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

(11) EP 2 639 071 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
18.09.2013 Bulletin 2013/38

(51) Int Cl.:
B41J 2/155 *(2006.01)* ***B41J 2/045*** *(2006.01)*
B41J 2/14 *(2006.01)*

(21) Application number: **13159425.1**

(22) Date of filing: **15.03.2013**

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

(30) Priority: **16.03.2012 JP 2012060492**

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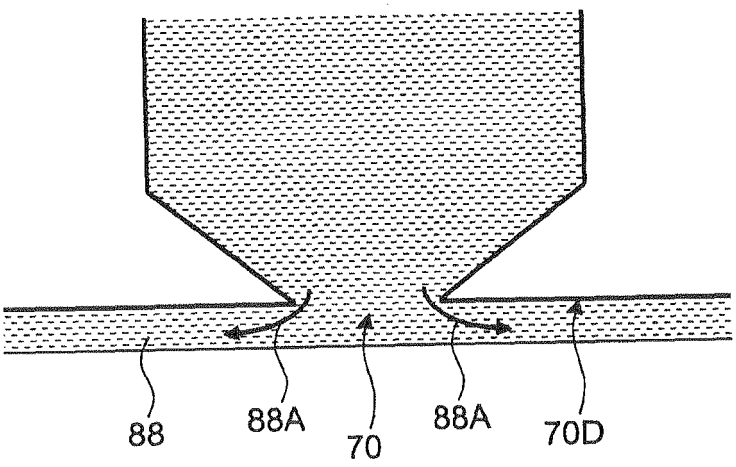
(54) Liquid ejection apparatus and inkjet head drive method

(57) According to an aspect of the invention, in a liquid ejection recording apparatus (10) which includes an inkjet head (24; 24C, 24M, 24Y, 24K) provided with a liquid ejection surface (70D) having lyophilic properties with respect to a dryable liquid having a component that is volatile in air, the inkjet head being used in a state where the liquid ejection surface is covered with liquid, a non-ejection drive voltage (200, 210) which does not cause ejection of liquid from a nozzle is supplied to the pressurization device (80), so as to cause liquid inside the nozzle to vibrate and to overflow out onto the liquid ejection surface, as well as causing a flowing movement of liquid which covers the liquid ejection surface, whereby increase in the viscosity of the liquid due to drying is suppressed.

FIG.9B



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a liquid ejection apparatus and an inkjet head drive method, and more particularly to drive technology for avoiding ejection abnormalities due to nozzle blockages in an inkjet head.

Description of the Related Art

[0002] An inkjet recording apparatus which forms a color image on a recording medium by ejecting color ink from an inkjet head is commonly used as a general image forming apparatus. An inkjet recording apparatus ejects very fine ink droplets from a plurality of nozzles provided in an inkjet head.

[0003] In an inkjet recording apparatus, if the nozzles which eject ink droplets are open to the air and the meniscus at the interface between the ink and the outside air is left for a long period of time, then the ink viscosity inside the nozzles increases due to drying and becomes a cause of ejection abnormalities.

[0004] In order to prevent drying of ink inside the nozzles, an ink ejection surface of an inkjet head (a nozzle surface in which nozzle openings are formed) is covered with a cap when printing has been completed. Furthermore, the technology disclosed in Japanese Patent Application Publication No. 7-137252 below is known as technology for preventing ink blockages in the nozzles.

[0005] Japanese Patent Application Publication No. 7-137252 discloses technology which prevents blockages caused by a film of ink formed in the vicinity of the nozzle openings when not printing, by applying a portion of a drive signal to piezoelectric elements belonging to nozzle openings which are not ejecting ink droplets, so as to cause the meniscus in the nozzle openings to vibrate.

[0006] In other words, by causing the meniscus to perform minute vibrations in the vicinity of the nozzles, the ink (solvent) in the vicinity of the nozzles which has increased in viscosity due to the evaporation of the solvent is churned, and increase in the viscosity of the ink in the vicinity of the nozzles is prevented, thereby preventing ejection abnormalities due to blockages of the nozzles.

SUMMARY OF THE INVENTION

[0007] However, ink mist which occurs due to ejection of ink, paper dust caused by conveyance of the recording medium, dust in the air, and the like, becomes attached to the ink ejection surface. Ejection abnormalities may occur due to the presence of adhering matter of this kind. In particular, when adhering matter is present in the edge portions of the nozzle openings and the vicinity thereof, then there is an increased possibility of causing ejection abnormalities.

[0008] With the technology disclosed in Japanese Patent Application Publication No. 7-137252, the volume of ink which can be circulated is very small, and therefore it is difficult to prevent increased viscosity of the ink in the vicinity of the nozzle surface by means of this technology alone.

[0009] In this way, in order to perform normal ink ejection from nozzles immediately after being idle, it is necessary to carry out nozzle maintenance, such as dummy ejection (spitting) or suctioning, or the like, at a position where no recording medium is present.

[0010] The present invention was devised in view of these circumstances, an object thereof being to provide a liquid ejection apparatus and an inkjet head drive method whereby ejection abnormalities caused by increase in the viscosity of ink inside nozzles are prevented.

[0011] According to this aspect of the invention, in a liquid ejection recording apparatus which includes an inkjet head provided with a liquid ejection surface having lyophilic properties with respect to a dryable liquid having a component that is volatile in air, the inkjet head being used in a state where the liquid ejection surface is covered with liquid, a non-ejection drive voltage which does not cause ejection of liquid from a nozzle is supplied to the pressurization device, so as to cause liquid inside the nozzle to vibrate and to overflow out onto the liquid ejection surface, as well as causing a flowing movement of liquid which covers the liquid ejection surface, whereby increase in the viscosity of the liquid due to drying is suppressed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The nature of this invention, as well as other objects and advantages thereof, will be explained in the following with reference to the accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures and wherein:

Fig. 1 is an external perspective drawing of an inkjet recording apparatus relating to a first embodiment of the present invention;
Fig. 2 is an illustrative diagram which shows a schematic drawing of a paper conveyance path in the inkjet recording apparatus shown in Fig. 1;
Fig. 3 is a plan diagram showing a composition of the image forming unit shown in Fig. 1;
Fig. 4 is a plan diagram showing a further mode of the composition of the image forming unit shown in Fig. 3;
Figs. 5A and 5B are plan diagrams of an ink ejection surface which shows a nozzle arrangement in an inkjet head;
Fig. 6 is a cross-sectional diagram showing an internal structure of an inkjet head;
Fig. 7 is a block diagram showing a principal composition of the control system of the inkjet recording apparatus shown in Fig. 1;
Fig. 8 is a block diagram showing a more detailed composition of the control system shown in Fig. 7;
Figs. 9A and 9B are illustrative diagrams showing a schematic view of the behavior of ink during supply of a non-ejection drive voltage, wherein Fig. 9A is an illustrative diagram of a flow of ink on an ink ejection surface and Fig. 9B is an illustrative diagram of a flow of ink from inside a nozzle onto an ink ejection surface;
Figs. 10A and 10B are illustrative diagrams showing a schematic view of the behavior of ink after halting supply of a non-ejection drive voltage, wherein Fig. 10A is an illustrative diagram of a flow of ink on an ink ejection surface and Fig. 10B is an illustrative diagram of a flow of ink from inside a nozzle onto an ink ejection surface;
Fig. 11 is an illustrative diagram of the effects of the first embodiment of the present invention;
Figs. 12A and 12B are waveform diagrams showing an example of a non-ejection drive voltage;
Fig. 13 is a flowchart showing a flow of control in an inkjet head drive method relating to the first embodiment of the present invention;
Fig. 14 is an illustrative diagram of an inkjet recording apparatus (inkjet head drive method) relating to a second embodiment of the present invention;
Fig. 15 is an illustrative diagram of the effects of the second embodiment of the present invention;
Figs. 16A and 16B are waveform diagrams showing an example of a non-ejection drive voltage which is applied in the second embodiment of the invention;
Fig. 17 is a block diagram showing a composition of a control system of an inkjet recording apparatus relating to the second embodiment of the invention;
Fig. 18 is a flowchart showing a flow of control in an inkjet head drive method relating to the second embodiment of the invention;
Fig. 19 is an illustrative diagram of an inkjet recording apparatus (inkjet head drive method) relating to a third embodiment of the present invention; and
Fig. 20 is an illustrative diagram of the effects of the third embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

(First embodiment)

(General composition of inkjet recording apparatus)

[0013] Fig. 1 is an external perspective drawing of an inkjet recording apparatus (a liquid ejection apparatus) relating to a embodiment of the present invention. This inkjet recording apparatus 10 is a wide-format printer which forms a color image on the recording medium 12 by using dryable ink. A wide-format printer is an apparatus which is suitable for recording a wide image formation range, such as for large posters or commercial wall advertisements, or the like. Here, a printer corresponding to a medium having a size of super A3 or greater is called "wide-format".

[0014] Furthermore, ink which includes a volatile solvent, such as water or alcohol, and from which a component evaporate off in air is called a "dryable ink (dryable liquid) ". In the present specification, the dryable ink may be simply called "ink".

[0015] The inkjet recording apparatus 10 includes an apparatus main body 20 and a stand 22 which supports the apparatus main body 20. The apparatus main body 20 includes a drop-on-demand type of inkjet head 24 which ejects ink toward a recording medium (medium) 12, a platen 26 which supports the recording medium 12, and a guide mechanism 28 and a carriage 30 which form a head movement device (scanning device).

[0016] The guide mechanism 28 is disposed so as to extend above the platen 26, following a scanning direction (hereinafter, this direction may be called a main scanning direction or Y direction) which is parallel to the medium supporting surface of the platen 26 and which is perpendicular to the conveyance direction (hereinafter, this direction may be called a sub-scanning direction or X direction) of the recording medium 12. The carriage 30 is supported so as to be able to perform reciprocal movement in the Y direction along a guide mechanism 28.

[0017] The inkjet head 24 disposed on the carriage 30 move in unison with (together with) the carriage 30 along the

guide mechanism 28. The reciprocal movement direction (Y direction) of the carriage 30 may be called the "main scanning direction" and the conveyance direction (X direction) of the recording medium 12 corresponds to the "sub-scanning direction".

[0018] Various media may be used for the recording medium 12, without any restrictions on the material, such as paper, unwoven cloth, vinyl chloride, compound chemical fibers, polyethylene, polyester, tarpaulin, or the like, or whether the medium is permeable or non-permeable. The recording medium 12 is supplied in a rolled state (see Fig. 2) from the rear surface of the apparatus, and after printing, the medium is rolled onto a take-up roller on the front side of the apparatus (not shown in Fig. 1 and reference numeral 44 in Fig. 2). Ink droplets are ejected from the inkjet head 24 onto the recording medium 12 which is conveyed on the platen 26.

[0019] In Fig. 1, the installation section 38 of an ink cartridge 36 is provided on the left-side front face of the apparatus main body 20 when the apparatus is viewed from the front. The ink cartridge 36 is an replaceable ink supply source (ink tank). The ink cartridge 36 is provided so as to correspond to respective inks which are used in the inkjet recording apparatus 10 of the present embodiment.

[0020] The respective ink cartridges 36 of each color are respectively connected to the inkjet head 24 by ink supply channels (not illustrated) which are formed independently. The ink cartridges 36 are replaced when the amount of remaining ink of the respective colors has become low.

[0021] Although not shown in the drawings, a maintenance unit for the inkjet head 24 is provided on the right-hand side of the apparatus main body 20 as viewed from the front side. This maintenance unit includes a cap for keeping the inkjet head 24 moist when not printing, and a wiping member (blade, web, etc.) for cleaning the nozzle surface (ink ejection surface) of the inkjet head 24. The cap which caps the nozzle surface of the inkjet head 24 is provided with an ink receptacle for receiving ink droplets ejected from the nozzles for the purpose of maintenance.

(Description of recording medium conveyance path)

[0022] Fig. 2 is an illustrative diagram showing a schematic view of the recording medium conveyance path in the inkjet recording apparatus 10. As shown in this figure, the platen 26 is formed in an inverted gutter shape and the upper surface thereof is a supporting surface (medium supporting surface) for a recording medium 12. A pair of nip rollers 40 which form a recording medium conveyance device for intermittently conveying the recording medium 12 are provided on the upstream side of the platen 26 in the recording medium conveyance direction (X direction), in the vicinity of the platen 26. These nip rollers 40 move the recording medium 12 in the recording medium conveyance direction over the platen 26.

[0023] The recording medium 12 which is output from a supply side roll (pay-out supply roll) 42 that constitutes a roll-to-roll type medium conveyance device is conveyed intermittently in the recording medium conveyance direction by the pair of nip rollers 40 which are provided in an inlet opening of the print unit (on the upstream side of the platen 26 in terms of the recording medium conveyance direction). When the recording medium 12 has arrived at the print unit directly below the inkjet head 24, printing is carried out by the inkjet head 24, and the recording medium is then wound up onto a take-up roll 44 after printing. A guide 46 for the recording medium 12 is provided on the downstream side of the print unit in the recording medium conveyance direction.

