second branching flow path portion which is disposed between the common ink flow path portion and the ink storage in the liquid delivery direction and causes the common ink flow path portion and the ink storage to communicate with each other not through the ink flow path portion of the plurality of the recording heads, and
the inkjet recording device has a switching means which is disposed within a range from the common ink flow path portion and the plurality of recording heads in the liquid delivery direction and opens or closes the first branching flow path portion, and a switching control means which closes the first branching flow path portion by the switching means while the liquid delivery operation is performed to circulate ink in the ink circulation path.

[0015] The invention according to claim 9, in the inkjet recording device according to any one of claims 1 to 8, comprising a deaerating means which is disposed in the ink circulation path and removes air in ink from the ink.

55 **[0016]** The invention according to claim 10, in the inkjet recording device according to any one of claims 1 to 9, component composing the ink circulation path is metal.

EFFECTS OF THE INVENTION

[0017] The present invention has an effect of stabilizing the temperature of ink supplied to recording heads more.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

FIG. 1 is a diagram showing a schematic configuration of the inkjet recording device.

FIG. 2A is a schematic drawing of the head unit when the head unit is viewed from the side face.

FIG. 2B is a schematic drawing of the head unit when the head unit is viewed from the side of the conveyance belt.

FIG. 3 is a schematic diagram showing a configuration of the ink supply machinery.

FIG. 4 is a block diagram showing a principal functional configuration of the inkjet recording device.

FIG. 5 is a flowchart showing a control procedure of the ink temperature adjusting process.

FIG. 6 is a flowchart showing a control procedure of the image recording process.

EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0019] Hereinafter an embodiment of the inkjet recording device in accordance with the present invention is described with reference to the drawings.

[0020] FIG. 1 is a diagram showing a schematic configuration of the inkjet recording device 1 as an embodiment of the present invention.

[0021] The inkjet recording device 1 incorporates a conveyer 10, a head unit 20, and so forth.

[0022] The conveyer 10 has a circular conveyance belt 103 supported inside by two conveyance rollers 101 and 102 which rotate centered around the rotation axis extended in the direction X in FIG. 1. The conveyer 10 conveys a recording medium P in the moving direction of the conveyance belt 103 (conveying direction; direction Y in FIG. 1), by a round movement of the conveyance belt 103 as the conveyance rollers 101 and 102 are rotated by a motor not shown in the drawings with the recording medium P being set on the conveying face of the conveyance belt 103.

[0023] The recording medium P may be a piece of paper being cut in a specific size. This recording medium P is supplied onto the conveyance belt 103 by a paper feeder not shown in the drawings and discharged from the conveyance belt 103 to a prescribed paper receiver after an image is recorded. A roll of paper may be used as the recording medium P. In this case, the recording medium P is pulled out from the roll on which the recording medium P is rolled, supplied onto the conveyance belt 103, and rolled on another roll after an image is recorded. Various kinds of media on whose surface dropped ink can be fixed, such as paper like plain paper and coated paper, fabric, or sheet resin, may be used as the recording medium P.

[0024] The conveyer 10 in the present embodiment is configured to be able to convey a large recording medium P of approximately 2 meters width in the direction X.

[0025] The head unit 20 discharges ink on the recording medium P conveyed by the conveyer 10 on the basis of image data at appropriate timings and records an image. Four head units 20 respectively corresponding to inks colored yellow (Y), magenta (M), cyan (C), and black (K) are arranged at prescribed intervals in an order of Y, M, C, and K from the upstream in the conveying direction of the recording medium P. The number of the head units 20 may be three or less, or five or more.

[0026] FIG. 2A is a schematic diagram of an inside configuration of the head unit 20 viewed from the side face. FIG. 2B is a schematic diagram of an inside configuration of the head unit 20 viewed from the side of the conveying belt 103. The state where the head unit 20 is viewed from the side face is the state where the head unit is viewed from the direction parallel to the conveying direction of the recording medium P at a location facing the head unit 20 on the conveying face of the conveyance belt 103.

[0027] The head unit 20 has multiple recording heads 22 which respectively incorporate multiple recording elements 221 (FIG. 4) to discharge ink. Each of the multiple recording elements 221 includes a pressure room to store ink, piezoelectric elements attached on the wall surface of the pressure room, and a nozzle 221n. The nozzle 221n among these discharges ink from an opening provided onto the side of ink discharge facing the conveying surface of the conveying belt 103 in the recording head 22. In the recording heads 22, multiple nozzles 221n are arranged in two rows in the direction X, forming two nozzle rows, and the two nozzle rows are arranged alternating reciprocally by a half interval of the arrangement of the nozzle 221n in the direction X.

[0028] In the head unit 20, a pair of the recording heads 22 neighboring with each other in the direction Y are arranged in zigzag at positions altering in the direction X, as shown in FIG. 2B. In the head unit 20 in the present embodiment, 24 pairs of the recording heads are arranged in zigzag, and accordingly, 48 recording heads 22 are provided to the head unit 20. The arrangement of the recording heads 22 like this allows a location range of the nozzles 221n in the direction

X included in the head unit 20 to cover the width in the direction X in a range where an image can be formed of the recording medium P conveyed by the conveyance belt 103. The head unit 20 is used with its location fixed in image recording. That is, the inkjet recording device 1 is an inkjet recording device which executes image recording in a single pass mode using a line scan head.

[0029] As shown in FIG. 2A, the recording head 22 has a flow path portion 222 (ink flow path portion) which functions as a flow path for the ink in the recording head 22, an inlet 223 which ink to be supplied to the flow path portion 222 flows into, an outlet 224 which ink to be discharged from the flow path portion 222 flows out to, and so forth. The flow path portion 222 among these communicates with the nozzle 221n via the pressure room.

[0030] Ink which is liquid at normal temperature is used as ink to be discharged from the nozzle 221n of the recording head 22. The amount and speed of ink to be discharged from the nozzle 221n vary according to the viscosity of ink. The viscosity of ink varies depending on the temperature. In the present embodiment, used is ink whose viscosity is higher as the temperature is lower.

[0031] Each of the head units 20 incorporates a recording head driver 21 (FIG. 4) which drives the recording head 22. The recording head driver 21 has a driving circuit which provides each of the recording heads 22 with a voltage signal in driving waveform (hereinafter also referred to as a driving signal) according to image data and a driving control circuit which provides the driving circuit with the image data at appropriate timings. From the driving circuit of the recording head driver 21, a voltage signal in driving waveform which causes deforming operation to piezoelectric elements is output according to the pixel value of the image data, and the recording elements 221 are configured to apply the voltage signal to the piezoelectric elements. When the voltage signal in driving waveform is applied to the piezoelectric elements, the pressure in the pressure room changes as the pressure room deforms according to the voltage signal and an ink discharge operation in which ink is discharged from the nozzle 221n communicating with the pressure room is executed. Eventually, ink is discharged in an amount according to the pixel value of the image data from the nozzle 221n. In the inkjet recording device 1, as the driving signal according to the image data is supplied to each of the recording heads 22 by the recording head driver 21, an image recording operation in which ink is discharged to the recording medium P from the multiple recording heads 22 to record an image on the recording medium P is executed.

[0032] As described above, the amount and speed of ink to be discharged vary according to the ink temperature even when the same driving signals are applied to the piezoelectric elements, because the viscosity of ink varies according to the temperature. In the inkjet recording device 1 in the present embodiment, the fluctuation of the amount and speed of discharged ink depending on the fluctuation of the ink temperature is suppressed by correction of the magnitude of voltage amplitude of the driving signal. That is, corrections are done so that the voltage amplitude is higher when the ink temperature is lower and the ink viscosity is higher. The magnitude of voltage amplitude can be corrected by changing the supply voltage to be input to the driving circuit, for example. Alternatively, the magnitude of voltage amplitude may be corrected by inputting multiple different supply voltages to the driving circuit and selecting the magnitude of the voltage signal to be output from the driving circuit from the different supply voltages.

[0033] Moreover, changes may be made to the duration of voltage application of the voltage signal instead of the correction of voltage amplitude or in addition to the correction of voltage amplitude. The duration of voltage application of the voltage signal may be corrected by changing the data of driving waveform pattern to be referred to when the driving signal is output from the driving circuit. The duration of voltage application is corrected so that the duration of voltage application is longer as the ink temperature is lower and the ink viscosity is higher.

[0034] The head unit 20 is set movable in the direction X between a position facing the conveyance belt 103 and a position facing a cleaner not shown in the drawings. The head unit 20, under the control by the controller 40, moves to the position facing the conveyance belt 103 when executing the image recording operation and moves to the position facing the cleaner when executing a discharge operation. The discharge operation indicates here an operation to discharge ink from the recording head 22 to an ink receiver disposed inside the cleaner, in view of adjusting the temperature of the recording head 22 by replacing the ink in the flow path portion 222 of the recording head 22 to the ink whose temperature is adjusted, or conditioning the liquid surface (meniscus) of ink in the nozzle 221n.

[0035] Next, the ink supply machinery which supplies ink to the recording heads 22 in the inkjet recording device 1 is described.

[0036] FIG. 3 is a schematic diagram showing a configuration of the ink supply machinery 30.

The ink supply machinery 30 concerning one of the head units 20 in the inkjet recording device 1 is exemplified and described in FIG. 3, but a similar ink supply machinery 30 also supplies ink to the recording heads 22 of the other head units 20. And in FIG. 3, the path of ink is indicated by a thick solid line. The ink delivery direction is indicated by arrows.

[0037] The ink supply machinery 30 incorporates a main tank 50, a sub tank 31 (ink storage), and an intermediate tank 33 to store ink, an ink temperature adjuster 25 (ink temperature adjusting means), a first ink temperature detector 24a (first ink temperature detecting means), a second ink temperature detector 24b (second ink temperature detecting means), a supplying pump 51, a liquid delivery pump 27 (liquid delivery means), a deaerator 60, recording heads 22, ink flow paths 301, 302a, 302b, 303, 305a, 305b, and 306, a common ink flow path portion 304a, a common waste liquid flow path portion 304b, a first valve 341 to sixth valve 346, and so forth.

[0038] The common ink flow path portion 304a, the common waste liquid flow path portion 304b, and the ink flow paths 301, 302a, 302b, 303, 305a, 305b, and 306 may be configured with a component forming a hollow circular tube, and be desirably configured with metal so that the temperature of those components be adjusted to the desirable temperature in a shorter time, though not particularly limited.

[0039] The main tank 50 is disposed on the exterior of the head unit 20 and stores ink in a color corresponding to the head unit 20. Ink stored in the main tank 50 is drawn out by the supplying pump 51 which operates on the basis of the control signal supplied by the CPU 41 (FIG 4) and supplied to the sub tank 31 in the head unit 20.