[0024] A temperature adjustment unit 50 for adjusting the temperature of the recording medium 12 during printing is provided on the rear surface (an opposite surface to the surface supporting the recording medium 12) of the platen 26 at a position opposing the inkjet head 24. When the recording medium 12 is adjusted to a prescribed temperature during printing, the viscosity, surface tension, and other physical properties, of the ink droplets deposited onto the recording medium 12, assume prescribed values and it is possible to obtain a desired dot diameter. According to requirements, it is possible to provide a heat pre-adjustment unit 52 on the upstream side of the temperature adjustment unit 50 or to provide a heat after-adjustment unit 54 on the downstream side of the temperature adjustment unit 50.

(Composition of the print unit)

[0025] Fig. 3 is a plan diagram showing a composition of a print unit, and depicts an arrangement mode of inkjet heads 24 which are arranged on a carriage 30.

[0026] Inkjet heads 24K, 24Y, 24M and 24C for ejecting inks of respective colors are provided for each of the ink colors: black (K), yellow (Y), magenta (M) and cyan (C). The types of ink color (number of colors) and the combination of colors are not limited to those of the present embodiment.

[0027] For example, it is possible to adopt a mode in which inkjet heads for light cyan (LC) and light magenta (LM) are provided, or a mode in which a plurality of inkjet heads are provided for colors having a high use frequency, and so on. Furthermore, the arrangement sequence of the inkjet heads 24K, 24Y, 24M and 24C of the different colors is not limited in particular.

[0028] Moreover, it is also possible to constitute an inkjet head comprising nozzles (nozzle rows) of a plurality of colors.

In the description given below, unless it is necessary to distinguish between the inkjet heads of the respective colors, the letter indicating the color is omitted and the description refers simply to inkjet head (s) 24.

[0029] Fig. 4 is a plan diagram showing a further mode of a composition of a print unit. The inkjet heads 24K', 24Y', 24M' and 24C' shown in Fig. 4 are full line heads, having a structure in which a plurality of nozzles are arranged through a length L_N exceeding the full width L_M of the recording medium 12 in a direction (y direction) perpendicular to the conveyance direction of the recording medium 12.

[0030] It is possible to form an image over the whole surface of the recording medium 12, by adopting a single pass method of relatively moving the recording medium 12 and the full line inkjet heads 24K', 24Y', 24M' and 24C' just once.

[0031] The nozzle arrangement of the full line inkjet heads may adopt a single row arrangement along the main scanning direction, a staggered two row arrangement, a matrix arrangement in which nozzles are arranged along a row direction following the main scanning direction and an oblique column direction which intersects with the sub-scanning direction, and the like.

(Structure of inkjet head)

[0032] Fig. 5A is a plan view perspective diagram showing a nozzle arrangement of an inkjet head 24. In the nozzle row 61 shown in Fig. 5A, nozzles 70 are arranged in one row along the recording medium conveyance direction (sub-scanning direction, the X direction shown in Fig. 1).

[0033] The nozzles 70 are connected to pressure chambers (liquid chambers) 72 (indicated by dotted lines) which accommodate ink. As shown in Fig. 5B, it is also possible to adopt a mode in which nozzles 70 are arranged in a two-row staggered arrangement.

[0034] The inkjet head 24 shown in Fig. 5A has a nozzle arrangement pitch (nozzle pitch) of 254 micrometers (100 dots per inch), the number of nozzles constituting one nozzle column is 256 nozzles, and the total length L_w of a nozzle column is approximately 65 millimeters (254 micrometers x 255 = 64.8 millimeters).

[0035] Fig. 6 is a cross-sectional diagram showing a three-dimensional structure of an inkjet head 24, and depicts a structure corresponding to one channel (one ejection element). The ink ejection method of the inkjet head 24 used in the present embodiment may employ a method which propels ink droplets by deformation of a piezoelectric element (piezo jet method).

[0036] As shown in Fig. 6, the nozzles 70 are connected to pressure chambers 72 via nozzle flow channels 71. The nozzles 70 are each constituted by an opening section 70B which is formed in an ink ejection surface 70D (liquid ejection surface) of the nozzle plate 70A and a tapered section 70C having a tapered shape (an approximately round conical shape).

[0037] As well as each being connected to a nozzle 70 via a nozzle flow channel 71, the pressure chambers 72 are also connected to a common flow channel 76 via a supply port (supply restrictor) 74. The common flow channel 76 is connected to the respectively corresponding pressure chambers 72 of the nozzles 70 which constitute the nozzle row 61 of one color (see Figs. 5A and 5B) and supplies ink to the pressure chambers 72.

[0038] Piezoelectric elements 80 (pressurizing devices) are provided on a diaphragm 78 which constitutes a ceiling surface of the pressure chambers 72, at positions corresponding to the pressure chambers 72 on the surface to the outside of the pressure chambers 72. The piezoelectric elements 80 have a structure in which a piezoelectric body is sandwiched between an upper electrode 82 and a lower electrode 84, and generate a distorting deformation, thereby causing the diaphragm 78 to deform, when a drive voltage is supplied between the upper electrode 82 and the lower electrode 84.

[0039] When a drive voltage is supplied to a piezoelectric element 80 in accordance with the image data, the diaphragm 78 deforms and the volume of the pressure chamber 72 is reduced, whereby ink of a volume corresponding to the volume reduction of the pressure chamber 72 is ejected from the nozzle 70. When supply of the drive voltage to the piezoelectric element 80 is halted, the distorting deformation of the piezoelectric element 80 is restored, the pressure chamber 72 reverts to its original shape, and ink is filled into the pressure chamber 72 from the common flow channel 76 via the supply port 74.

[0040] The ink ejection surface 70D of the nozzle plate 70A of the inkjet head 24 has lyophilic properties.

[0041] Here, an "ink ejection surface having lyophilic properties" means that an ink film of about several micrometers is present thereon at all times, regardless of whether or not ink is ejected from the nozzles. In a steady state where ink is not ejected from the nozzles, the ink film on the ink ejection surface is separated from the ink inside the nozzles (a meniscus formed at a position withdrawn from the ink ejection surface) .

[0042] On the other hand, an "ink ejection surface having lyophobic properties" is an ink ejection surface which is always dry and free from the presence of an ink film, regardless of whether or not ink is ejected from the nozzles. With an ink ejection surface having lyophobic properties, the meniscus is kept at the same position inside the nozzle and withdrawn from the ink ejection surface, and therefore ejection deflection is not liable to occur and the ejected ink has good linearity.

[0043] For example, the angle of contact of the ink with respect to the ink ejection surface 70D having lyophilic properties is no more than 40°, which is a value exceeding the angle of contact of the ink inside the nozzle 70 (in the tapered section 70C, for example).

[0044] A concrete example of lyophilic treatment of the ink ejection surface 70D may involve forming an oxide film through oxidization processing of the ink ejection surface 70D or forming a metal film by sputtering, or the like.

[0045] As shown in Fig. 6, a liquid layer made of ink (an ink layer) 88 is formed on the ink ejection surface 70D, and the ink ejection surface 70D is used in a state of being covered with ink. In a state where the meniscus (not illustrated) inside the nozzles 70 is stable (a steady state), the ink covering the ink ejection surface 70D and the ink inside the nozzles 70 is separated.

[0046] By providing an ink ejection surface 70D having lyophilic properties of this kind, it is possible to obtain the following beneficial effects. Firstly, if the ink ejection surface 70D has lyophobic properties, ink mist accumulates, giving rise to ejection failures and deflection. On the other hand, if the ink ejection surface 70D has lyophilic properties, the ink mist is absorbed into the ink layer on the ink ejection surface 70D and therefore deflection or ejection failure due to the ink mist does not occur.

[0047] Furthermore, since ink mist does not accumulate, then there is little change in the ejection characteristics over time. More specifically, compared to an inkjet head having an ink ejection surface with lyophobic properties, deflection of ejection is large, but there is little change in ejection characteristics over time.

[0048] Moreover, since the maintenance of the nozzle plate can be performed easily, in other words, wet wiping is possible by means of the ink layer on the ink ejection surface 70D, then the nozzle plate has strong durability against wiping.

(Composition of control system)

[0049] Fig. 7 is a block diagram showing the principal composition of a control system of the inkjet recording apparatus 10. As shown in Fig. 7, the inkjet recording apparatus 10 is provided with a control apparatus 102 as a control device.

[0050] For this control apparatus 102, it is possible to use, for example, a computer equipped with a central processing unit (CPU), or the like. The control apparatus 102 functions as a control apparatus for controlling the whole of the inkjet recording apparatus 10 in accordance with a prescribed program, as well as functioning as a calculation apparatus for performing respective calculations.

[0051] The control apparatus 102 includes a recording medium conveyance control unit 104, a carriage drive control unit 106, an image processing unit 110, and an ejection control unit 112. These respective units are achieved by a hardware circuit or software, or a combination of these.

[0052] The recording medium conveyance control unit 104 controls the conveyance drive unit 114 for conveying the recording medium 12 (see Fig. 1). The conveyance drive unit 114 comprises a drive motor which drives the nip rollers 40 shown in Fig. 2, and a drive circuit thereof. The recording medium 12 which is conveyed on the platen 26 (see Fig. 1) is conveyed intermittently in the sub-scanning direction, in accordance with a reciprocal scanning action (printing pass action) in the main scanning direction performed by the inkjet head 24.

[0053] The carriage drive control unit 106 shown in Fig. 7 controls the main scanning drive unit 116 for moving the carriage 30 (see Fig. 1) in the main scanning direction. The main scanning drive unit 116 includes a drive motor which is connected to a movement mechanism of the carriage 30, and a control circuit thereof.

[0054] An input apparatus 120, such as an operating panel, and a display apparatus 122, are connected to the control apparatus 102. The input apparatus 120 is a device by which manually performed external operating signals are input to the control apparatus 102, and may employ various formats, such as a keyboard, a mouse, a touch panel, or operating buttons, or the like. The display apparatus 122 may employ various formats, such as a liquid crystal display, an organic EL display, a CRT, or the like.

[0055] An operator is able to select an image formation mode (synonymous with an "image formation format"), input print conditions, and input and edit additional conditions, and the like, by operating the input apparatus 120, and is able to confirm the input details and various information such as search results, via the display on the display apparatus 122.

[0056] Furthermore, an information storage unit 124 which stores various information and an image input interface (I/F) 126 for acquiring image data for printing are provided in the inkjet recording apparatus 10. It is possible to employ a serial interface or a parallel interface for the image input interface. It is also possible to install a buffer memory (not illustrated) for achieving high- speed communications.

[0057] The image data input via the image input interface 126 is converted into data for printing (dot data) by the image processing unit 110. In general, the dot data is generated by subjecting the multiple-tone image data to color conversion processing and half-tone processing. The color conversion processing is processing for converting image data represented by an sRGB system, for instance (for example, 8-bit RGB image data of respective colors of RGB) into image data of the respective colors of ink used by the inkjet recording apparatus 10.

[0058] A half-toning process is processing for converting the color data of the respective colors generated by the color

conversion processing into dot data of respective colors by error diffusion, a threshold value matrix, or the like. The device carrying out the half-toning process may employ commonly known methods of various kinds, such as an error diffusion method, a dithering method, a threshold value matrix method, a density pattern method, and the like. The half-toning process generally converts tonal image data having M values ($M \geq 3$) into tonal image data having N values ($N < M$). In the simplest example, the image data is converted into dot image data having 2 values (dot on / dot off), but in a half-toning process, it is also possible to perform quantization in multiple values which correspond to different types of dot size (for example, three types of dot: a large dot, a medium dot and a small dot).

[0059] The binary or multiple-value image data (dot data) obtained in this way is used for driving (on) or not driving (off) the respective nozzles, or in the case of multiple-value image data, is used as ink ejection data (droplet ejection control data) for controlling the droplet volume (dot size).

[0060] The ejection control unit 112 generates an ejection control signal for the head drive circuit 128 (drive voltage supply device) on the basis of dot data generated in the image processing unit 110. Furthermore, the ejection control unit 112 comprises a drive waveform generation unit (not illustrated). The drive waveform generation unit is a device which generates a voltage waveform of a drive voltage for driving the ejection energy generation elements (in the present embodiment, piezo elements) which correspond to the respective nozzles of the inkjet head 24. The drive waveform data is stored previously in the information storage unit 124 and drive waveform data to be used is output as and when required. The drive waveform output from the drive waveform generation unit is supplied to the head drive circuit 128. The signal output from the drive waveform generation unit may be digital waveform data or an analog voltage signal.

[0061] Ink is ejected from the corresponding nozzles by applying a common drive voltage to the ejection energy generation devices of the inkjet head 24 via the head drive circuit 128 and switching the switching elements (not illustrated) which are connected to the individual electrodes of the energy generating elements on and off in accordance with the ejection timings of the respective nozzles.

[0062] The inkjet recording apparatus 10 shown in the present embodiment has an ejection frequency of 15 kHz, and can selectively eject droplet volumes of three types, 10 picoliter, 20 picoliter and 30 picoliter, by changing the drive waveform.

[0063] Programs to be executed by the CPU of the system controller 102 and various data required for control purposes are stored in the information storage unit 124. The information storage unit 124 stores resolution settings information corresponding to the image formation mode, the number of passes (number of scanning repetitions), and feed amount information required to control the sub-scanning feed amount, and the like.

[0064] An encoder 130 is attached to the drive motor of the main scanning drive unit 116 and the drive motor of the conveyance drive unit 114, and outputs a pulse signal corresponding to the amount of rotation and the speed of rotation of the drive motor, this pulse signal being supplied to the control apparatus 102. The position of the carriage 30 and the position of the recording medium 12 (see Fig. 1) are ascertained on the basis of the pulse signal output from the encoder 130.

[0065] A sensor 132 is installed on the carriage 30, and the width of the recording medium 12 is ascertained on the basis of a sensor signal obtained from the sensor 132. The composition shown in Fig. 7 can be suitably modified, added or deleted.

(Image formation mode)

[0066] The inkjet recording apparatus 10 shown in this embodiment employs multi-pass image formation control, and the print resolution (recording resolution) can be varied by changing the number of printing passes. For example, three image formation modes are used: high-productivity mode, standard mode, high-quality mode, and the print resolution is different in each respective mode. It is possible to select the image formation mode in accordance with the print objective and application.

[0067] In high-productivity mode, printing is carried out at a resolution of 600 dots per inch (main scanning direction) by 400 dots per inch (sub-scanning direction). In high-productivity mode, a resolution of 600 dots per inch is achieved by two passes (two scanning actions) in the main scanning direction. In the first scanning action (the outward movement of the carriage 30), dots are formed at a resolution of 300 dots per inch.

[0068] In the second scanning action (return movement), dots are formed so as to be interpolated at 300 dots per inch between the dots formed by the first scanning action (outward movement), and a resolution of 600 dots per inch is obtained in the main scanning direction.

[0069] On the other hand, the nozzle pitch is 100 dots per inch in the sub-scanning direction, and dots are formed at a resolution of 100 dots per inch in the sub-scanning direction by one main scanning action (one pass). Consequently, a resolution of 400 dots per inch is achieved by performing interpolated printing so as to cover the spaces in the nozzle pitch, by four-pass printing (four scanning actions).

[0070] The main scanning speed of the carriage 30 in high-productivity mode is 1270 millimeters per second.

[0071] In standard mode, printing is carried out at a resolution of 600 dots per inch by 800 dots per inch, and this 600

dots per inch by 800 dots per inch resolution is achieved by means of two-pass printing in the main scanning direction and eight-pass printing in the sub-scanning direction.

[0072] In high-quality mode, printing is carried out at a resolution of 1200 dots per inch by 1200 dots per inch, and this 1200 dots per inch by 1200 dots per inch resolution is achieved by means of four passes in the main scanning direction and twelve passes in the sub-scanning direction.

(Swath width by singling scans)

[0073] In the image formation mode of a wide-format machine, the image formation conditions for singling (interlacing) are determined respectively for different resolution settings. More specifically, since image formation by singling is carried out by dividing the width of the ejection nozzle row (nozzle row length L_w) of the inkjet head by the number of passes (number of scanning repetitions), then the swath width varies with the nozzle row width L_w of the inkjet head and the number of passes in the main scanning direction and the sub-scanning direction (the number of interlaced divisions).

[0074] The details of singling image formation based on a multi-pass method are described in Japanese Patent Application Publication No. 2004-306617, for example.

[0075] For instance, the relationship between the number of passes and the swath width in singling image formation when using a FUJIFILM Dimatix QS-10 head (100 dots per inch, 256 nozzles) is as shown in Table 1 below. The envisaged swath width is a value obtained by dividing the width of the nozzle row L_w used by the product of the number of passes in the main scanning direction and the number of passes in the sub-scanning direction.

(Table 1)

Used nozzle row width (mm)	64.8	64.8	64.8	64.8
Number of main passes	1	1	2	2
Number of sub passes	2	4	2	4
Swath width (mm)	32.4	16.2	16.2	8.1

(Detailed description of drive control of inkjet head)

[0076] Next, the drive control of the inkjet head will be described in detail. Fig. 8 is a block diagram showing a more detailed composition of a control system illustrated in Fig. 7 and depicts a composition in which one of an ejection waveform or non- ejection waveform is set for each nozzle 70.

[0077] As shown in Fig. 8, the information storage unit 124 includes an ejection waveform storage unit 125A in which an ejection waveform is stored, and a non-ejection waveform storage unit 125B in which a non-ejection waveform is stored. The ejection waveform and the non-ejection waveform are generated previously by the drive waveform generation unit (not illustrated).

[0078] The waveform setting unit 140 shown in Fig. 8 generates a waveform setting signal for each nozzle 70 which sets the nozzle either as an ejection nozzle which is used to eject ink, or as a non-ejecting nozzle which is not used to eject ink, on the basis of the image data, at each ejection timing. The waveform setting signal is sent to the head drive circuit 128.

[0079] In the inkjet recording apparatus 10 according to the present embodiment, a non-ejection drive voltage generated on the basis of a non-ejection waveform is applied to non-ejecting nozzles, and an ejection drive voltage generated on the basis of the ejection waveform is applied to ejecting nozzles.

[0080] Figs. 9A and 9B are illustrative diagrams showing a schematic view of the behavior of ink during supply of a non-ejection drive voltage (indicated by reference numerals 200 and 210 in Figs. 12A and 12B). Fig. 9A shows a flow of ink on the ink ejection surface 70D, and Fig. 9B shows a flow of ink from the interior of a nozzle 70 to the ink ejection surface 70D.

[0081] As shown in Fig. 9A, when a non-ejection drive voltage having the same voltage and the same frequency is supplied to the piezoelectric elements 80 (see Fig. 6) corresponding to the plurality of nozzles 70 which are arranged in one row, then the meniscuses in the nozzles 70 corresponding to the piezoelectric elements 80 are vibrated and ink also overflows out from the nozzles 70 onto the ink ejection surface 70D.

[0082] Immediately after supply of the non-ejection drive voltage, the ink on the ink ejection surface 70D is moved in the direction of the edges of the ink ejection surface from the nozzles 70. As shown in Figs. 9A and 9B, the flow of ink from the nozzles 70 towards the edges of the ink ejection surface 70D is indicated by the arrows labeled with reference symbols 88A.

[0083] Looking in particular at one nozzle 70, the ink overflows from the nozzle 70 in a radiating fashion, but the ink

that has overflowed from each nozzle 70 collides with ink that has overflowed from adjacent nozzles 70, and consequently, a flow of ink is produced from the nozzle 70 towards the edges of the ink ejection surface 70D in a direction perpendicular to the direction of arrangement of the nozzles 70.

[0084] Figs. 10A and 10B are illustrative diagrams showing a schematic view of the behavior of ink after halting the supply of a non-ej ection drive voltage. Fig. 10A shows a flow of ink on the ink ejection surface 70D, and Fig. 10B shows a flow of ink from the interior of a nozzle 70 to the ink ejection surface 70D.

[0085] When a prescribed period of time (about several microseconds) has passed after halting the supply of the non-ejection drive voltage, the ink on the ink ejection surface 70D moves from the edges of the ink ejection surface 70D towards the centers of the nozzles 70. In Figs. 10A and 10B, the flow of ink from the edges of the ink ejection surface 70D towards the nozzles 70 is indicated by the arrows labeled with reference symbols 88B.

[0086] In other words, the piezoelectric elements 80 to which a non-ejection drive voltage is supplied do not cause ejection of ink from the corresponding nozzles 70, but rather pressurize the corresponding pressure chambers 72 so as to cause ink to seep out from the nozzles 70 onto the ink ejection surface 70D. When the supply of the non-ejection drive voltage is halted, the deformation of the piezoelectric elements 80 is restored, and the ink which has seeped out onto the ink ejection surface 70D is recovered inside the nozzles 70.

[0087] In this way, by causing ink to seep out onto the ink ejection surface 70D from the nozzles 70 and then recovering the ink that has seeped out onto the ink ejection surface 70D, back inside the nozzles 70, a flowing movement is created in the ink layer 88 formed on the ink ejection surface 70D, and a large amount of ink is circulated inside the ink ejection surface 70D and the nozzles 70. As a result of this, it is possible to avoid a situation where the ink solidifies in the vicinity of the nozzles 70 (nozzle openings) due to increase in the viscosity of the ink as a result of drying and the nozzles cannot be used, and therefore ejection abnormalities resulting from this can be prevented.

[0088] If the ink ejection surface 70D does not have prescribed lyophilic properties with respect to the ink used, then even if a non-ejection drive voltage is applied to non-ejecting nozzles, ink does not overflow from these non-ejecting nozzles, and it is not possible to form a flow of ink on the ink ejection surface 70D.

[0089] Fig. 11 is an illustrative diagram of the beneficial effects of an inkjet recording apparatus (inkjet head drive method) relating to a first embodiment of the present invention, and shows the rate of occurrence of ejection failure nozzles with respect to the elapsed time (minutes) from the last ejection timing.

[0090] The solid line labeled with reference numeral 90 in Fig. 11 is the evaluation result obtained when a flowing movement of the ink is generated on the ink ejection surface 70D by applying a non-ejection drive voltage to the non-ejecting nozzles, and the dotted line labeled with reference numeral 92 in Fig. 11 is the evaluation result obtained when a non-ejection drive voltage is not applied to the non-ejecting nozzles.

[0091] As shown by Fig. 11, when a non-ejection drive voltage is applied, the occurrence rate of ejection failure nozzles is no more than several per cent, even when five minutes have elapsed from the last ejection timing. On the other hand, when the non-ejection drive voltage is not applied, all of the nozzles suffer ejection failure when four minutes have elapsed from the last ejection timing.

[0092] The conditions of the evaluation experiment which yielded the results shown in Fig. 11 are indicated below. The total number of nozzles in the inkjet head is 256 nozzles, and a non-ejection drive voltage is applied to all of the nozzles.

[0093] Furthermore, a non- ejection drive voltage 200 shown in Fig. 12A and a non- ejection drive voltage 210 shown in Fig. 12B are used as the non- ej ection drive voltage.

[0094] The non-ejection drive voltage 200 shown in Fig. 12A has a trapezoid shape including: a rising section 202 which rises from a reference potential (zero volts) to a maximum voltage, a maximum voltage section (fixed voltage section) 204, and a falling section 206 which falls from a maximum voltage to a reference voltage.

[0095] Furthermore, the maximum amplitude (potential difference) of the non- ejection drive voltage 200 is 25 V (approximately 36% of the ejection drive voltage (70 V)) , and the time from the start timing of the rising section 202 to the start timing of the falling section 206 is 5 microseconds.

[0096] The non-ejection drive voltage (group) 210 shown in Fig. 12B includes the non-ejection drive voltage 200 shown in Fig. 12A generated continuously at a prescribed cycle apart, this cycle being approximately 66.7 microseconds. Converted to a frequency, this cycle is 15 kHz, which coincides with the ejection frequency (the frequency of the ejection drive voltage).

[0097] The non-ejection drive voltage 210 shown in Fig. 12B is a mode in which one non-ejection drive voltage 200 is contained in one ejection cycle. In other words, it is possible to avoid the occurrence of ejection failure nozzles, provided that at least one non-ejection drive voltage 200 is supplied in each ejection cycle.

[0098] The non-ejection drive voltage 200 shown in Fig. 12A and the non-ejection drive voltage 210 shown in Fig. 12B are no more than examples, and it is also possible to cause the ink to seep out onto the ink ejection surface 70D from the nozzles 70 without ejecting ink from the nozzles 70 (and without separating the ink from the ink inside the nozzles 70).

[0099] For example, it is possible to employ a square wave or a triangular wave for the non-ejection drive voltage 200, and it is possible to include a plurality of non-ejection drive voltages 200 in each ejection cycle. In other words, the "non-ejection drive voltage" is a drive voltage which is applied to the piezoelectric elements 80 corresponding to nozzles 70

when the ink inside the nozzles 70 is to be caused to seep out onto the ink ejection surface 70D without ink being ejected from the nozzles 70; for example, the non-ejection drive voltage has an amplitude of no less than 10 per cent and no more than 50 per cent of the amplitude of the ejection drive voltage.

[0100] More specifically, the ink inside the nozzles 70 is caused to vibrate, and is also caused to overflow onto the ink ejection surface 70D, by setting the amplitude of the non-ejection drive voltage to no less than 10 per cent of the amplitude of the ejection drive voltage.

[0101] Furthermore, by setting the amplitude of the non- ejection drive voltage to no more than 50 per cent of the amplitude of the ejection drive voltage, the ink is prevented from being ejected mistakenly from the nozzles 70.