[0040] The sub tank 31 stores ink supplied from the main tank 50 and to be supplied to the recording head 22. In the present embodiment, a metal container of approximately 40 litre volume is used as the sub tank 31. The sub tank 31 communicates with the ink flow paths 301 and 306. The sub tank 31 is a container open to the exterior, and is kept at atmosphere pressure regardless of increase and decrease of the ink amount.

[0041] In the neighboring section of the sub tank 31 in the ink flow path 301, the second temperature detector 24b which detects the temperature of ink right after flowing out of the sub tank 31 to the ink flow path 301 (hereinafter referred to as the second ink temperature T2) is disposed. The neighboring section of the sub tank 31 indicated in this case is the range where the ink temperature is generally identical to the ink temperature in the sub tank 31. The description that the temperature is generally identical may indicate that the difference in temperature is 1°C or less, for example.

[0042] The second ink temperature detector 24b has temperature detecting elements such as a thermistor, for example, and outputs the data concerning the second ink temperature T2 on the basis of the control signal supplied by the CPU 41 to the controller 40.

[0043] The ink temperature adjuster 25 has a heater 25a which heats ink stored in the sub tank 31 and a cooler 25b which cools the ink. The ink temperature adjuster 25 executes an ink temperature changing operation which changes the ink temperature in the sub tank 31 by heating with the heater 25a or by cooling with the cooler 25b. The heater 25a and the cooler 25b may be configured to be disposed on the exterior of the sub tank 31 and heat or cool the sub tank 31 to heat or cool ink in the sub tank 31, though not particularly limited. Alternatively, they may be configured to have a container communicating with the sub tank 31, heat or cool the ink transferred from the sub tank 31 to the container, and flow it back to the sub tank 31.

[0044] The ink temperature adjuster 25 adjust the ink temperature in the sub tank 31 so as to approach the target temperature within the prescribed temperature range described later by the ink temperature changing operation on the basis of the control signal supplied by the CPU 41. The ink temperature in the sub tank 31 is detected as the second ink temperature T2 by the second ink temperature detector 24b here. In the sub tank 31, a temperature detector which detects the ink temperature in the sub tank 31 may be disposed besides the second ink temperature detector 24b. In the present embodiment, the ink temperature adjusting means is configured with the ink temperature adjuster 25 and the CPU 41.

[0045] The liquid delivery pump 27 is disposed in the ink flow path 301 and performs liquid delivery in which ink is flown in the flowing direction from the sub tank 31 via the ink flow path 301 to the common ink flow path portion 304a by applying pressure to ink in the ink flow path 301 (liquid delivery operation). The configurations of the liquid delivery pump 27 are not particularly limited, but a volume transfer type pump such as a diaphragm pump or a tube pump which wrings a tube by a roller to deliver liquid may be used, for example. The liquid delivery pump 27 operates under the control by the controller 40.

[0046] The deaerater 60 incorporates a deaerating module 32 disposed in the ink flow path 301 (deaerating means), a chamber 521 connected to the deaerating module 32, a vacuum pump 52 connected to the chamber 521, and so forth. The deaerater 60 performs deaeration, where air in ink flown from the sub tank 31 into the deaerating module 32 is removed from the ink.

[0047] A vacuum path from the deaerating module 32 to the vacuum pump 52 is formed, as the vacuum tube connects the deaerating module 32 with the chamber 521, and the chamber 521 with vacuum pump 52. As the vacuum pump 52 executes suction operation so that the pressure in the vacuum path is within a prescribed range of negative pressure lower than the atmospheric pressure, air is removed from ink in the deaerating module 32 and the removed air flows in the vacuum path. The vacuum pump 52 does not necessarily set the inside of the vacuum path to an ultra high vacuum state, but executes decompression to an extent just necessary for deaeration. The vacuum pump 52 operates on the basis of the control signal supplied by the CPU 41.

[0048] The deaerating module 32 incorporates an air-permeable deaerating film which permeates air but does not permeate liquid, and it deaerates air in ink drawn to the vacuum path by touching ink flown into the deaerating module 32 with one side of the deaerating film and drawing air with the vacuum pump 52 on the other side. The deaerating module 32 may be configured to have multiple deaerating films which form a structure with multiple hollow microfibers with one end closed (hollow fiber film) and draw out air with the vacuum pump 52 from the other end of the hollow fiber film to lower the pressure inside the hollow fiber film, though not limited. As ink touches the membrane side (exterior side) of the hollow fiber film in this state, only air in ink selectively passes through the membrane side to be drawn to the inside of the hollow fiber film, and ink is deaerated. The deaerating module 32 may be configured to separate air in

ink passing through the inside of the hollow fiber film to the outside of the hollow fiber film as the outside of the hollow fiber film being decompressed.

[0049] When liquid besides air is drawn through the deaerating module 32 and flown into the vacuum path, the chamber 521 separates liquid from air to play a role as a trap of preventing occurrence of problems such as destroying the vacuum pump 52 with liquid being drawn into the vacuum pump 52. The chamber 521 may be, for example, in a shape of a small sized tank and stores liquid at the bottom thereof.

[0050] Ink deaerated by the deaerating module 32 is sent out to the ink flow path 302a and the ink flow path 302b. The ink flow path 302a of those two incorporates a first valve 341 to switch opening and closing of the ink flow path 302a. The ink flow path 302b incorporates a third valve 343 and a fourth valve 344 to switch opening and closing of the ink flow path 302b. The first valve 341, the third valve 343, and the fourth valve 344 are valves which open and close to open or close the ink flow path according to the input of the prescribed valve driving signals, and electromagnetic valves may be used, for example. The second valve 342, the fifth valve 345, and the sixth valve 346 are similarly configured.

[0051] The intermediate tank 33 is arranged between the third valve 343 and the fourth valve 344 of the ink flow path 302b. The intermediate tank 33 is a small sized ink room temporally storing ink to be supplied to the recording heads 22 and is sealed except for at the connecting point with the ink flow path 302b. In the present embodiment, a metal container of approximately 1 litre volume is used as the intermediate tank 33.

[0052] The ink flow path 302a and the ink flow path 302b join the ink flow path 303.

[0053] The common ink flow path portion 304a is a component in a shape of tube communicating with the inlet 223 of each of the 48 recording heads 22 and the ink flow paths 303 and 305a disposed in the head unit 20. The common ink flow path portion 304a stores ink right before being supplied to the recording heads 22.

[0054] In the ink flow path between the common ink flow path portion 304a and the recording head 22, the fifth valve 345 (switching means) to switch opening and closing of the ink flow path is provided to each set of the recording heads 22, summing up to 24 of those in total. From the common ink flow path portion 304a, in a state where the second valve 342 disposed in the ink flow path 305a is open and the fifth valve 345 is closed, ink flown in from the ink flow path 303 is sent out to the ink flow path 305a according to the liquid delivery operation by the liquid delivery pump 27. From the common ink flow path portion 304a, in a state where the second valve 342 is closed and the fifth valve 345 is open, ink flown in from the ink flow path 303 is sent out to the flow path portion 222 via the inlets 223 of the recording heads 22, according to the liquid delivery operation by the liquid delivery pump 27 or the ink discharge operation by the recording heads 22. A component with a diameter larger than that of the ink flow paths 301, 302a, 302b, 303, 305a, 305b, or 306 is used as the common ink flow path portion 304a in order to suppress the change in pressure inside the tube because of the fluctuation of the amount of ink flowing out to the recording heads 22.

[0055] The recording head 22 is disposed at such a position that the location of the nozzle 221n is higher than the ink liquid surface of the intermediate tank 33, and in a state where the first valve 341 is closed and the fourth valve 344 and the fifth valve 345 are open, ink in the recording head 22 is set at negative pressure because of hydraulic head difference between the ink in the recording head 22 and the ink in the intermediate tank 33. As a result of this, unintended leaks of ink from the nozzle 221n which does not discharge ink are restrained.

[0056] Each of the recording heads 22 is provided with a head temperature detector 23 (head temperature detecting means) to detect the temperature of a section of the recording head 22 corresponding to the ink temperature in the flow path portion 222 (for example, section to which the heat of ink in the flow path portion 222 is transferred, such as a nozzle plate with an opening of the nozzle 221n) (hereinafter also referred to as head temperature T_h). The head temperature detector 23 has temperature detecting elements such as a thermistor, for example, and outputs the detection result of the head temperature T_h to the controller 40 on the basis of the control signal provided by the CPU 41.

[0057] The common waste liquid flow path portion 304b is a component identical to the common ink flow path portion 304a in shape and material, and communicates with each outlet of the 48 recording heads 22 and the ink flow path 305b. In a state where the sixth valve 346 disposed in the ink flow path 305b is open, ink not discharged by the nozzles 221n of the recording heads 22 is flown in from the outlets 224 of the recording heads 22 to the common waste liquid flow path portion 304b. From the common waste liquid flow path portion 304b, ink flown in from the recording heads 22 is sent out to the ink flow path 305b according to the liquid delivery operation by the liquid delivery pump 27.

[0058] The ink flow path 305a incorporates the second valve 342 (switching means) to switch opening and closing of the ink flow path 305a. The ink flow path 305b incorporates the sixth valve 346 to switch opening and closing of the ink flow path 305b. The ink flow path 305a and the ink flow path 305b join the ink flow path 306. The ink flow path 306 communicates with the sub tank 31.

[0059] In the neighboring section of the sub tank 31 of the ink flow path 306, the first ink temperature detector 24a which detects the temperature of ink right before flowing into the sub tank 31 from the ink flow path 306 (hereinafter referred to as the first ink temperature T_1) is disposed. The neighboring section of the sub tank 31 indicated in this case is the range where the ink temperature is generally identical to the temperature of ink when flowing into the sub tank 31. The description that the temperature is generally identical may indicate that the difference in temperature is 1°C or less, for example.

[0060] The first ink temperature detector 24a has temperature detecting elements such as a thermistor, for example, and outputs the data concerning the first ink temperature T1 on the basis of the control signal supplied by the CPU 41.

[0061] In the ink supply machinery 30, in a state where the first valve 341 and the second valve 342 are open and the third to sixth valves are closed (hereinafter referred to as the first state), ink stored in the sub tank 31 circulates in the ink circulation path which passes through the ink flow paths 301, 302a, 303, the common ink flow path portion 304a, and the ink flow paths 305a and 306 according to the liquid delivery operation by the liquid delivery pump 27.