[0102] Furthermore, the frequency of the non- ejection drive voltage 210 is specified in such a manner that the volume of ink which is caused to overflow from the non- ejecting nozzles coincides with the volume of ink which is sucked into (recovered into) the nozzles 70 by halting (terminating supply of) the non- ejection drive voltage 200.

(Control flow)

[0103] Fig. 13 is a flowchart showing a flow of control in a method of driving an inkjet head relating to a first embodiment of the present invention.

[0104] When the driving of the inkjet head 24 is started (step S10), all of the nozzles are set to be either ejecting nozzles or non-ejecting nozzles, on the basis of the image data (step S12).

[0105] The nozzles which are set to be non-ejecting nozzles in step S12 (Yes verdict) are set to receive a non-ejection waveform (step S14), and the frequency of this non-ejection waveform (non-ej ection drive voltage) is established (step S16). It is also possible to adopt a mode in which the frequency setting of the non-ejection drive voltage is omitted and the frequency of the non-ejection drive voltage is set to a prescribed value.

[0106] The supply of a non-ejection drive voltage to the piezoelectric elements 80 corresponding to the non-ejecting nozzles is started (step S18), and subsequently the supply of the non-ejection drive voltage is halted (step S20).

[0107] It is then monitored whether or not a prescribed time has elapsed from the halting of the supply of the non-ejection drive voltage (the time until the ink that has seeped out onto the ink ejection surface 70D is recovered inside the nozzles 70) (step S22).

[0108] If it is judged in step S22 that the prescribed time has not elapsed (No verdict), then monitoring of the elapsed time from the halting of supply of the non-ejection drive voltage is continued, and if it is judged that the prescribed time has elapsed (Yes verdict), then the procedure advances to step S24.

[0109] In step S24, it is judged whether or not there is data for the next ejection timing, and if there is data for the next ejection timing (No verdict), then the procedure advances to step S12 and the steps from step S12 are repeated. On the other hand, if there is no data for the next ejection timing (Yes verdict at step S24), then the driving of the inkjet head is halted (step S32).

[0110] In step S12, the nozzles which have been set as ejection nozzles (No verdict) are set to receive an ejection waveform (step S26), an ejection drive voltage is supplied to the piezoelectric elements 80 corresponding to these nozzles (step S28), and when the supply of this ejection drive voltage is ended (step S30), the procedure advances to step S24.

[0111] In the inkjet head drive method described in the present embodiment, a non-ejection drive voltage is used for at least one portion of the non-ejecting nozzles at all times during printing (during image formation based on image data), and therefore the occurrence of ejection failure nozzles during printing is prevented reliably.

(Beneficial Effects)

[0112] According to the inkjet recording apparatus and the inkjet head drive method composed as described above, in an inkjet head provided with an ink ejection surface having lyophilic properties with respect to dryable ink, a non-ejection drive voltage is supplied to piezoelectric elements 80 corresponding to non-ejecting nozzles so as to cause ink to seep out onto the ink ejection surface 70D from the non-ejecting nozzles and to cause the ink to move on the ink ejection surface 70D, whereby a large volume of ink can be moved between the inside of the nozzles 70 and the ink ejection surface 70D, and the occurrence of ejection abnormality nozzles due to increase in the viscosity of the ink inside the nozzles 70 can be prevented.

[0113] Furthermore, since an ink flow also occurs inside the nozzles 70 due to the ink moving from the nozzles 70 towards the edges of the ink ejection surface 70D, and moving from the ink ejection surface 70D to the nozzles 70, then increase in the viscosity of the ink inside the nozzles 70 can be prevented effectively.

[0114] In the present embodiment, a mode is described in which a non-ejection drive voltage is supplied to all of the piezoelectric elements 80 corresponding to non-ejecting nozzles, but it is possible to adopt another mode in which a non-ejection drive voltage is supplied selectively to the piezoelectric elements 80 corresponding to a portion of the non-ejecting nozzles, provided that a flowing movement of the ink sufficient to avoid curing of ink on the ink ejection surface

70D is produced.

(Second embodiment)

(Overview)

[0115] Next, a second embodiment of the present invention will be described. In the following description, parts which are the same as or similar to the first embodiment which was described previously are labeled with the same reference numerals and further explanation thereof is omitted here. Fig. 14 is an illustrative diagram of an inkjet head drive method employed in an inkjet recording apparatus relating to a second embodiment of the present invention.

[0116] The inkjet head drive method shown in the present embodiment changes the frequency of the non-ejection drive voltage (group) in a portion of the non-ejecting nozzles, and makes the flow of ink on the ink ejection surface 70D faster compared to a case where a non-ejection drive voltage group having the same frequency is used for all of the non-ejecting nozzles, thereby preventing curing of the ink in the vicinity of the nozzles 70, in particular.

[0117] If a high-frequency non-ejection drive voltage is applied to a nozzle group 73A in the upper half of Fig. 14, and a low-frequency non-ejection drive voltage is applied to a nozzle group 73B in the lower half of Fig. 14, then as shown by the arrow labeled with reference symbol F in Fig. 14, a flow of ink is generated along the arrangement direction of the nozzles 70 (a flow of ink from the side of the nozzle group 73A to which the high-frequency non-ejection drive voltage is applied towards the side of the nozzle group 73B to which the low-frequency non-ejection drive voltage is applied).

[0118] On the other hand, if a low-frequency non-ejection drive voltage is applied to a nozzle group 73A in the upper half of Fig. 14, and a high-frequency non-ejection drive voltage is applied to a nozzle group 73B in the lower half of Fig. 14, then as shown by the arrow labeled with reference symbol R in Fig. 14, a flow of ink is generated along the arrangement direction of the nozzles 70 (a flow of ink from the side of the nozzle group 73B to which the high-frequency non-ejection drive voltage is applied towards the side of the nozzle group 73A to which the low-frequency non-ejection drive voltage is applied).

[0119] The nozzle group 73A in the upper half of Fig. 14 may also include ejecting nozzles, and the nozzle group 73B in the lower half of Fig. 14 may also include ejecting nozzles. In other words, the nozzles to which the non-ejection drive voltage is applied are selected from all or a portion of the non-ejecting nozzles, excluding the ejecting nozzles, in the nozzle group 73A and the nozzle group 73B, and a high-frequency non-ejection drive voltage (having a frequency of 30 kHz, which is two times the ejection frequency, for example) is applied to one of the nozzle group 73A and the nozzle group 73B, while a low-frequency non-ejection drive voltage (having a frequency of 3 kHz, which is one-fifth of the ejection frequency, for example) is applied to the other of the nozzle group 73A and the nozzle group 73B.

[0120] Fig. 15 is an illustrative diagram of the beneficial effects of an inkjet head drive method relating to the second embodiment, and shows the rate of occurrence of ejection failure nozzles with respect to the elapsed time (minutes) from the last ejection timing.

[0121] The solid line labeled with reference numeral 94 in Fig. 15 indicates the evaluation results when the drive method described in the present embodiment is applied, and the dotted line labeled with the reference numeral 92 in Fig. 15 indicates the evaluation results when a non-ejection drive voltage is not applied to the non-ejecting nozzles. As shown in Fig. 15, according to the drive method described in this embodiment, it is possible to obtain at least similar beneficial effects to those of the first embodiment.

(Non-ejection drive voltage)

[0122] Figs. 16A and 16B are waveform diagrams showing one example of a high-frequency non-ejection drive voltage 210A and a low-frequency non-ejection drive voltage 210B, Fig. 16A shows a high-frequency non-ejection drive voltage 210A and Fig. 16B shows a low-frequency non-ejection drive voltage 210B.

[0123] The high-frequency non-ejection drive voltage 210A shown in Fig. 16A has a frequency of 30 kHz (two times the frequency of the ejection drive voltage), and the low-frequency non-ejection drive voltage 210B shown in Fig. 16B has a frequency of 15 kHz (the same frequency as the ejection drive voltage). Furthermore, the high-frequency non-ejection drive voltage 210A has a frequency of two times the low-frequency non-ejection drive voltage 210B.

[0124] The high-frequency non-ejection drive voltage should have a frequency no less than one half of the maximum ejection frequency. Furthermore, the low-frequency non-ejection drive voltage should have a frequency which is less than the frequency of the high-frequency non-ejection waveform and no more than one half of the maximum ejection frequency.

(Composition of control system)

[0125] Fig. 17 is a block diagram showing a composition of a control system in an inkjet recording apparatus relating

to a second embodiment. In Fig. 17, parts which are the same as or similar to Fig. 8 are labeled with the same reference numerals and further explanation thereof is omitted here.

[0126] The ejection control unit 112 shown in Fig. 17 includes a frequency setting unit 142 and a switching cycle setting unit 144, in addition to the waveform setting unit 140 shown in Fig. 8. The frequency setting unit 142 generates a frequency setting signal which represents frequency information for setting the frequency of the non-ejection drive voltage, and sends the frequency setting signal to the head drive circuit 128.

[0127] The switching cycle setting unit 144 generates a switching cycle signal representing switching cycle information for the high-frequency non-ejection drive voltage 210A and the low-frequency non-ejection drive voltage 210B, and sends this switching cycle signal to the head drive circuit 128. The head drive circuit 128 sets the frequency of the non-ejection drive voltage for each ejection timing and each nozzle, on the basis of the frequency setting signal, as well as setting a switching cycle for the high-frequency non-ejection drive voltage and the low-frequency non-ejection drive voltage, for each ejection timing and each nozzle, on the basis of the switching cycle setting signal.

(Control flow)

[0128] Fig. 18 is a flowchart showing a flow of control in a method of driving an inkjet head relating to the second embodiment. In Fig. 18, parts which are the same as or similar to Fig. 13 are labeled with the same reference numerals and further explanation thereof is omitted here.

[0129] In the flowchart shown in Fig. 18, step S16 in Fig. 13 (frequency setting step) is changed, and step S17 (switching cycle setting step) is added. The frequency setting step (step S16') shown in Fig. 18 sets a high frequency or a low frequency for the nozzles to which the non-ejection drive voltage is applied. The switching cycle step (step S17) sets a cycle at which the low frequency and high frequency are switched.

[0130] The switching cycle can be set to approximately 1 second to 10 seconds (to 3 seconds, for example), and is specified appropriately on the basis of the drive conditions and environmental conditions of the inkjet head 24, and so on.

(Beneficial Effects)

[0131] According to the inkjet recording apparatus (inkjet head drive method) relating to the second embodiment, a low-frequency non-ejection drive voltage 210B is applied to a portion of the nozzles to which the non-ejection drive voltage is applied, and a high-frequency non-ejection drive voltage 210A is applied to the remaining portion of nozzles to which the non-ejection drive voltage is applied, thereby generating a faster flow of ink from the side of the nozzles to which the high-frequency non-ej ection drive voltage 210A is applied, towards the side of the nozzles to which the low-frequency non-ejection drive voltage 210B is applied, on the ink ejection surface 70D, and thus preventing curing of the ink in the vicinity of the opening sections 70B of the nozzles 70.

[0132] In the present embodiment, a mode is described in which all of the nozzles 70 are divided into two regions (nozzle groups 73A and 73B) and non-ejection drive voltages having different frequencies are applied to the respective nozzle groups, but it is also possible to divide all of the nozzles 70 into three or more regions and to apply non-ejection drive voltages having three or more different frequencies to the three or more regions.

(Third embodiment)

(Overview)

[0133] Next, a third embodiment of the present invention will be described. Fig. 19 is an illustrative diagram of an inkjet head drive method relating to a third embodiment. In Fig. 19, parts which are the same as or similar to Fig. 14 are labeled with the same reference numerals and further explanation thereof is omitted here.

[0134] In the inkjet head drive method shown in Fig. 19, the nozzles to which the non-ejection drive voltage is to be applied are set selectively from among the non-ejecting nozzles, and an ink flow is generated in accordance with the positions where ink drying is more liable to occur on the ink ejection surface 70D.

[0135] For example, the beneficial effect of preventing curing of the ink on the ink ejection surface 70D is raised by making the ink flow faster in the central portion and the vicinity of the central portion of the nozzles where curing of ink is liable to occur on the ink ejection surface 70D.

[0136] In the inkjet head drive method shown in Fig. 19, a non-ejection drive voltage is applied to a nozzle group 73C in a region including a central portion of the ink ejection surface 70D, and a non-ejection drive voltage is not applied to a nozzle group 73D in a region that does not include the central portion of the ink ejection surface 70D.

[0137] In so doing, a flow of ink from the side of the nozzle group 73C towards the side of the nozzle group 73D is generated, in other words, a flow of ink from approximately the center of the ink ejection surface 70D towards either end in the lengthwise direction of the inkjet head 24 as indicated by the reference symbols R1, R2, F1 and F2.

[0138] According to the inkjet head drive method shown in Fig. 19, it is possible to effectively prevent curing of ink in a position where drying of the ink is liable to occur, such as the central portion and vicinity of the central portion of the ink ejection surface 70D.

[0139] The inkjet head drive method relating to the third embodiment can also be combined with the inkjet drive method relating to the second embodiment, which was described previously. For example, a composition can be adopted in which a faster flow of ink is generated from the central portion of the ink ejection surface 70D towards the respective end portions by applying a high-frequency non-ejection drive voltage to the nozzle group 73C in the central portion shown in Fig. 19 and applying a low-frequency non-ejection drive voltage to the nozzle group 73D in the respective end portions, and the high-frequency non-ejection drive voltage and the low-frequency non-ejection drive voltage are switched at a prescribed switching timing.

(Beneficial Effects)

[0140] Fig. 20 is an illustrative diagram of the beneficial effects of an inkjet head drive method relating to the third embodiment. As indicated by the solid line labeled with reference numeral 96 in Fig. 20, according to the inkjet head drive method relating to the third embodiment, the occurrence of ejection failure nozzles is prevented effectively.

[0141] On the other hand, the curve labeled with reference numeral 92 in Fig. 20 indicates a case where the non-ejection drive voltage is not applied to the non-ejecting nozzles, and here, all of the nozzles have suffered ejection failure by the time that four minutes have elapsed from the last ejection timing.

[0142] In the first to third embodiments described above, an inkjet recording apparatus which forms a color image on a recording medium using color inks is illustrated, but the scope of application of the present invention covers liquid ejection apparatuses which eject liquid onto a medium by an inkjet method.

[0143] The inkjet recording apparatus and the inkjet head drive method to which the present invention are applied have been described in detail above, but suitable modifications are possible in a range which does not depart from the essence of the present invention.

(Invention disclosed by the present specification)

[0144] As has become evident from the detailed description of the embodiments given above, the present specification includes disclosure of various technical ideas including the inventions described below.

[0145] (First aspect) : A liquid ejection apparatus, including: an inkjet head equipped with: a nozzle plate, in which an opening of a nozzle ejecting a dryable liquid having a component that is volatile in air, onto a medium, is formed, and which has a liquid ejection surface displaying lyophilic properties with respect to the liquid; and a pressurization device which pressurizes liquid inside a liquid chamber connected to the nozzle, with the inkjet head being used in a state where the liquid ejection surface is covered by the liquid; and a drive voltage supply device which supplies a non- ejection drive voltage that does not cause liquid ejection to a pressurization device corresponding to a non- ejecting nozzle, which is not used to eject liquid, wherein the non- ejection drive voltage is supplied to the pressurization device corresponding to the non- ejecting nozzle by the drive voltage supply device so as to cause the liquid inside the non- ejecting nozzle to vibrate and to also overflow out onto the liquid ejection surface, as well as causing the liquid covering the liquid ejection surface to be subjected to a flowing movement.

[0146] According to this aspect of the invention, in a liquid ejection recording apparatus which includes an inkjet head provided with a liquid ejection surface having lyophilic properties with respect to a dryable liquid having a component that is volatile in air, the inkjet head being used in a state where the liquid ejection surface is covered with liquid, a non-ejection drive voltage which does not cause ejection of liquid from a nozzle is supplied to the pressurization device, so as to cause liquid inside the nozzle to vibrate and to overflow out onto the liquid ejection surface, as well as causing a flowing movement of liquid which covers the liquid ejection surface, whereby increase in the viscosity of the liquid due to drying is suppressed.

[0147] (Second aspect) : In the liquid ejection apparatus, the inkjet head may include a plurality of nozzles, and the drive voltage supply device supplies, to pressurization devices corresponding to a portion of the non- ej ecting nozzles, a non- ej ection drive voltage having a frequency relatively higher than that of a non- ejection drive voltage which is supplied to pressurization devices corresponding to the other non- ejecting nozzles.

[0148] According to this aspect of the invention, the flowing movement of liquid on the liquid ejection surface is made faster than in a case where a non-ejection drive voltage having the same frequency is applied to all of the non-ejecting nozzles, thereby preventing curing of liquid in the vicinity of the nozzles.

[0149] Furthermore, it is possible to create a flowing movement of liquid adhering to the liquid ejection surface, from the nozzles to which the non- ejection drive voltage having a relatively high frequency is applied, towards the nozzles to which a non- ejection drive voltage having a relatively low frequency is applied.

[0150] (Third aspect) : The liquid ejection apparatus may further include a frequency switching device which implements

switching between pressurization devices to which the non- ejection drive voltage having a relatively high frequency is supplied by the drive voltage supply device and pressurization devices to which the non- ejection drive voltage having a relatively low frequency is supplied.

[0151] According to this aspect of the invention, it is possible to switch the direction of flow of the liquid adhering to the liquid ejection surface, and curing of the liquid is prevented more effectively.

[0152] (Fourth aspect) : The liquid ejection apparatus may further include a switching cycle setting device which sets a switching cycle of the non- ejection drive voltage by the frequency switching device.

[0153] According to this aspect of the invention, it is possible to switch the direction of flow of the liquid adhering to the liquid ejection surface, at a prescribed cycle, and curing of the liquid is prevented more effectively.

[0154] (Fifth aspect) : In the liquid ejection apparatus, the inkjet head may include a plurality of nozzles, and the drive voltage supply device supplies a non- ejection drive voltage only to pressurization devices corresponding to a portion of a plurality of the non- ejecting nozzles.

[0155] According to this aspect of the invention, the flow of liquid becomes faster in the positions of non-ejecting nozzles to which the non-ejection drive voltage is applied, and curing of liquid at the positions of the non-ejecting nozzles, and the vicinity thereof, is prevented.

[0156] (Sixth aspect) : In the liquid ejection apparatus, the drive voltage supply device may include a supply switching device which implements selectively switching between the pressurization devices to which the non- ejection drive voltage is supplied and the pressurization devices to which the non- ejection drive voltage is not supplied.

[0157] According to this aspect of the invention, it is possible to apply a non-ejection drive voltage to non-ejecting nozzles in positions which are liable to be struck by an active light beam.

[0158] (Seventh aspect) : In the liquid ejection apparatus, the non- ejection drive voltage may be supplied only to the pressurization devices corresponding to non- ejecting nozzles in a central portion of the liquid ejection surface and in the vicinity of the central portion.

[0159] According to this aspect of the invention, curing of liquid in the central portion of the ink ejection surface which is relatively liable to be struck by an active light beam, and the vicinity of this central portion, can be prevented more effectively.

[0160] (Eighth aspect) : In the liquid ejection apparatus, the drive voltage supply device may supply a non- ejection drive voltage to pressurization devices corresponding to non- ejecting nozzles, during ejection of liquid on the basis of the ejection data.

[0161] According to this aspect of the invention, curing of the liquid on the liquid ejection surface can be prevented during liquid ejection based on ejection data.

[0162] (Ninth aspect) : In the liquid ejection apparatus, the drive voltage supply device may supply a next non- ejection drive voltage when a prescribed time has elapsed after halting the supply of the non- ejection drive voltage.

[0163] According to this mode, since liquid that has been caused to seep out from the nozzles is recovered into the nozzles, then it is possible to generate a flow of liquid towards the nozzles.

[0164] (Tenth aspect) : A drive method for an inkjet head equipped with: a nozzle plate in which an opening of a nozzle ejecting a dryable liquid having a component that is volatile in air, onto a medium, is formed, and which has a liquid ejection surface displaying lyophilic properties with respect to the liquid; and a pressurization device which pressurizes liquid inside a liquid chamber connected to the nozzle, with the inkjet head being used in a state where the liquid ejection surface is covered by the liquid, the method including: supplying a non- ejection drive voltage which does not cause liquid ejection to the pressurization device corresponding to a non- ejecting nozzle that is not used to eject liquid, and causing the liquid inside the non- ejecting nozzle to vibrate, and to overflow out onto the liquid ejection surface, as well as causing the liquid covering the liquid ejection surface to be subjected to a flowing movement. The drive method may be executed by the liquid ejection apparatus according to the above aspects.

[0165] It should be understood, however, that there is no intention to limit the invention to the specific forms disclosed, but on the contrary, the invention is to cover all modifications, alternate constructions and equivalents falling within the spirit and scope of the invention as expressed in the appended claims.

Claims

1. A liquid ejection apparatus (10), comprising:

an inkjet head (24; 24C, 24M, 24Y, 24K) equipped with: a nozzle plate (70A), in which an opening (70B) of a nozzle (70) ejecting a dryable liquid having a component that is volatile in air, onto a medium (12), is formed, and which has a liquid ejection surface (70D) displaying lyophilic properties with respect to the liquid; and a pressurization device which pressurizes liquid inside a liquid chamber (72) connected to the nozzle (70), with the inkjet head being used in a state where the liquid ejection surface (70D) is covered by the liquid; and

a drive voltage supply device (128) which supplies a non-ejection drive voltage (200, 210) that does not cause liquid ejection to a pressurization device (80) corresponding to a non-ejecting nozzle, which is not used to eject liquid, wherein
the non-ejection drive voltage (200, 210) is supplied to the pressurization device (80) corresponding to the non-ejecting nozzle by the drive voltage supply device (128) so as to cause the liquid inside the non-ejecting nozzle to vibrate and to also overflow out onto the liquid ejection surface (70D), as well as causing the liquid covering the liquid ejection surface to be subjected to a flowing movement.

2. The liquid ejection apparatus (10) as defined in claim 1, wherein
the inkjet head (24; 24C, 24M, 24Y, 24K) comprises a plurality of nozzles, and
the drive voltage supply device (128) supplies, to pressurization devices (80) corresponding to a portion of the non-ejecting nozzles, a non-ejection drive voltage having a frequency relatively higher than that of a non-ejection drive voltage which is supplied to pressurization devices (80) corresponding to the other non-ejecting nozzles.

3. The liquid ejection apparatus (10) as defined in claim 2, further comprising a frequency switching device (142) which implements switching between pressurization devices (80) to which the non-ejection drive voltage (210A) having a relatively high frequency is supplied by the drive voltage supply device (128) and pressurization devices (80) to which the non-ejection drive voltage (210B) having a relatively low frequency is supplied.

4. The liquid ejection apparatus (10) as defined in claim 3, further comprising a switching cycle setting device (144) which sets a switching cycle of the non-ejection drive voltage (210A, 210B) by the frequency switching device.

5. The liquid ejection apparatus (10) as defined in claim 1, wherein
the inkjet head (24; 24C, 24M, 24Y, 24K) includes a plurality of nozzles, and
the drive voltage supply device (128) supplies a non-ejection drive voltage only to pressurization devices (80) corresponding to a portion of a plurality of the non-ejecting nozzles.

6. The liquid ejection apparatus (10) as defined in claim 5, wherein the drive voltage supply device (128) comprises a supply switching device which implements selectively switching between the pressurization devices to which the non-ejection drive voltage is supplied and the pressurization devices (80) to which the non-ejection drive voltage is not supplied.

7. The liquid ejection apparatus (10) as defined in claim 6, wherein the non-ejection drive voltage is supplied only to the pressurization devices (80) corresponding to non-ejecting nozzles in a central portion of the liquid ejection surface and in the vicinity of the central portion.

8. The liquid ejection apparatus (10) as defined in any one of claims 1 to 7, wherein the drive voltage supply device (128) supplies a non-ejection drive voltage to pressurization devices (80) corresponding to non-ejecting nozzles, during ejection of liquid on the basis of the ejection data.

9. The liquid ejection apparatus (10) as defined in any one of claims 1 to 8, wherein the drive voltage supply device (128) supplies a next non-ejection drive voltage when a prescribed time has elapsed after halting the supply of the non-ejection drive voltage.

10. A drive method for an inkjet head (24; 24C, 24M, 24Y, 24K) equipped with: a nozzle plate (70A) in which an opening (70B) of a nozzle (70) ejecting a dryable liquid having a component that is volatile in air, onto a medium (12), is formed, and which has a liquid ejection surface (70D) displaying lyophilic properties with respect to the liquid; and a pressurization device (80) which pressurizes liquid inside a liquid chamber (72) connected to the nozzle (70), with the inkjet head being used in a state where the liquid ejection surface is covered by the liquid,
the method comprising:

supplying a non-ejection drive voltage which does not cause liquid ejection to the pressurization device (80) corresponding to a non-ejecting nozzle that is not used to eject liquid, and causing the liquid inside the non-ejecting nozzle to vibrate, and to overflow out onto the liquid ejection surface, as well as causing the liquid covering the liquid ejection surface (70D) to be subjected to a flowing movement.