[0062] In a state where the second valve 342 is closed and the fifth valve 345 and the sixth valve 346 are open in the first state (hereinafter referred to as the second state), ink can circulate in the path which passes through the flow path portion 222 of the recording head 22, the common waste liquid flow path portion 304b, and the ink flow path 305b instead of the ink flow path 305a in the ink circulation path described above. The first branching flow path portion is configured with the ink flow path 305a, and the second branching flow path portion is configured with the flow path portion 222 of the recording head 22, the common waste liquid flow path portion 304b, and the ink flow path 305b here.

[0063] As described above, in the ink supply machinery 30, the state where the ink circulation path passes through the first branching flow path portion and the state where it passes through the second branching flow path portion can be switched to each other.

[0064] In a state where the first valve 341 is closed and the third valve 343 and the fourth valve 344 are open in the first state (hereinafter referred to as the third state), ink can circulate in the path passing through the ink flow path 302b instead of the ink flow path 302a in the ink circulation path described above.

[0065] In a state where the first valve 341, the second valve 342, and the sixth valve 346 are closed and the third to fifth valves are open (hereinafter referred to as the fourth state), ink stored in the sub tank 31 may be supplied to the recording heads 22 via the intermediate tank 33 and the common ink flow path portion 304a, and negative pressure of ink in the recording heads 22 because of hydraulic head difference described above can be generated. In the present embodiment, the discharge operation and the recording operation are executed in this fourth state.

[0066] FIG. 4 is a block diagram showing a principal functional configuration of the inkjet recording device 1.

[0067] The inkjet recording device 1 incorporates a controller 40, an electromagnetic valve driver 26, a conveyance driver 53, a head unit movement driver 54, an operation display 55, an input/output interface 56, and a bus 57, besides the head unit 20, the recording head driver 21, the recording head 22, the head temperature detector 23, the first ink temperature detector 24a, the second ink temperature detector 24b, the ink temperature adjuster 25, the liquid delivery pump 27, the supplying pump 51, and the vacuum pump 52. Among these, the controller 40 has a central processing unit (CPU) 41 (ink temperature adjusting means, liquid delivery control means, determining means, recording control means, switching control means), a random access memory (RAM) 42, a read only memory (ROM) 43, and a memory 44.

[0068] The CPU 41 performs various kinds of operating processes by reading out the programs and setting data for various kinds of controls stored in the ROM 43, storing them in the RAM 42 and executing the programs. The CPU 41 controls generally the entire operation of the inkjet recording device 1. For example, the CPU 41 operates the conveyer 10 and head unit 20 on the basis of the image data stored in the memory 44 to record an image on the recording medium P. The CPU 41 operates each section of the ink supply machinery 30, circulates ink in the ink circulation path, and then supplies ink to the recording heads 22.

[0069] The RAM 42 stores temporary data, providing the working memory space to the CPU 41. The data indicating the setting of the pressure of the liquid delivery pump are stored in the RAM 42. The RAM 42 may include a non-volatile memory.

[0070] The ROM 43 stores the programs, setting data, and so forth for various kinds of controls executed by the CPU 41. The data of table storing the head temperature Th and the correction value of voltage amplitude of the driving signal corresponding to each other are included in the setting data. A non-volatile memory rewritable such as an electrically erasable programmable read only memory (EEPROM) or a flash memory may be used instead of the ROM 43.

[0071] In the memory 44, the print jobs input from the external device 2 via the input/output interface 56 (command to record image) and the image data concerning the print jobs are stored. As the memory 44, a hard disk drive (HDD) is used, for example, and a dynamic random access memory (DRAM) or such may be used together.

[0072] The electromagnetic valve driver 26 opens and closes separately each of the first valve 341 to the sixth valve 346 by outputting the driving signal respectively to the first valve 341 to the sixth valve 346 on the basis of the control signal supplied by the CPU 41.

[0073] The conveyance driver 53 rotates the conveyance belt 103 at a prescribed speed and timings by supplying the driving signal to the motor which drives the conveyance rollers 101 and 102 of the conveyer 10 on the basis of the control signal supplied by the CPU 41.

[0074] The head unit movement driver 54 moves the head unit 20 in the direction X between the position facing the conveyance belt 103 and the position facing the cleaner by outputting the driving signal to the motor not described in the drawings on the basis of the control signal supplied by the CPU 41.

[0075] The operation display 55 incorporates a display device such as a liquid crystal display or an organic electroluminescent display, and an input device such as a touch panel arranged to be superposed on the screen of the display

device or operation keys. The operation display 55 displays various kinds of information on the display device, converts the input operation to the input device by user into the operation signal, and outputs it to the controller 40.

[0076] The input/output interface 56 mediates the transmission and reception of data between the external device 2 and the controller 40. The input/output interface 56 is configured, for example, with any of various kinds of serial interfaces and various kinds of parallel interfaces, or a combination thereof.

[0077] The bus 57 is a path to perform the transmission and reception of signals between the controller 40 and the other components.

[0078] The external device 2, which is exemplified by a personal computer, supplies print jobs, image data, and so forth, via the input/output interface 56 to the controller 40.

[0079] Next, an ink temperature adjusting operation which is executed in the inkjet recording device 1 is described.

[0080] In the inkjet recording device 1, in order to discharge ink from the nozzles 22n of the recording heads 22 in an appropriate amount and speed, the ink temperature adjusting operation to adjust the temperature of ink supplied to the recording heads 22 within the prescribed temperature range at which ink discharge is properly done is executed before the image recording operation. In the present embodiment, the prescribed temperature range described above is set within a range of five degrees each on the plus and minus side with the target temperature T_c being set to 25°C (which is a range from 20°C to 30°C). The minimum value of the temperature range is hereinafter referred to as the minimum temperature T_{min} and the maximum value as the maximum temperature T_{max} .

[0081] The inkjet recording device 1 in the present embodiment is a large sized device which performs image recording to the recording medium P of approximately two meters width, and ink of more than 40 litres is stored and circulates in the ink circulation path in the ink supply machinery 30 in each of the head units 20. The large part of this ink (90 percent or more) is stored in the sub tank 31. Thus, in a case where the ink temperature in the ink circulation path is out of the temperature range described above, it takes time to adjust the ink temperature in the entire ink circulation path, even when ink is heated or cooled in the common ink flow path portion 304a which stores ink right before being supplied to the recording heads 22, for example, as the amount of ink to be heated or cooled is in a small ratio to the amount of ink in the entire ink circulation path. In this case, ink needs to be heated or cooled for temperature adjustment continuously because ink which is out of the appropriate temperature range is flown into the common ink flow path portion 304a sequentially until the ink temperature in the entire ink circulation path is adjusted. However, it is not easy to adjust flowing ink to the desirable temperature, and high efficacy of heating or cooling cannot be obtained by heating or cooling of ink flowing in the common ink flow path portion 304a.

[0082] In the ink temperature adjusting operation in the present embodiment, ink stored in the sub tank 31 is heated or cooled with the ink temperature adjuster 25 and the ink heated or cooled is circulated in the ink circulation path. By this process, as circulating ink acts as a heating medium, the temperature of the components of the ink circulation path and the entire ink in the ink circulation path are adjusted so as to approach the target temperature T_c . In a case where ink flowing into the sub tank 31 after circulating in the ink circulation path gets within the prescribed temperature range including the target temperature T_c , the ink temperature adjusting operation ends and the image recording operation to the recording medium P starts.

[0083] When the ink temperature adjusting operation starts, detection of the first ink temperature T_1 by the first ink temperature detector 24a is performed. When the first ink temperature T_1 is lower than the minimum temperature T_{min} , heating of ink in the sub tank 31 by the heater 25a of the ink temperature adjuster 25 starts. Then the first valve 341 and the second valve 342 are opened and the third to sixth valves are closed, and the ink supply machinery 30 is set to the first state and the liquid delivery operation by the liquid delivery pump 27 starts. This liquid delivery operation may start after ink in the sub tank 31 is within the prescribed temperature range described above or before the temperature of ink in the sub tank 31 is within the prescribed temperature range described above. By this process, ink stored in the sub tank 31 and heated by the ink temperature adjuster 25 circulates in the ink circulation path which passes through the ink flow paths 301, 302a, and 303, the common ink flow path portion 304a, and the ink flow paths 305a and 306.

[0084] In a phase where the temperature of the entire ink circulation path is not adjusted enough, heat of ink sent out of the sub tank 31 transfers to the components of the ink circulation path, and the ink temperature falls before ink flows into the sub tank 31 again. The ink flown into the sub tank 31 is heated again by the ink temperature adjuster 25 and sent out from the sub tank 31. In this way, as the heating of ink in the sub tank 31 and the ink delivery in the ink circulation path continue, heat transfers from the circulating ink to the components of the ink circulation path and the temperature of the entire ink circulation path rises.

[0085] Thus, right after the ink delivery in the ink circulation path starts, difference ΔT develops between the first ink temperature T_1 detected by the first ink temperature detector 24a disposed in the ink flow path 306 and the second ink temperature T_2 detected by the second ink temperature detector 24b disposed in the ink flow path 301, and the difference ΔT declines as the ink delivery continues. When the first ink temperature T_1 is equal to or higher than the minimum temperature T_{min} and equal to or lower than the maximum temperature T_{max} here, the temperature of ink sent out from the sub tank 31 and having circulated in the ink circulation path by one round is within the prescribed temperature range described above, therefore it is determined that the entire ink in the ink circulation path is adjusted to within the prescribed

temperature range. When the difference ΔT is equal to or smaller than the prescribed reference difference ΔT_a , it is determined that the temperature in the entire ink circulation path is in a generally balanced state. The reference difference ΔT_a may be set to 2°C here, for example, but the duration of the ink temperature adjusting operation can be set shorter as a larger value is used as far as the appropriate ink discharge by the recording heads 22 is possible.

[0086] In the present embodiment, until the first ink temperature T_1 is equal to or higher than the minimum temperature $T_{\min}$ and equal to or lower than the maximum temperature $T_{\max}$ and the difference ΔT is equal to or smaller than the reference difference ΔT_a , the liquid delivery in the ink circulation path continues.

[0087] When the first ink temperature T_1 is equal to or higher than the minimum temperature $T_{\min}$ and equal to or lower than the maximum temperature $T_{\max}$ and the difference ΔT is equal to or smaller than the reference difference ΔT_a , the heating with the heater 25a ends. The first valve 341 is closed and the third valve 343 and the fourth valve 344 are opened to set the ink supply machinery 30 to the third state, and then ink in the sub tank 31 whose temperature is adjusted passes through the ink flow path 302b and is stored in the intermediate tank 33. By this process, the temperature of the intermediate tank 33 and ink flow path 302b is adjusted to a temperature within the prescribed temperature range described above.

[0088] The amount of ink stored in the intermediate tank 33 and the ink flow path 302b is adequately small in comparison to the amount of ink in the entire ink circulation path, and the heat capacity of the intermediate tank 33 and the ink flow path 302b is adequately small in comparison to the heat capacity of the entire ink circulation path here. Thus, the temperature drop in the entire ink circulation path with ink flowing into the intermediate tank 33 and the ink flow path 302b is scarce enough to be ignored in the present embodiment.

[0089] When the prescribed amount of ink is stored in the intermediate tank 33, the liquid delivery operation by the liquid delivery pump 27 stops.

[0090] When ink is stored in the intermediate tank 33, the second valve 342 is closed and the fifth valve is opened to set the ink supply machinery 30 to the fourth state. The head unit 20 is moved to the position facing the cleaner and the discharge operation described above is executed. In this discharge operation, ink in the flow path portions 222 of the recording heads 22 is discharged from the nozzles 221n to the ink receiver and ink in the common ink flow path portion 304a whose temperature is adjusted to within the prescribed temperature range described above flows into the flow path portions 222 at the same time. By this process, the ink temperature in the flow path portion 222 and the temperature at a section of the recording head 22 to which the heat of ink transfers are adjusted to a temperature within the prescribed temperature range described above.

[0091] The amount of ink stored in the recording heads 22 is adequately small in comparison to the amount of ink in the entire ink circulation path, and the heat capacity of the recording heads 22 is adequately small in comparison to the heat capacity of the entire ink circulation path here. Thus, in the discharge operation, the temperature drop in the entire circulation path with ink flowing into the flow path portions 222 of the recording heads 22 is scarce enough to be ignored in the present embodiment.

[0092] When the ink discharge from each of the nozzles 221n of the recording heads 22 is executed for the prescribed number of times, the discharge operation ends. The head unit 20 is moved to the position facing the conveyance belt 103 and the ink temperature adjusting operation ends. The discharge operation may be configured to end after a prescribed time has passed in a case where ink is discharged from the nozzles 221n at prescribed intervals to execute the discharge operation. The discharge operation may be configured to end when the head temperature T_h detected by the head temperature detector 23 is a temperature within a temperature range from the minimum temperature $T_{\min}$ to the maximum temperature $T_{\max}$ or within a range otherwise prescribed within that range.

[0093] In the above description, the first ink temperature T_1 detected by the first ink temperature detector 24a right after the beginning of the ink temperature adjusting operation is lower than the minimum temperature $T_{\min}$, but when the first ink temperature T_1 is higher than the maximum temperature $T_{\max}$, the temperature adjustment is performed so that the temperature of the entire ink circulation path falls by cooling of ink in the sub tank 31 with the cooler 25b.

[0094] Next, the ink temperature adjusting process by the CPU 41 in the ink temperature adjusting operation is described with reference to a flowchart.

[0095] FIG. 5 is a flowchart showing a control procedure of the ink temperature adjusting process.

[0096] The ink temperature adjusting process starts when image data of an image to be recorded on the recording medium P and a command to record image which requests recording of the image are supplied from the external device 2 via the input/output interface 56 and stored in the memory 44, or when the input operation by user requesting execution of the ink temperature adjusting operation is performed to the operation display 55.

[0097] When the ink temperature adjusting process starts, the CPU 41 supplies a control signal to the first ink temperature detector 24a, causing it to detect the first ink temperature T_1 and to output the detection result to the controller 40. Whether the first temperature T_1 is lower than the minimum temperature $T_{\min}$ or not is determined then (Step S101).

[0098] If it is determined that the first ink temperature T_1 is lower than the minimum temperature $T_{\min}$ ("YES" in the step S101), the CPU 41 sets the ink supply machinery 30 to the first state by supplying a control signal to the electro-magnetic valve driver 26 to open the first valve 341 and the second valve 342 and to close the third valve 343 to the

sixth valve 346 (Step S102).

[0099] The CPU 41 supplies a control signal to the ink temperature adjuster 25 to start heating of ink in the sub tank 31 with the heater 25a (Step S103).

[0100] The CPU 41 supplies a control signal to the liquid delivery pump 27 to start the liquid delivery by the liquid delivery pump 27 (Step S104). By this process, ink in the sub tank 31 circulates in the ink circulation path which passes through the ink flow paths 301, 302a, and 303, the common ink flow path portion 304a, and the ink flow paths 305a and 306. The process of the step S104 may be executed before the process of the step S103.

[0101] The CPU 41 supplies a control signal to the first ink temperature detector 24a and the second ink temperature detector 24b to cause them to detect the first ink temperature T1 and the second ink temperature T2 and to output the detection result to the controller 40. Then, whether the temperature condition that the first ink temperature T1 is equal to or higher than the minimum temperature Tmin and equal to or lower than the maximum temperature Tmax and the difference ΔT between the first ink temperature T1 and the second ink temperature T2 is equal to or smaller than the reference difference ΔTa is satisfied or not is determined (Step S105). If it is determined that the temperature condition is not satisfied ("No" in the step S105), the CPU 41 repeatedly executes the process of the step S105 at prescribed intervals of time.

[0102] If it is determined that the temperature condition described above is satisfied ("Yes" in the step S105), the CPU 41 supplies a control signal to the ink temperature adjuster 25 to end the heating of ink in the sub tank 31 with the heater 25a (Step S106).

[0103] The CPU 41 sets the ink supply machinery 30 to the third state by supplying a control signal to the electromagnetic valve driver 26 to close the first valve 341 and to open the third valve 343 and the fourth valve 344. By this process, the ink storage to the intermediate tank 33 starts (Step S107).

[0104] The CPU 41 supplies a control signal to the liquid delivery pump 27 to end the liquid delivery by the liquid delivery pump 27 when ink in a prescribed amount is stored in the intermediate tank 33 (Step S108).

[0105] The CPU 41 sets the ink supply machinery 30 to the fourth state by supplying a control signal to the electromagnetic valve driver 26 to close the second valve 342 and to open all the fifth valves 345 (Step S109).

[0106] The CPU 41 supplies a control signal to the head unit movement driver 54 to move the head unit 20 to a position facing the cleaner. A control signal is then supplied to the recording head driver 21 to cause each of the recording heads 22 to execute the discharge operation (Step S110). When the ink discharge from each of the nozzles 221n of the recording heads 22 is executed for the prescribed number of times, the CPU 41 ends the discharge operation and moves the head unit 20 to a position facing the conveyance belt 103.

[0107] In the process of the step S101, if it is determined that the first ink temperature T1 is equal to or higher than the minimum temperature Tmin ("No" in the step S101), the CPU 41 determines whether the first ink temperature T1 is higher than the maximum temperature Tmax or not (Step S111).

[0108] If it is determined that the first ink temperature T1 is higher than the maximum temperature Tmax ("Yes" in the step S111), the CPU 41 executes the processes of the step S112 to the step S116 in order. The processes of the step S112, the step S 114, and the step S 115 are respectively identical to the processes of the step S 102, the step S104, and the step S105. In the process of the step S113, the CPU 41 supplies a control signal to the ink temperature adjuster 25 to start cooling of ink in the sub tank 31 with the cooler 25b. In the process of the step S116, the CPU 41 supplies a control signal to the ink temperature adjuster 25 to end the cooling of ink in the sub tank 31 with the cooler 25b. When the process of the step S116 ends, the CPU 41 moves the process to the step S107.

[0109] If it is determined that the first ink temperature T1 is equal to or lower than the maximum temperature Tmax in the process of the step S111 ("No" in the step S111) or if the process of the step S110 ends, the CPU 41 ends the ink temperature adjusting process.

[0110] FIG. 6 is a flowchart showing a control procedure of the image recording process.

[0111] The image recording process starts after the ink temperature adjusting process has ended where a command to record image is stored in the memory 44.

[0112] As the image recording process starts, the CPU 41 supplies a control signal to each of the head temperature detectors 23 to cause them to detect the head temperature Th and to output the detection result of each to the controller 40 (Step S201).

[0113] The CPU 41 sets the voltage correction value concerning each of the recording heads 22 according to the head temperature Th corresponding to each of the recording heads 22 (Step S202). That is, the CPU 41 refers to the data of table stored in the ROM 403 and obtains the correction value of the voltage magnitude corresponding to the head temperature Th of each obtained in the step S201. The correction value is set as the voltage correction value concerning each of the recording heads 22 and stored in the memory 44.

[0114] The CPU 41 causes each of the recording heads 22 to record the image according to the image data on the basis of the voltage correction value set in the step S202 (Step S203). That is, the CPU 41 supplies a control signal to the conveyance driver 53 to cause the conveyance rollers 101 and 102 of the conveyer 10 to rotate and the conveyance belt 103 to move to convey the recording medium P. The image is recorded with ink being discharged from the nozzles

221n to recording medium P conveyed by the conveyer 10 as the CPU 41 supplies image data and a control signal to cause the recording head driver 21 to output the driving signal of the voltage correction value set in the step S202 to the recording heads 22.

[0115] The CPU 41 determines whether a command to record image undone is stored in the memory 44 or not (Step S204). If it is determined that a command to record image undone is recorded ("Yes" in the step S204), the CPU 41 moves the process to the step S201.

[0116] If it is determined that no command to record image undone is recorded ("No" in the step S204), the CPU 41 ends the image recording process.

[0117] As described above, the inkjet recording device 1 in accordance with the present embodiment includes the multiple recording heads 22 which respectively have the nozzle 221n discharging ink and the flow path portion 222 communicating with the nozzle 221n, the sub tank 31 which stores ink to be supplied to the multiple recording heads 22, the ink temperature adjuster 25 and CPU 41 which adjust the temperature of ink stored in the sub tank 31 to within the prescribed temperature range, the ink circulation path which passes through the sub tank 31 and the common ink flow path portion 304a communicating with the flow path portions 222 of the multiple the recording heads 22 and circulates ink stored in the sub tank 31, and the liquid delivery pump 27 which performs the liquid delivery operation to cause ink in the ink circulation path to flow in the prescribed liquid delivery direction and to circulate ink in the sub tank 31 in the ink circulation path. The CPU 41 causes the liquid delivery pump 27 to perform the liquid delivery operation so that a temperature of ink in the ink circulation path approaches a target temperature T_c which is within the prescribed temperature range (liquid delivery control means). With such a configuration, ink heated or cooled in the sub tank 31 acts as a heating medium and circulates in the ink circulation path, and the temperature of the entire ink circulation path is adjusted as heat transfers between the ink and the components of the ink circulation path. Thus, the temperature of ink supplied to the multiple recording heads 22 can be stabilized more in comparison to a configuration where ink flowing in the ink flow path is heated or cooled. The ink temperature is adjusted more effectively as ink stored and retained in the sub tank 31 is heated and cooled.