FIG.1

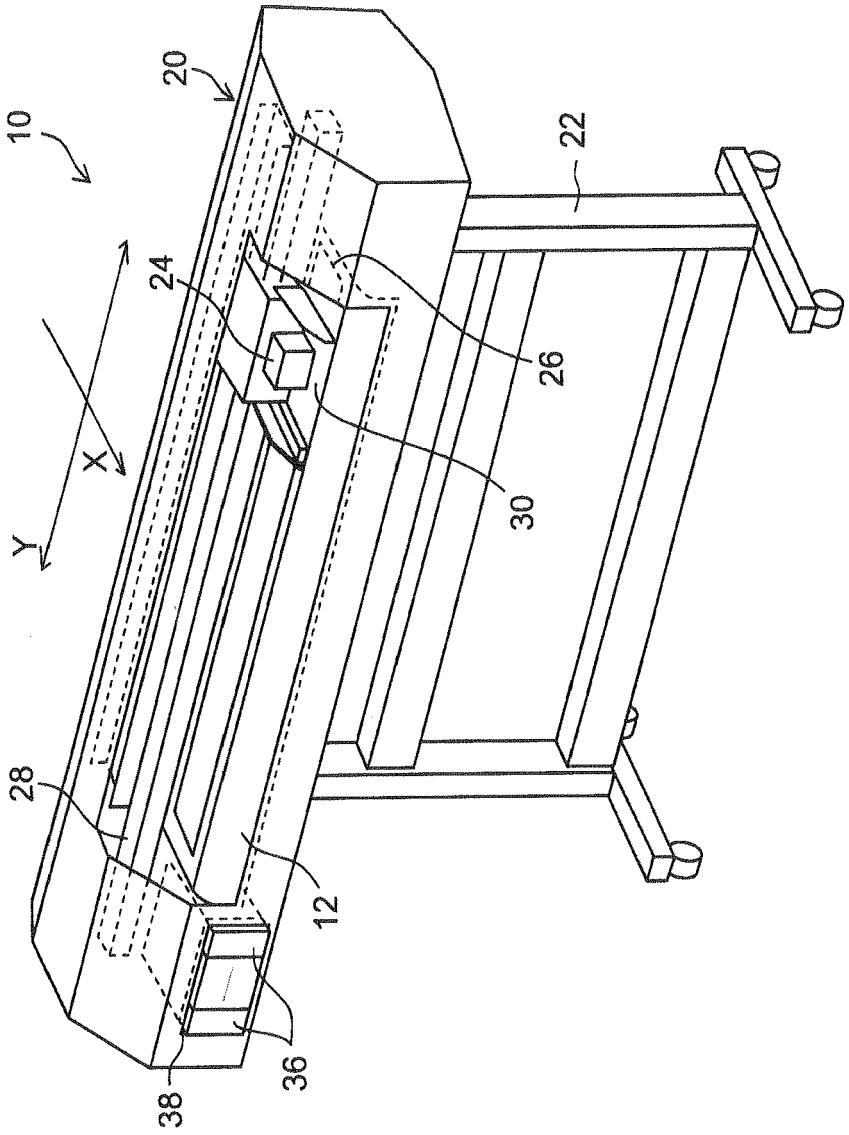


FIG.2

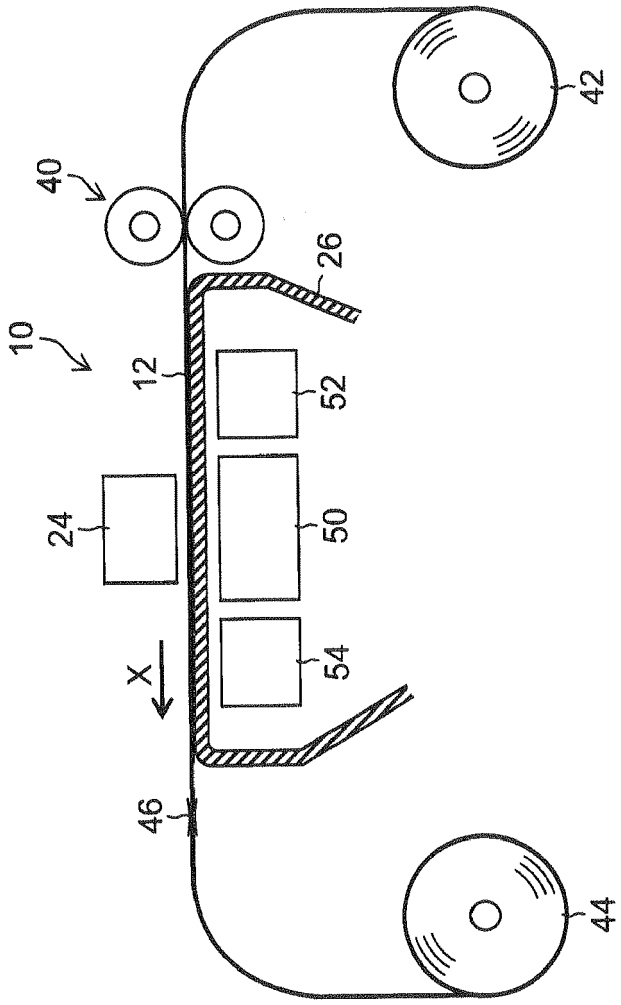


FIG.3

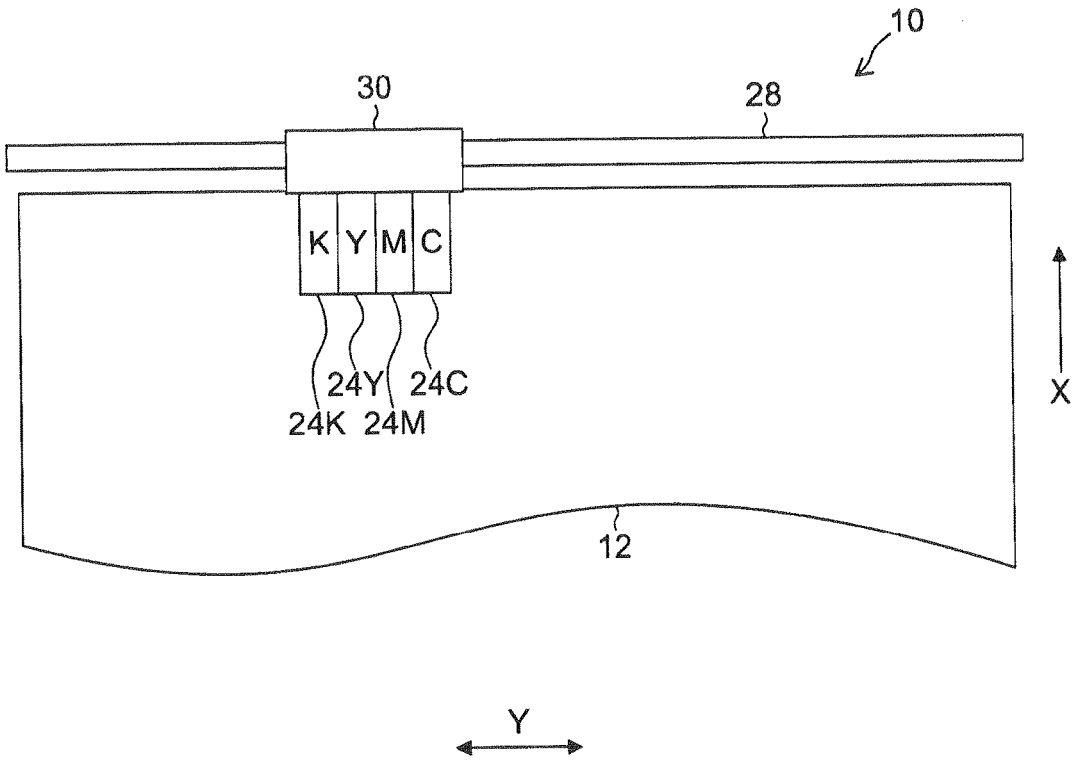


FIG.4

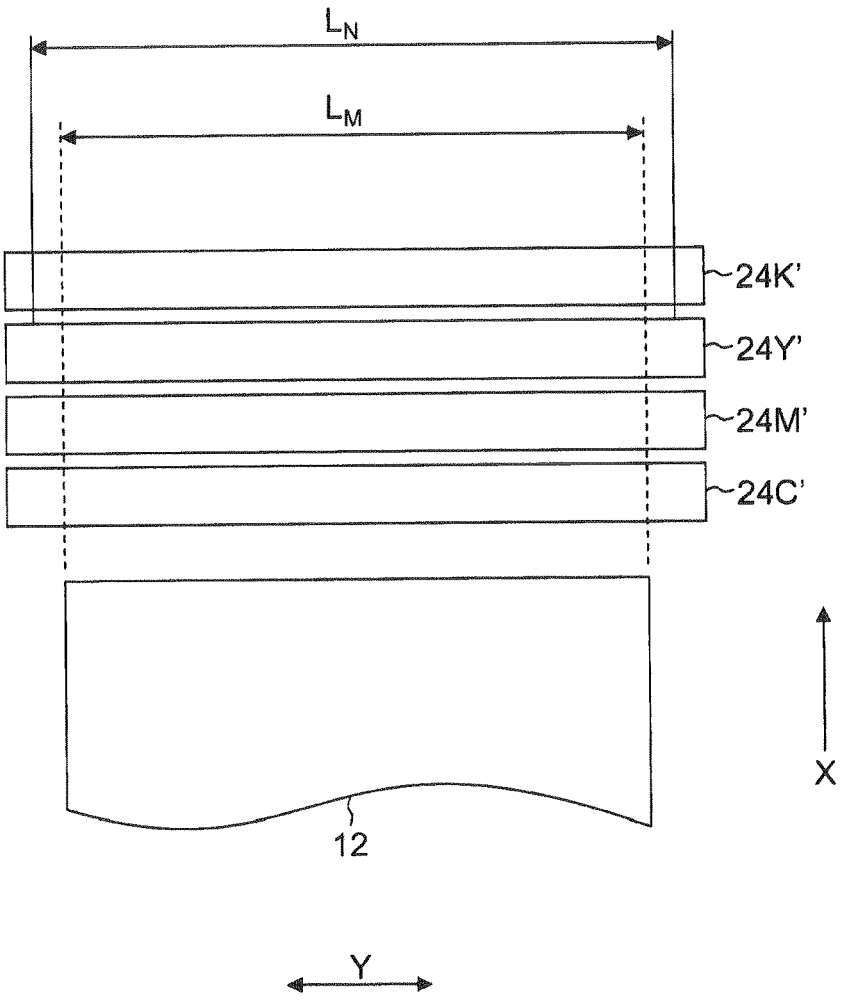


FIG.5A

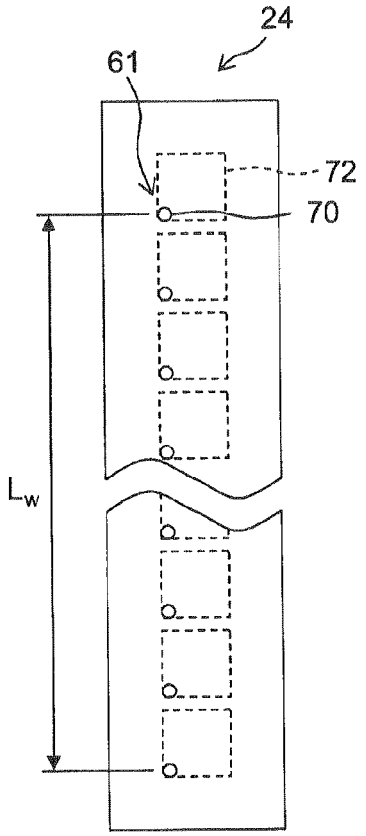


FIG.5B

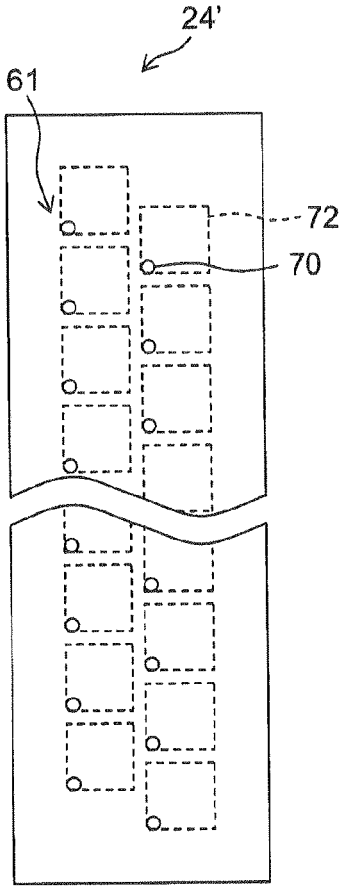


FIG.6

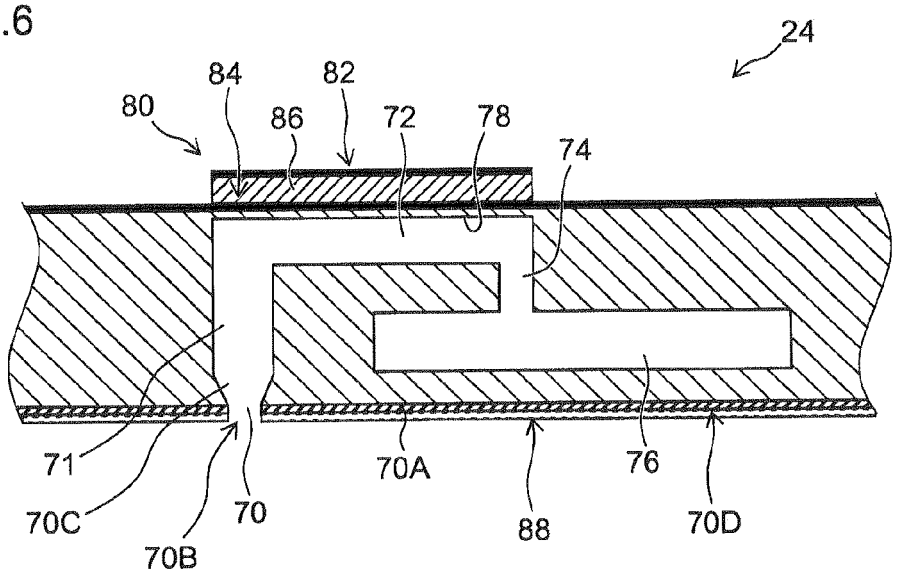


FIG.7

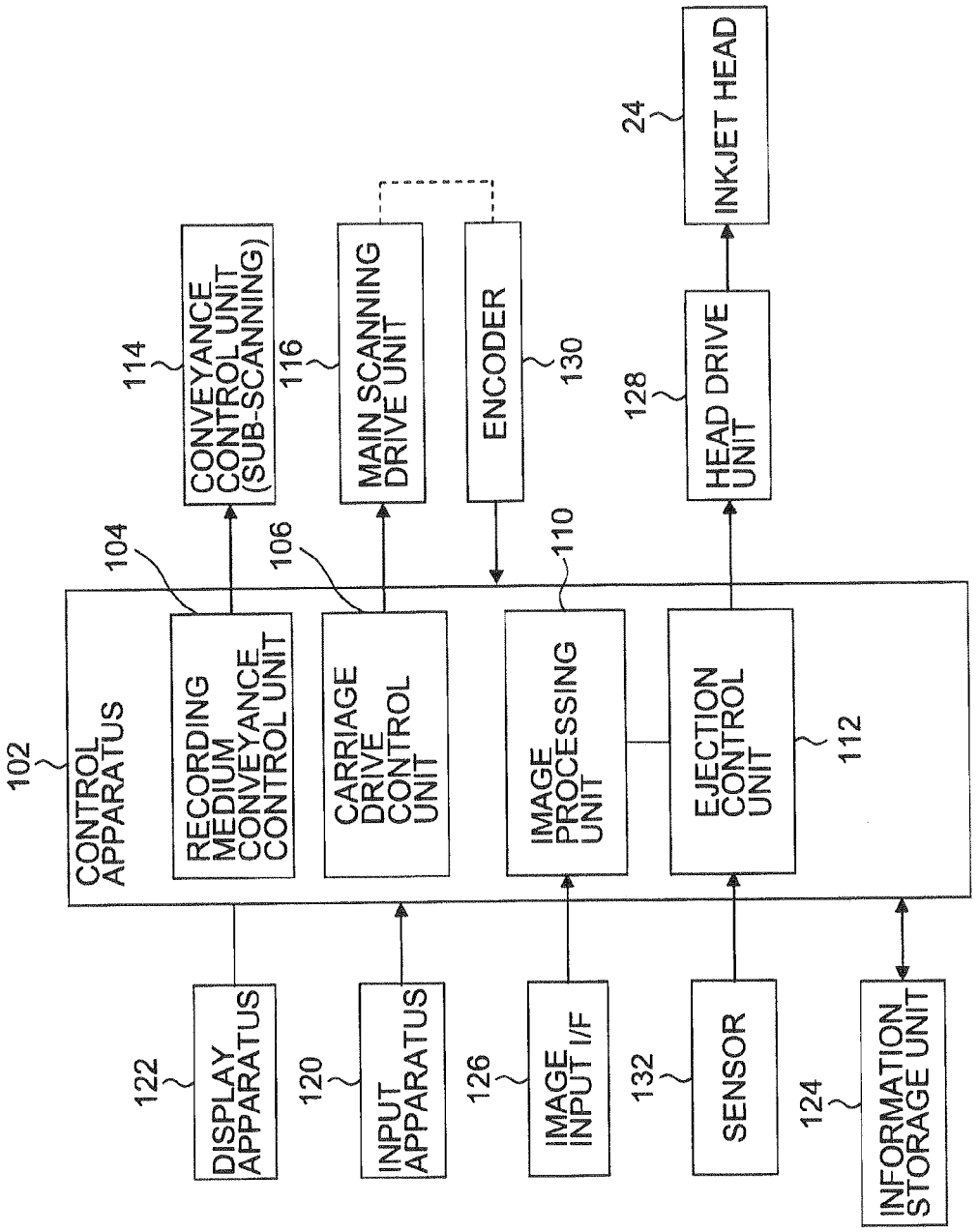

102
CONTROL APPARATUS
104
RECORDING MEDIUM CONVEYANCE CONTROL UNIT
106
CARRIAGE DRIVE CONTROL UNIT
110
IMAGE PROCESSING UNIT