[0118] The inkjet recording device 1 incorporates the first ink temperature detector 24a which detects the temperature of ink right before flowing into the sub tank 31 in the ink circulation path, the CPU 41 determines whether the first ink temperature T_1 detected by the first ink temperature detector 24a is within the prescribed temperature range or not (determining means) and causes the liquid delivery pump 27 to execute a liquid delivery operation if it is determined that the first ink temperature T_1 is out of the prescribed temperature range (liquid delivery control means). As ink right before flowing into the sub tank 31 is ink after heat has been exchanged with the components of the ink circulation path, the first ink temperature T_1 concerning the ink reflects the temperature of the entire ink circulation path. Thus, with the configuration described above, whether the ink temperature in the ink circulation path is out of the prescribed temperature range is determined, and when the determination is done, the ink temperature in the ink circulation path can be adjusted so as to approach the target temperature T_c .

[0119] The inkjet recording device 1 includes the second ink temperature detector 24b which detects the temperature of ink right after flowing out of the sub tank 31 in the ink circulation path, and the CPU 41 determines whether the difference ΔT between the first ink temperature T_1 detected by the first ink temperature detector 24a and the second ink temperature T_2 detected by the second ink temperature detector 24b is equal to or smaller than the prescribed reference difference ΔT_a or not (determining means) and causes the liquid delivery pump 27 to execute the liquid delivery operation if it is determined that the difference ΔT is larger than the reference difference ΔT_a (liquid delivery control means). In the inkjet recording device 1, when the temperature distribution of the ink circulation path is more flat, the difference ΔT is smaller as the temperature fluctuation of ink circulating in the ink circulation path is smaller and the first ink temperature T_1 gets to the value close to the second ink temperature T_2 . Thus, with the configuration described above, the ink temperature can be adjusted so that the temperature distribution of the ink circulation path gets generally flat. As a result, the temperature of ink supplied to the recording head 22 can be stabilized more.

[0120] The CPU 41 causes the multiple recording heads 22 to discharge ink on the recording medium P to execute the recording operation to record an image on the recording medium P, if it is determined that the first ink temperature T_1 is within the prescribed temperature range. By this process, ink whose temperature and viscosity are adjusted can be supplied to the recording heads 22 and the recording heads 22 can perform ink discharge appropriately. As a result, the image can be recorded in an appropriate resolution.

[0121] The CPU 41 causes the multiple recording heads 22 to execute the recording operation if it is determined that the first ink temperature T_1 is within the prescribed temperature range and that the difference ΔT is equal to or smaller than the reference difference ΔT_a (recording control means). With such a configuration, the recording heads 22 can start the recording operation in a state where the difference ΔT is equal to or smaller than the reference difference ΔT_a and the ink temperature is stable. This allows the recording heads 22 to execute an appropriate ink discharge more stably.

[0122] The inkjet recording device 1 is provided with the multiple head temperature detectors 23 which detects the temperature of each section of the multiple recording heads 22 corresponding to the ink temperature in the flow path portion 222, and the CPU 41 causes the multiple recording heads 22 to execute a recording operation by a driving signal

of which at least one of voltage amplitude and voltage application duration is corrected according to the temperature detected by each of the multiple head temperature detectors 23 (recording control means). With such a configuration, the appropriate ink discharge is possible even when the ink temperature fluctuates according to the operation of the recording elements 221 in the recording heads 22. This can suppress the deterioration in image quality of the image recorded. Correction ranges of the voltage amplitude and voltage application duration of the driving signal can be lowered, because the temperature of ink supplied to the recording heads 22 is adjusted to within the prescribed temperature range.

[0123] The ink circulation path includes the first branching flow path portion which is disposed between the common ink flow path portion 304a and the sub tank 31 in the liquid delivery direction and causes the common ink flow path portion 304a and the sub tank 31 to communicate with each other through the flow path portion 222 of the multiple recording heads 22, and the second branching flow path portion which is disposed between the common ink flow path portion 304a and the sub tank 31 in the liquid delivery direction and causes the common ink flow path portion 304a and the sub tank 31 to communicate with each other not through the flow path portion 222 of the multiple recording heads 22. The inkjet recording device 1 includes the fifth valve 345 which is disposed within a range from the common ink flow path portion 304a and the multiple recording heads 22 in the liquid delivery direction and opens or closes the first branching flow path portion, and the CPU 41. The CPU 41 closes the first branching flow path portion with the fifth valve 345 while the liquid delivery operation is performed to circulate ink in the ink circulation path (switching control means). Such a configuration can prevent occurrence of malfunctioning like ink leakage from the nozzles 221n when ink circulates in the ink circulation path.

[0124] The inkjet recording device 1 incorporates a deaerating module 32 which is disposed in the ink circulation path and removes air in ink from the ink. This makes it possible to deaerate ink circulating in the ink circulation path in parallel with the ink temperature adjustments.

[0125] The components composing the ink circulation path are metal. With such a configuration, the temperature of the components composing the ink circulation path can be adjusted effectively by the heat of circulating ink. As a result, the temperature of the ink circulation path may be adjusted in a shorter period of time.

[Modification Example]

[0126] Next, a modification example of the embodiment described above is described. The present modification example is different from the embodiment described above in that the amount of liquid delivery by the liquid delivery pump 27 per prescribed unit of time is altered while the ink temperature adjusting operation is executed. Hereinafter differences from the embodiment described above are described.

[0127] In the present modification example, the first ink temperature T1 is detected by the first ink temperature detector 24a per prescribed unit of time after heating with the heater 25a or cooling with the cooler 25b starts in the ink temperature adjusting operation. The amount of liquid delivery by the liquid delivery pump 27 per prescribed unit of time is modified according to the difference between the detected first ink temperature T1 and the target temperature Tc. That is, the amount of liquid delivery by the liquid delivery pump 27 per prescribed unit of time is modified to gradually increase as the difference between the first ink temperature T1 and the target temperature Tc increases. When the difference between the first ink temperature T1 and the prescribed target temperature Tc is equal to or smaller than the prescribed value, the pressure of liquid delivery by the liquid delivery pump 27 may be set constant disregarding the value of the difference.

[0128] As described above, in the inkjet recording device 1 in accordance with the present modification example, the CPU 41 causes the liquid delivery pump 27 to execute the liquid delivery operation so that the amount of liquid delivery gradually increases as the difference between the first ink temperature T1 detected by the first ink temperature detector 24a and the target temperature Tc gets larger (liquid delivery control means). With such a configuration, the amount of heat transferred between each section of the ink circulation path and ink as a heating medium may increase, because the amount of ink passing through each section of the ink circulation path per prescribed unit of time as the difference between the first ink temperature T1 and the target temperature Tc gets larger. As a result, the temperature of the ink circulation path may be adjusted to within the prescribed temperature range in a shorter period of time.

[0129] The embodiment and modification example described above do not limit the scope of the invention and various modifications can be made to them.

[0130] For example, in the embodiment and modification example described above, the ink temperature adjuster 25 having the heater 25a and the cooler 25b is described as an example, but the ink temperature adjuster 25 may be configured with the heater 25a only in a case where the minimum temperature T_{min} is higher than the environment temperature of the inkjet recording device 1. Also, in a case where the maximum temperature T_{max} is lower than the environment temperature of the inkjet recording device 1, the ink temperature adjuster 25 may be configured with the cooler 25b only.

[0131] In the embodiment and modification example described above, the determination whether the first ink temperature T1 is within the prescribed temperature range or not and the determination whether the difference ΔT is equal to or smaller than the reference difference ΔT_a or not are both done, as an example. However, it is not intended to limit

the scope of the invention.

[0132] For example, the temperature distribution in the ink circulation path does not largely fluctuate in the ink temperature adjusting operation, it is not necessary to determine whether the difference ΔT is equal to or smaller than the reference difference ΔT_a or not. In this case, the second ink temperature detector 24b may be omitted.

[0133] Further, the ink temperature may be adjusted without determination whether the first ink temperature T_1 is within the prescribed temperature range or not. In this case, the ink temperature adjusting operation may be executed on the basis of the operation setting of the ink temperature adjuster 25 and the liquid delivery pump 27 which is predetermined corresponding to the environment temperature of the inkjet recording device 1 and the lapsed time after the last ink temperature adjusting operation, for example. The first ink temperature detector 24a may be omitted in this case.

[0134] In the embodiment and modification example described above, the ink flow paths 301, 302a, 302b, 303, 305a, 305b, and 306, the common ink flow path portion 304a, the common waste liquid flow path portion 304b, the sub tank 31, and the intermediate tank 33 are configured to be composed of metal, for example, but part or all of these may be composed of material other than metal, exemplified by resin such as fluororesin or epoxy resin. In this case, material which has a lower specific heat and higher heat conductivity is desirable so that the temperature of the ink circulation path is adjusted in a shorter period of time.

[0135] In the embodiment and modification example described above, ink in the sub tank 31 is heated or cooled with the ink temperature adjuster 25, but heaters to heat and/or coolers to cool ink passing through maybe provided to part or all of the ink flow paths 301, 302a, 302b, 303, 305a, 305b, and 306, the common ink flow path portion 304a, the common waste liquid flow path portion 304b, and the intermediate tank 33 in addition to the ink temperature adjuster 25.

[0136] In the embodiment and modification example described above, the temperature of ink right after flowing out of the sub tank 31 (the second ink temperature T_2) is configured to be detected by the second ink temperature detector 24b as an example, but alternatively the second ink temperature detector 24b may be provided to the inside of the sub tank 31 and detect the ink temperature in the sub tank 31 as the second ink temperature T_2 .

[0137] Also, in the embodiment and modification described above, the temperature of ink right before flowing into the sub tank 31 (the first ink temperature T_1) is configured to be detected by the first ink temperature detector 24a, as an example, but alternatively the first ink temperature detector 24a may be provided near the section where ink flows in from the ink flow path 306 in the sub tank 31 and detect the temperature of ink before flowing in from the ink flow path 306 and being mixed with ink in the sub tank 31 as the first ink temperature T_1 .

[0138] In the present embodiment and modification example, ink whose temperature is adjusted flows into the flow path portions 222 of the recording heads 22 by the discharge operation. However, it is not intended to limit the scope of the invention. Instead of or before the discharge operation, the temperature of the flow path portion 222 may be adjusted by circulating ink in the ink circulation path passing through the flow path portions 222 of the recording heads 22 with the ink supply machinery 30 being set to the second state.

[0139] In the embodiment and modification example described above, the ink circulation path with the first and second branching flow paths is described as an example, but the ink circulation path may be configured to pass through the flow path portion of the recording head without a branching flow path.

[0140] In the embodiment and modification example described above, the ink temperature is adjusted to within a range between plus and minus 5°C from the target temperature T_c (25°C) (20°C to 30°C), but the temperature range on the plus side of the target temperature T_c may be smaller than the temperature range on the minus side. For example, the ink temperature may be adjusted to be within the range of 20°C to 26°C with the temperature range on the minus side being set to 5°C and the temperature range on the plus side to 1°C. With such a configuration, even when the ink temperature in the recording heads 22 increases corresponding to the operation frequency of the recording elements 221, the ink temperature can be prevented from overly deviating from the target temperature T_c .

[0141] In the embodiment and modification example described above, ink which is liquid at room temperature is used as an example. However, it is not intended to limit the scope of the invention. The present invention may be applied to inkjet recording devices which discharge ink which is in a gel state at room temperature and given a sol state by heating, after heating to be in a sol state.

[0142] In the embodiment and modification example described above, the ink jet recording device 1 of a single pass mode is described as an example, but the present invention may be applied to the inkjet recording devices which executes image recording while the head unit is scanning.

[0143] In the embodiment and modification example described above, the recording medium P is conveyed by the conveyer 10 provided with the conveyance belt 103 as an example. However, it is not intended to limit the scope of the invention, and the conveyer 10 may retain and convey the recording medium P along the perimeter of a rotating conveyance drum.

[0144] Although some embodiments of the invention are described, the scope of the invention is not limited to the above embodiments, but includes the scope of the invention described in the scope of claims and the scope of equivalents thereof.

INDUSTRIAL APPLICABILITY

[0145] The present invention is applicable to an inkjet recording device.

5 DESCRIPTION OF REFERENCE NUMERALS

[0146]

	1	Inkjet Recording Device
10	2	External Device
	10	Conveyer
	101,102	Conveyance Roller
	103	Conveyance Belt
	20	Head Unit
15	21	Recording Head Driver
	22	Recording Head
	221	Recording Element
	221n	Nozzle
	222	Flow Path Portion
20	223	Inlet
	224	Outlet
	23	Head Temperature Detector
	24a	First Ink Temperature Detector
	24b	Second Ink Temperature Detector
25	25	Ink Temperature Adjuster
	25a	Heater
	25b	Cooler
	26	Electromagnetic Valve Driver
	27	Liquid Delivery Pump
30	30	Ink Delivery Machinery
	301, 302a, 302b, 303, 305a, 305b, 306	Ink Flow Path
	304a	Common Ink Flow Path Portion
	304b	Common Waste Liquid Flow Path Portion
	31	Sub Tank
35	32	Deaerating Module
	33	Intermediate Tank
	341	First Valve
	342	Second Valve
	343	Third Valve
40	344	Fourth Valve
	345	Fifth Valve
	346	Sixth Valve
	40	Controller
	41	CPU
45	42	RAM
	43	ROM
	44	Memory
	50	Main Tank
	51	Supplying Pump
50	52	Vacuum Pump
	521	Chamber
	53	Conveyance Driver
	54	Head Unit Movement Driver
	55	Operation Display
55	56	Input/Output Interface
	57	Bus
	60	Deaerater
	P	Recording Medium

Claims

1. An inkjet recording device comprising:

5 a plurality of recording heads which respectively have a nozzle discharging ink and an ink flow path portion communicating with the nozzle;
 an ink storage which stores ink to be supplied to the plurality of recording heads;
 an ink temperature adjusting means which adjusts a temperature of ink stored in the ink storage to within a prescribed temperature range;
 10 an ink circulation path which passes through the ink storage and a common ink flow path portion communicating with the ink flow path portion of the plurality of the recording heads and circulates ink stored in the ink storage;
 a liquid delivery means which performs a liquid delivery operation to cause ink in the ink circulation path to flow in a prescribed liquid delivery direction and to circulate ink in the ink storage in the ink circulation path; and
 15 a liquid delivery control means which causes the liquid delivery means to perform the liquid delivery operation so that a temperature of ink in the ink circulation path approaches a prescribed target temperature which is within the prescribed temperature range.

2. The inkjet recording device according to claim 1, comprising:

20 a first ink temperature detecting means which detects a temperature of ink right before flowing into the ink storage from ink in the ink circulation path; and
 a determining means which determines whether a temperature detected by the first ink temperature detecting means is within the prescribed temperature range or not,
 wherein the liquid delivery control means causes the liquid delivery means to perform the liquid delivery operation
 25 when the determining means determines that the temperature is out of the prescribed temperature range.

3. The inkjet recording device according to claim 2, comprising a second ink temperature detecting means which detects a temperature of ink in the ink storage or a temperature of ink right after flowing out of the ink storage in the ink circulation path,
 30 wherein the determining means determines whether a difference between a temperature detected by the first ink temperature detecting means and a temperature detected by the second ink temperature detecting means is equal to or smaller than a prescribed reference difference or not, and
 wherein the liquid delivery control means causes the liquid delivery means to perform the liquid delivery operation when the determining means determines that the difference is larger than the reference difference.

4. The inkjet recording device according to claim 2, comprising a recording control means which causes the plurality of recording heads to perform a recording operation to record an image on a recording medium by discharging ink to the recording medium when the determining means determines that the temperature is within the prescribed temperature range.

5. The inkjet recording device according to claim 4, comprising a second ink temperature detecting means which detects a temperature of ink in the ink storage or a temperature of ink right after flowing out of the ink storage in the ink circulation path,
 wherein the determining means determines whether a difference between a temperature detected by the first ink temperature detecting means and a temperature detected by the second ink temperature detecting means is equal to or smaller than a prescribed reference difference or not, and
 45 wherein the recording control means causes the plurality of recording heads to perform the recording operation when the determining means determines that the temperature is within the prescribed temperature range and that the difference is equal to or smaller than the reference difference.

6. The inkjet recording device according to claim 4 or 5, comprising a plurality of head temperature detecting means which respectively detect a temperature of a section of each of the plurality of recording heads, the temperature of the section corresponding to a temperature of ink in the ink flow path portion,
 wherein the recording control means causes the plurality of the recording heads to perform the recording operation
 55 by a driving signal of which at least one of voltage amplitude and voltage application duration is corrected according to a temperature detected by each of the plurality of the head temperature detecting means.

7. The inkjet recording device according to any one of claims 2 to 6, wherein the liquid delivery control means causes

the liquid delivery means to perform the liquid delivery operation so that an amount of liquid delivery of ink per prescribed unit of time gradually increases as the difference between a temperature detected by the first ink temperature detecting means and the prescribed target temperature gets larger.

- 5 **8.** The inkjet recording device according to any one of claims 1 to 7,
wherein the ink circulation path has a first branching flow path portion which is disposed between the common ink
flow path portion and the ink storage in the liquid delivery direction and causes the common ink flow path portion
and the ink storage to communicate with each other through the ink flow path portion of the plurality of the recording
heads, and a second branching flow path portion which is disposed between the common ink flow path portion and
10 the ink storage in the liquid delivery direction and causes the common ink flow path portion and the ink storage to
communicate with each other not through the ink flow path portion of the plurality of the recording heads, and
wherein the inkjet recording device has a switching means which is disposed within a range from the common ink
flow path portion and the plurality of recording heads in the liquid delivery direction and opens or closes the first
branching flow path portion, and a switching control means which closes the first branching flow path portion by the
15 switching means while the liquid delivery operation is performed to circulate ink in the ink circulation path.
- 9.** The inkjet recording device according to any one of claims 1 to 8, comprising a deaerating means which is disposed
in the ink circulation path and removes air in ink from the ink.
- 20 **10.** The inkjet recording device according to any one of claims 1 to 9, wherein component composing the ink circulation
path is metal.