112
EJECTION CONTROL UNIT
114
CONVEYANCE CONTROL UNIT (SUB-SCANNING)
116
MAIN SCANNING DRIVE UNIT
130
ENCODER
128
HEAD DRIVE UNIT
24
INKJET HEAD
122
DISPLAY APPARATUS
120
INPUT APPARATUS
126
IMAGE INPUT I/F
132
SENSOR
124
INFORMATION STORAGE UNIT

FIG.8

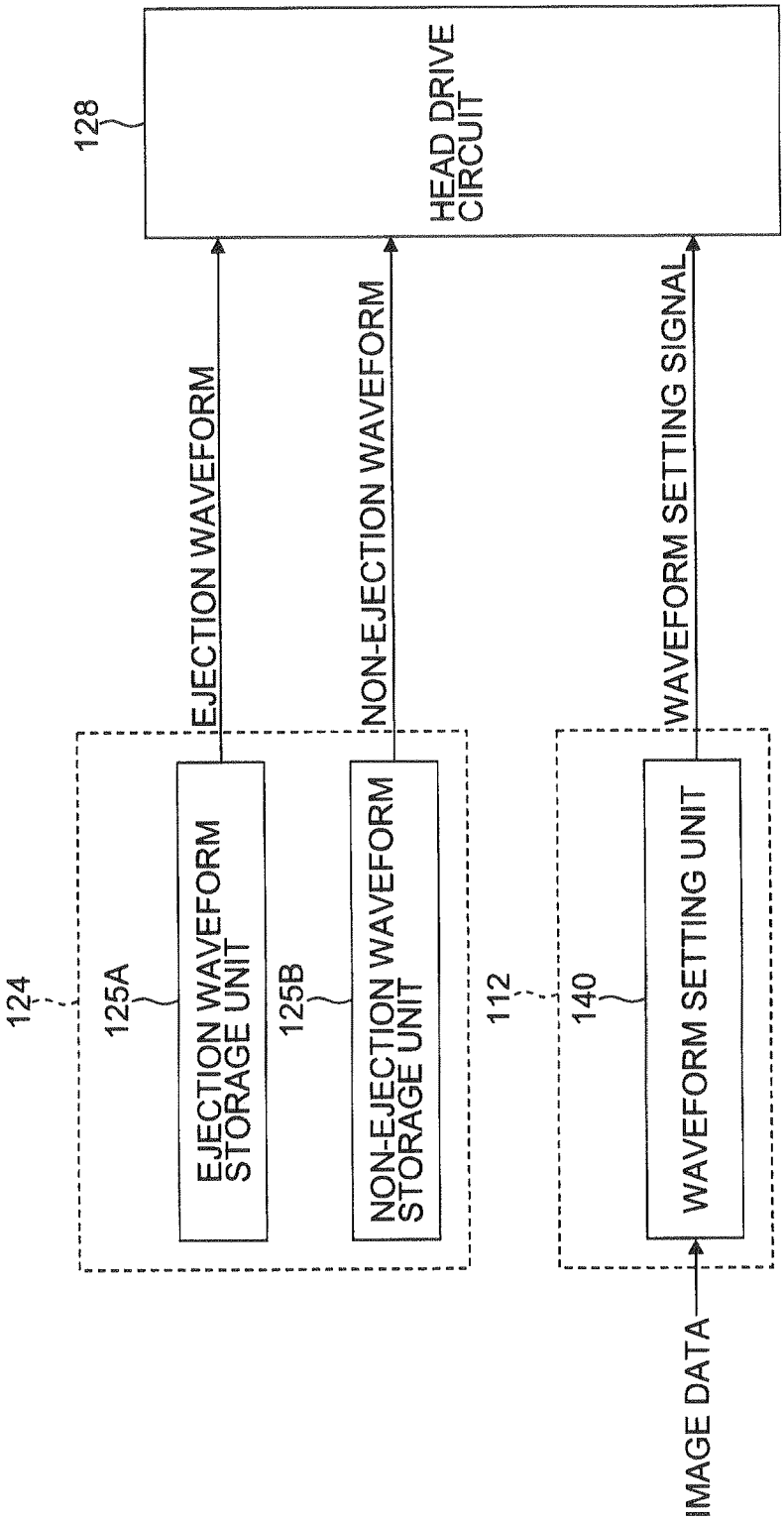

128
HEAD DRIVE CIRCUIT
EJECTION WAVEFORM
NON-EJECTION WAVEFORM
WAVEFORM SETTING SIGNAL
124
125A
EJECTION WAVEFORM STORAGE UNIT
125B
NON-EJECTION WAVEFORM STORAGE UNIT
112
140
WAVEFORM SETTING UNIT
IMAGE DATA