FIG.1

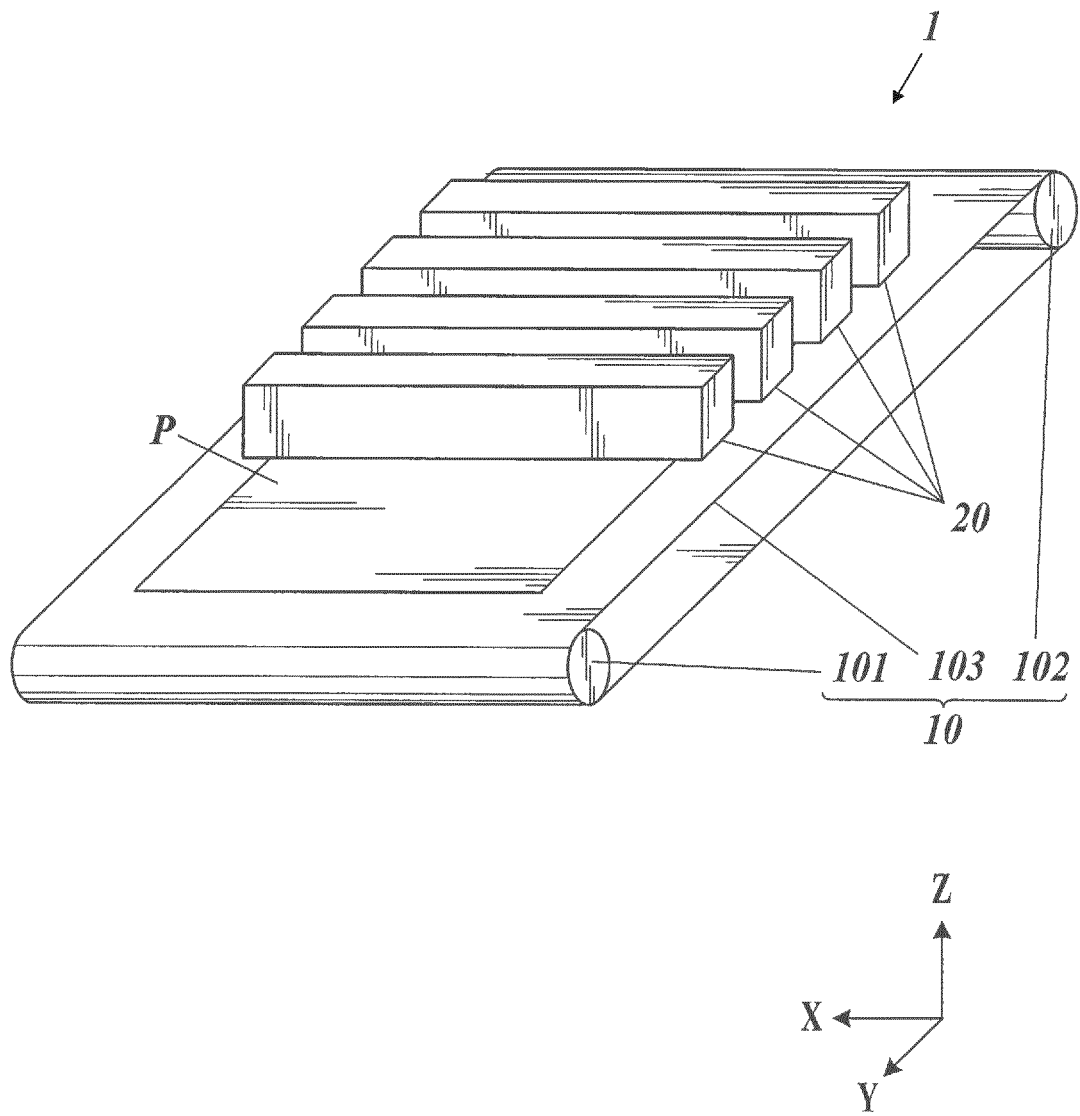


FIG.2A

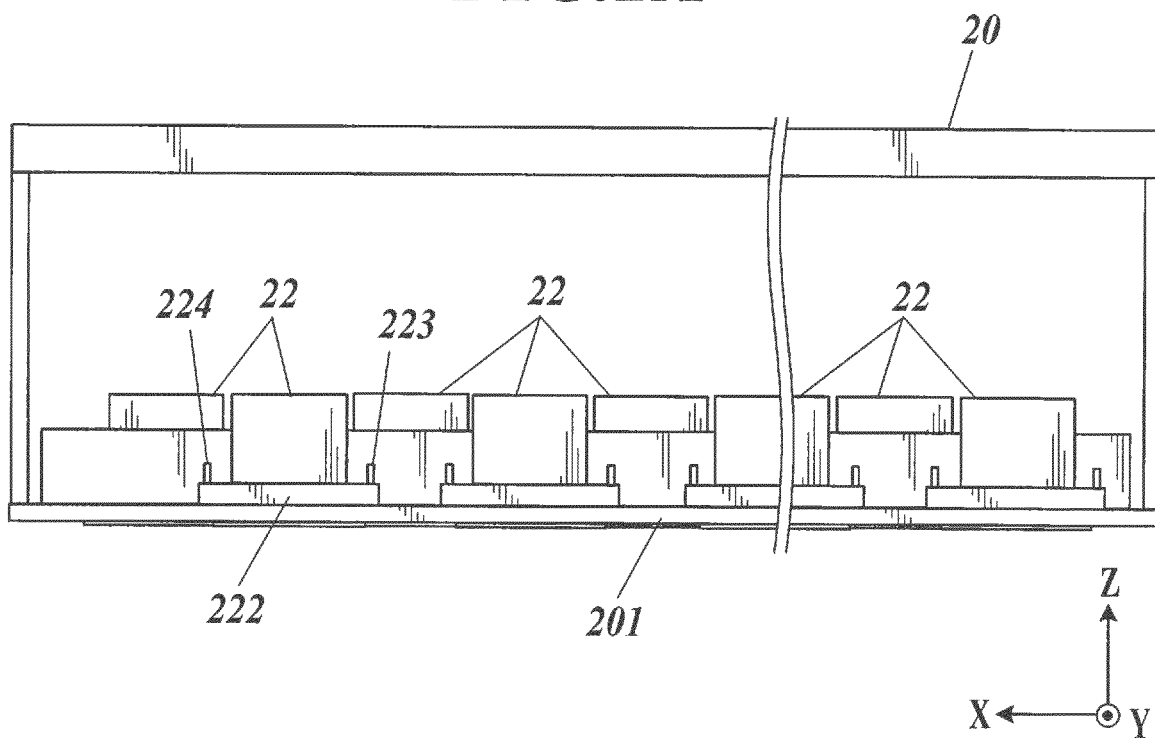


FIG.2B

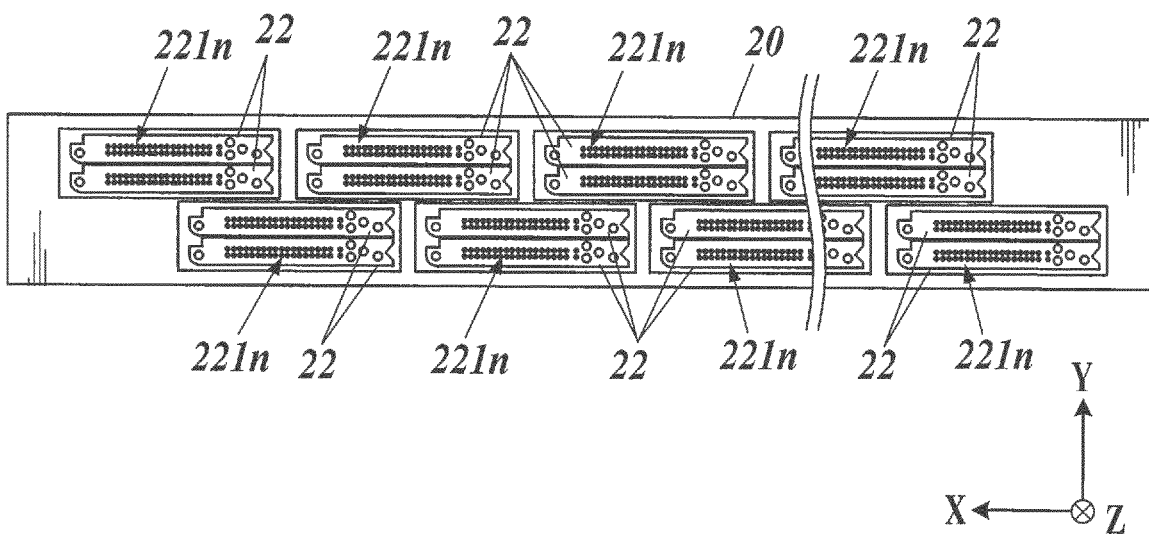


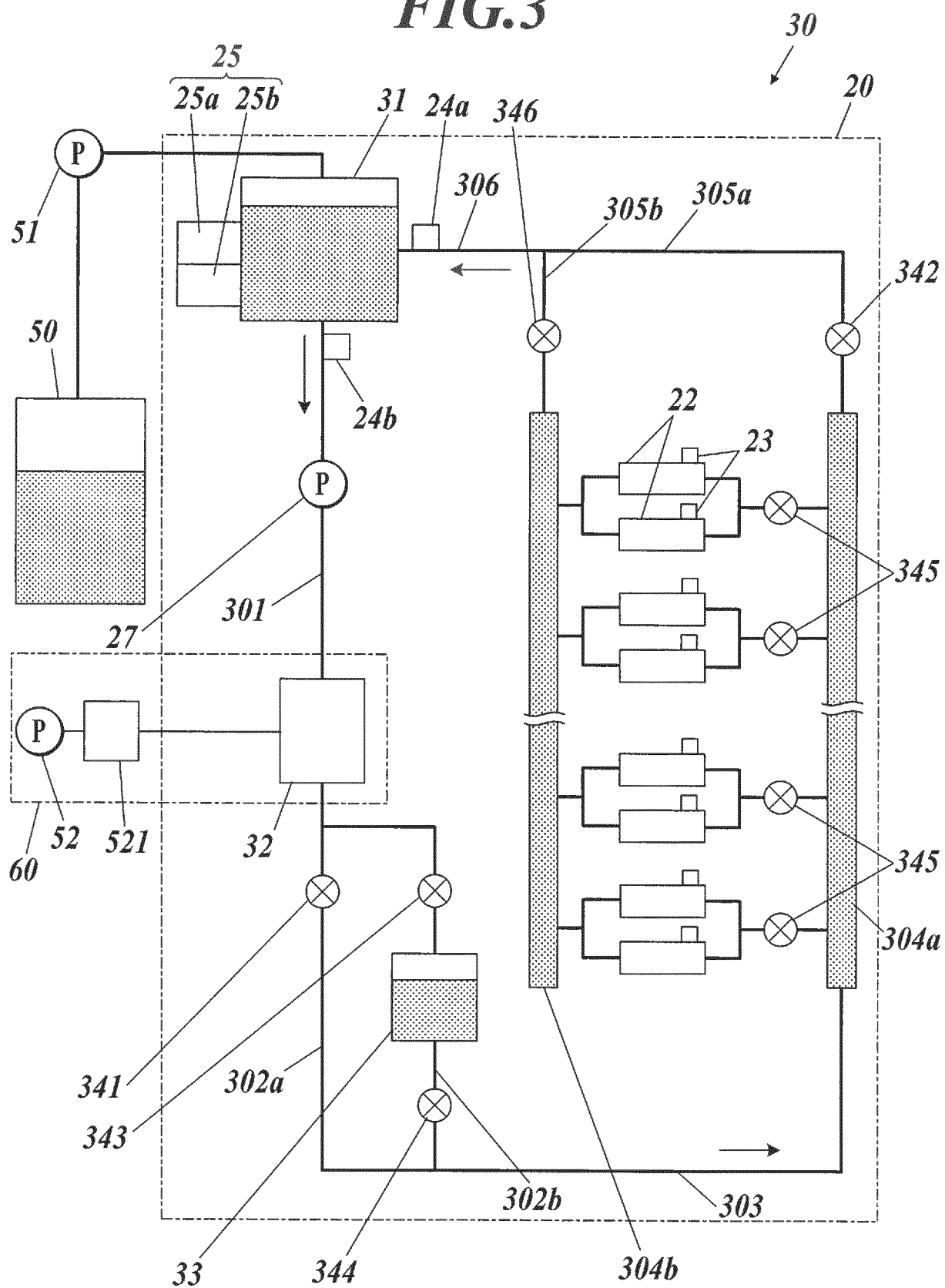
FIG.3

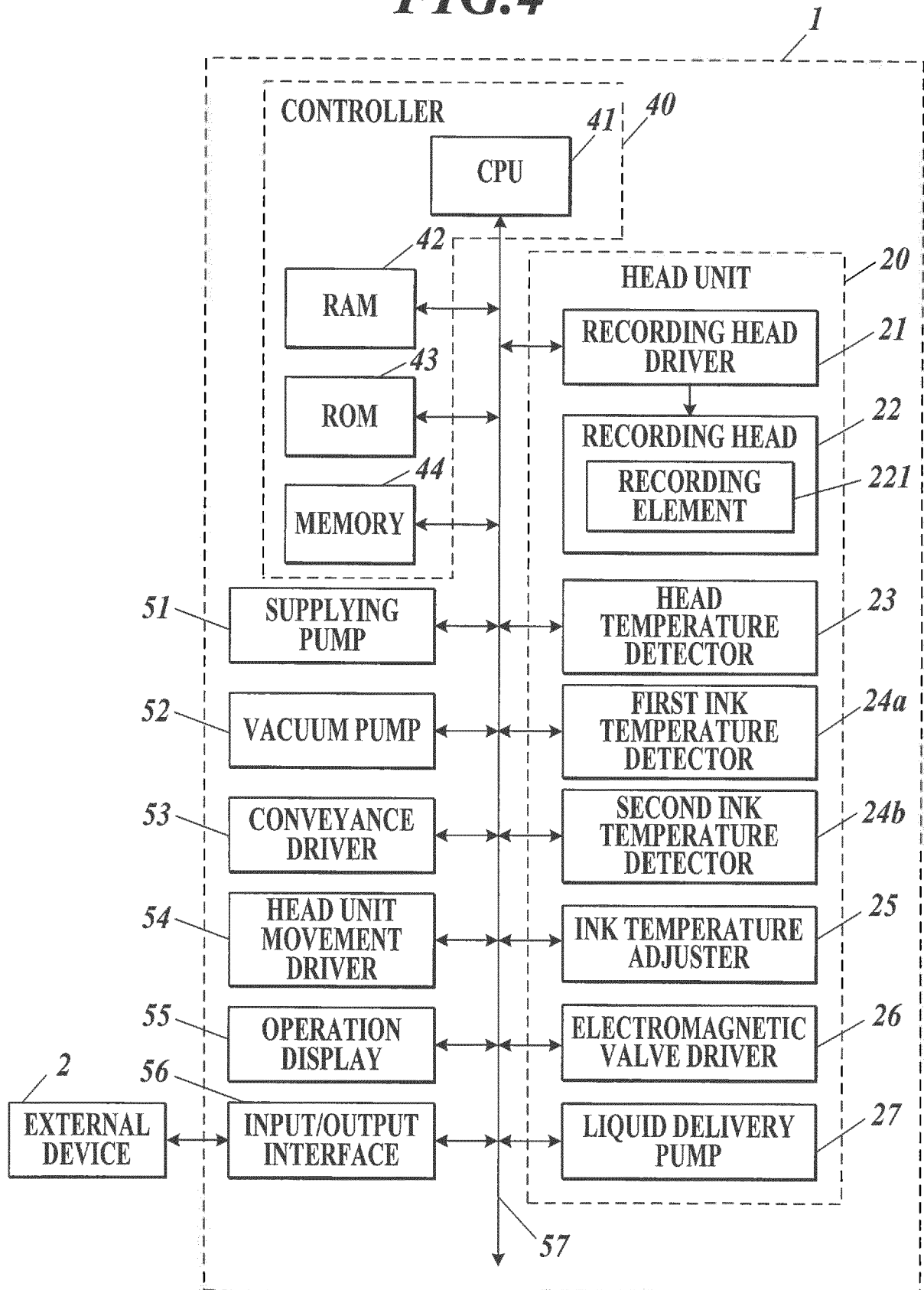
FIG.4

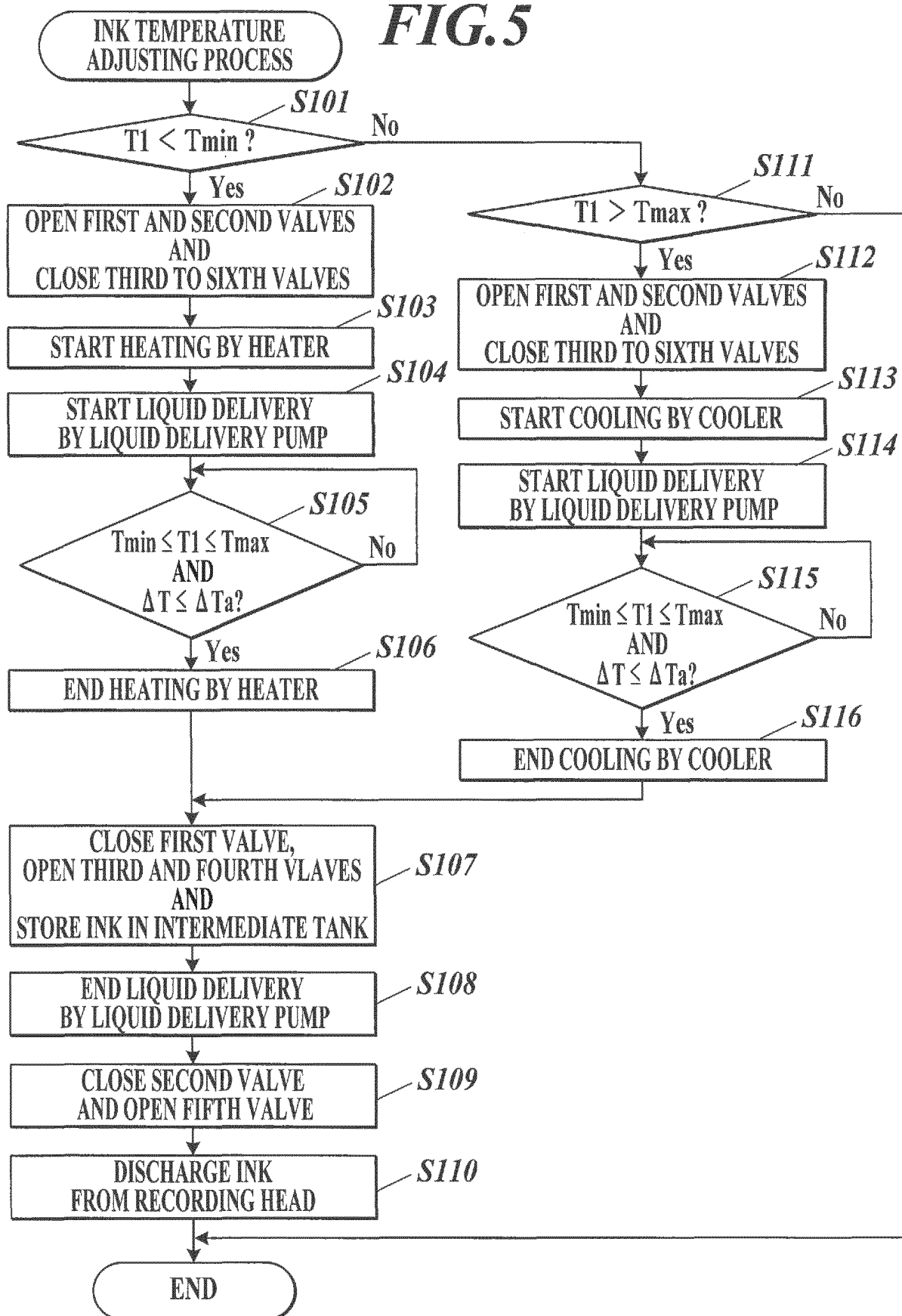
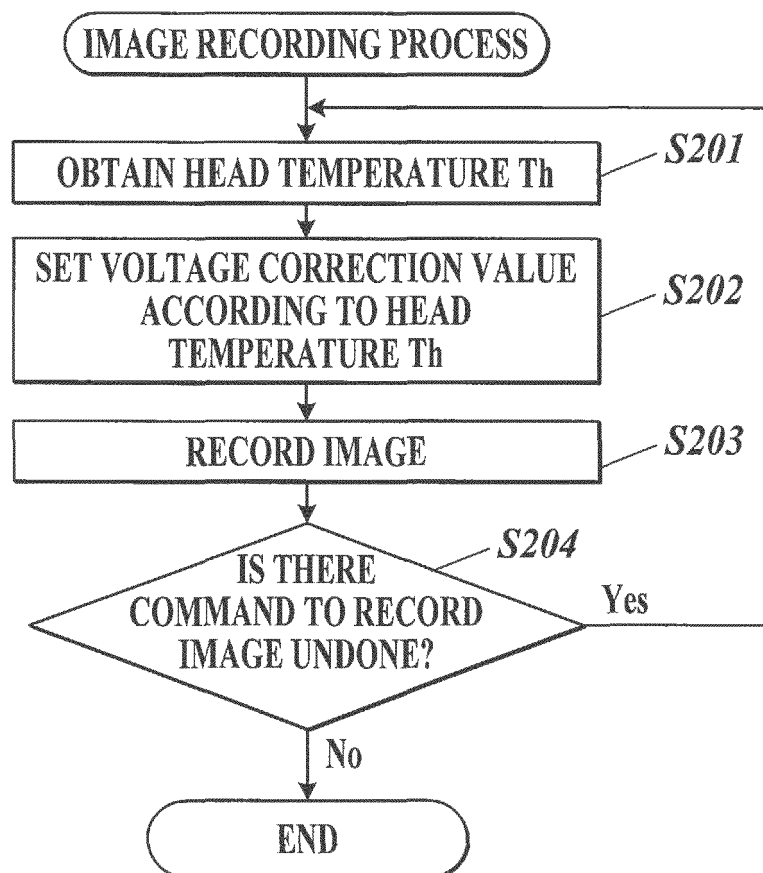
FIG.5

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/084064

A. CLASSIFICATION OF SUBJECT MATTER

B41J2/18(2006.01)i, B41J2/01(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)

B41J2/18, B41J2/01, 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 1996-2017

Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2011-51172 A (Seiko Epson Corp.),	1
Y	17 March 2011 (17.03.2011),	9-10
A	paragraphs [0032] to [0051]; fig. 1 to 2 (Family: none)	2-8
Y	JP 2015-518 A (Fujifilm Corp.),	9
	05 January 2015 (05.01.2015),	
	paragraphs [0079] to [0085]; fig. 3 to 4 (Family: none)	
Y	JP 2015-147365 A (Seiko Epson Corp.),	9
	20 August 2015 (20.08.2015),	
	paragraph [0023]; fig. 1	
	& US 2015/0224786 A1	
	paragraph [0032]; fig. 1	
	& EP 2905142 A2	

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

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
11 January 2017 (11.01.17)Date of mailing of the international search report
24 January 2017 (24.01.17)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/084064

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 2014-825 A (Seiko Epson Corp.), 09 January 2014 (09.01.2014), paragraphs [0008], [0021] to [0051]; fig. 1 to 6 & US 2009/0295867 A1 paragraphs [0005] to [0007], [0031] to [0061]; fig. 1 to 6 & CN 101590729 A	10
Y	JP 2004-181829 A (Toshiba Tec Corp.), 02 July 2004 (02.07.2004), paragraph [0005] (Family: none)	10
A	JP 2015-157362 A (Seiren Co., Ltd.), 03 September 2015 (03.09.2015), entire text; all drawings & CN 104859310 A entire text; all drawings	1-10

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

REFERENCES CITED IN THE DESCRIPTION

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- JP 2009178996 A [0004]