FIG.9A

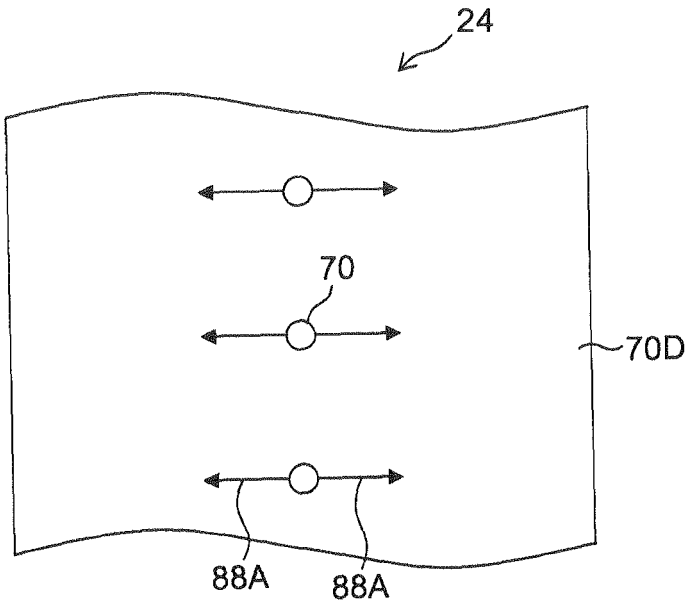


FIG.9B

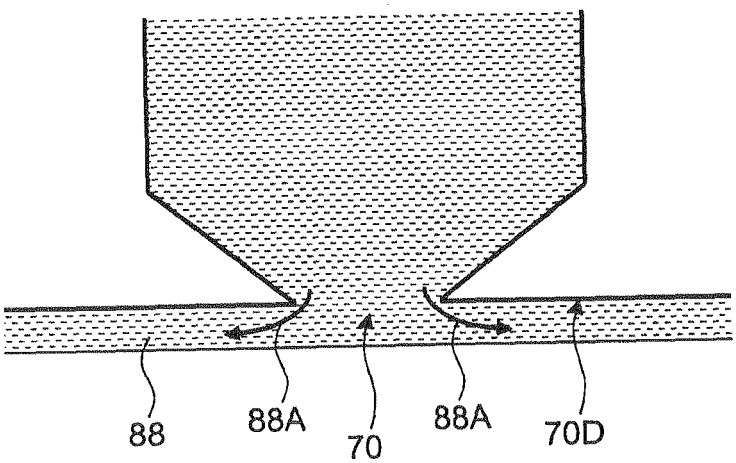


FIG.10A

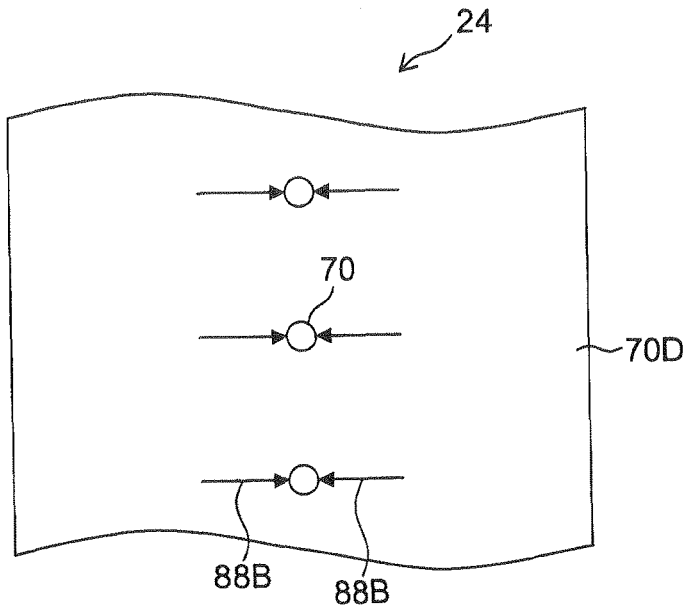


FIG.10B

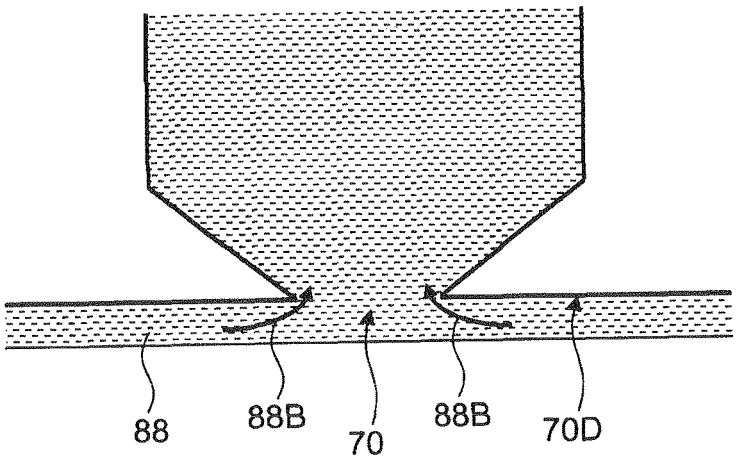


FIG.11

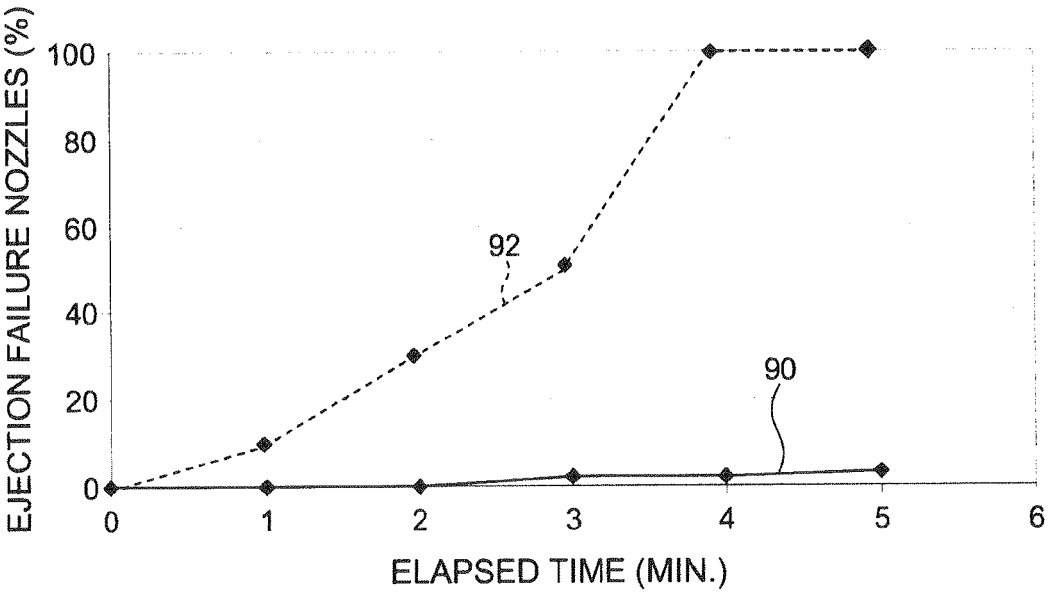

EJECTION FAILURE NOZZLES (%)
100
80
60
40
20
0
0
1
2
3
4
5
6
ELAPSED TIME (MIN.)
92
90

FIG.12A

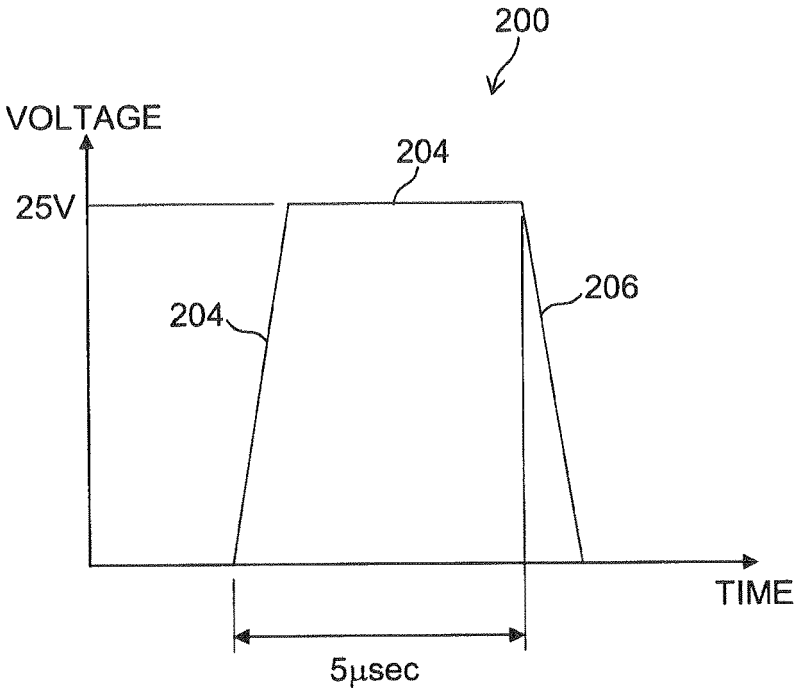


FIG.12B

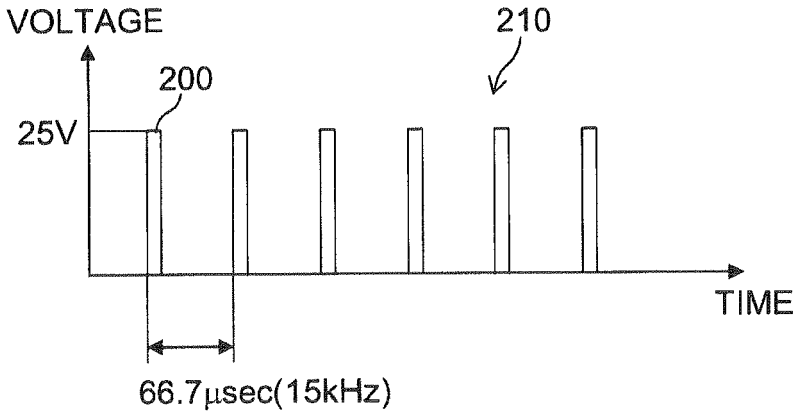


FIG.13

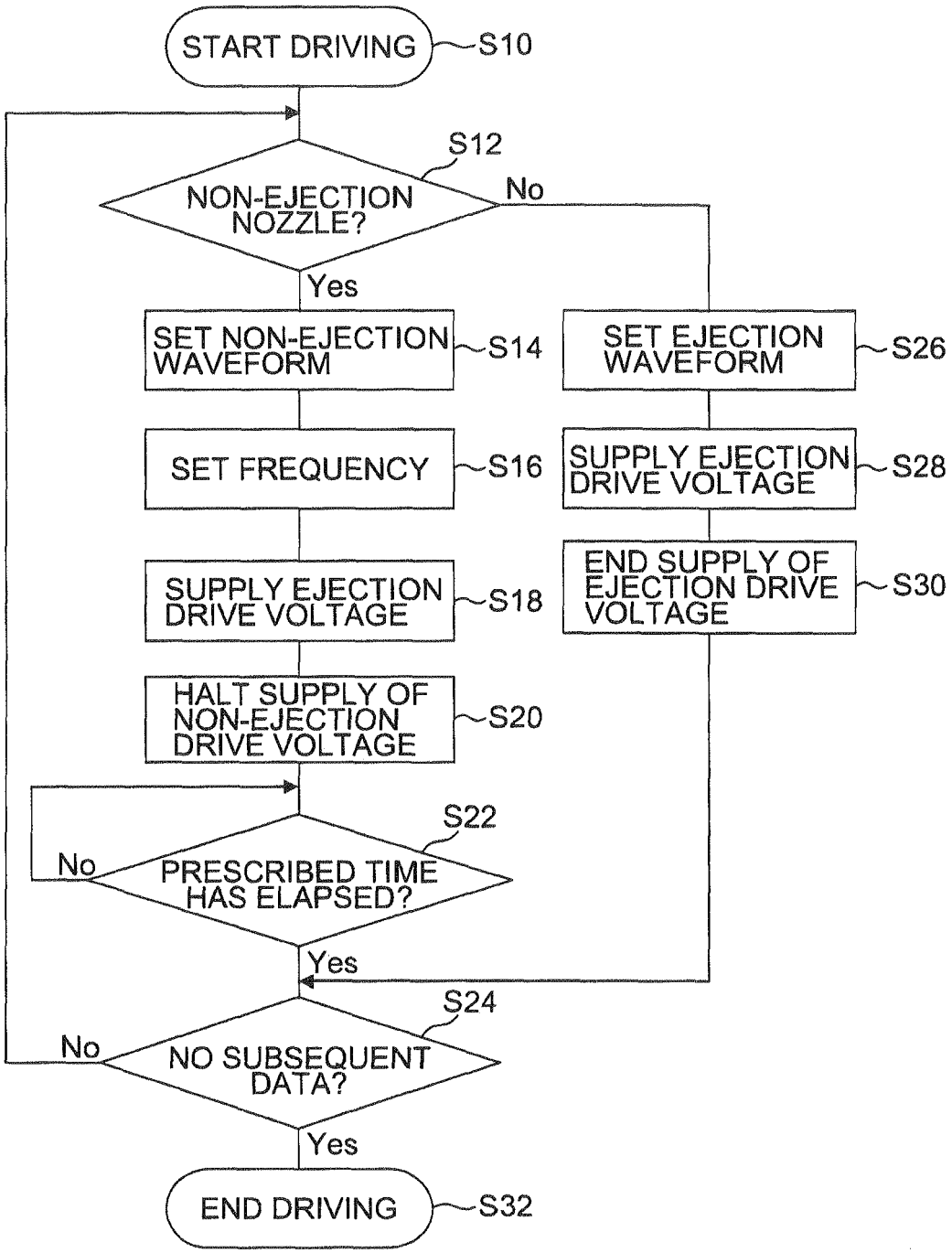

START DRIVING
S10
S12
NON-EJECTION NOZZLE?
No
Yes
SET NON-EJECTION WAVEFORM
S14
SET EJECTION WAVEFORM
S26
SET FREQUENCY
S16
SUPPLY EJECTION DRIVE VOLTAGE
S28
SUPPLY EJECTION DRIVE VOLTAGE
S18
END SUPPLY OF EJECTION DRIVE VOLTAGE
S30
HALT SUPPLY OF NON-EJECTION DRIVE VOLTAGE
S20
S22
No
PRESCRIBED TIME HAS ELAPSED?
Yes
S24
No
NO SUBSEQUENT DATA?
Yes
END DRIVING
S32

FIG.14

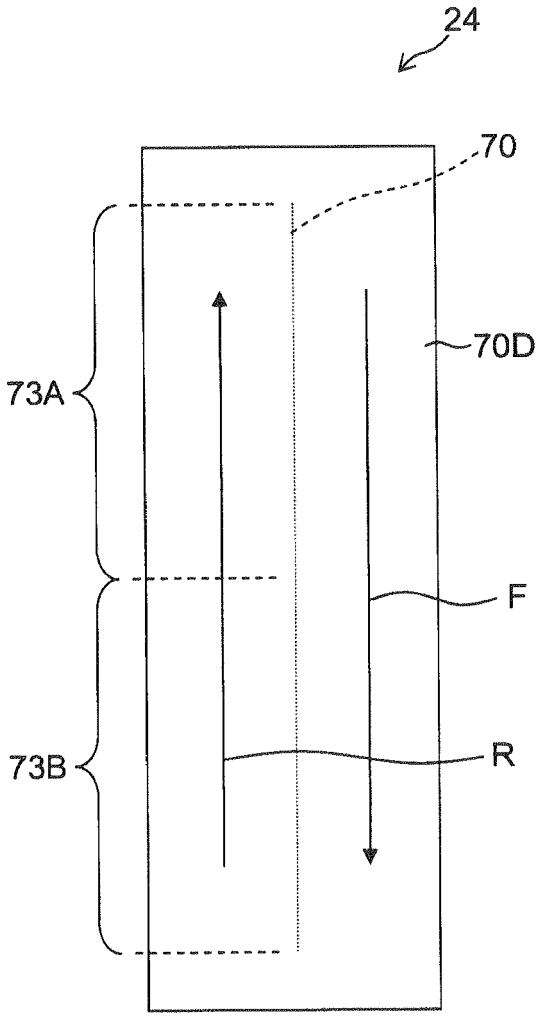


FIG.15

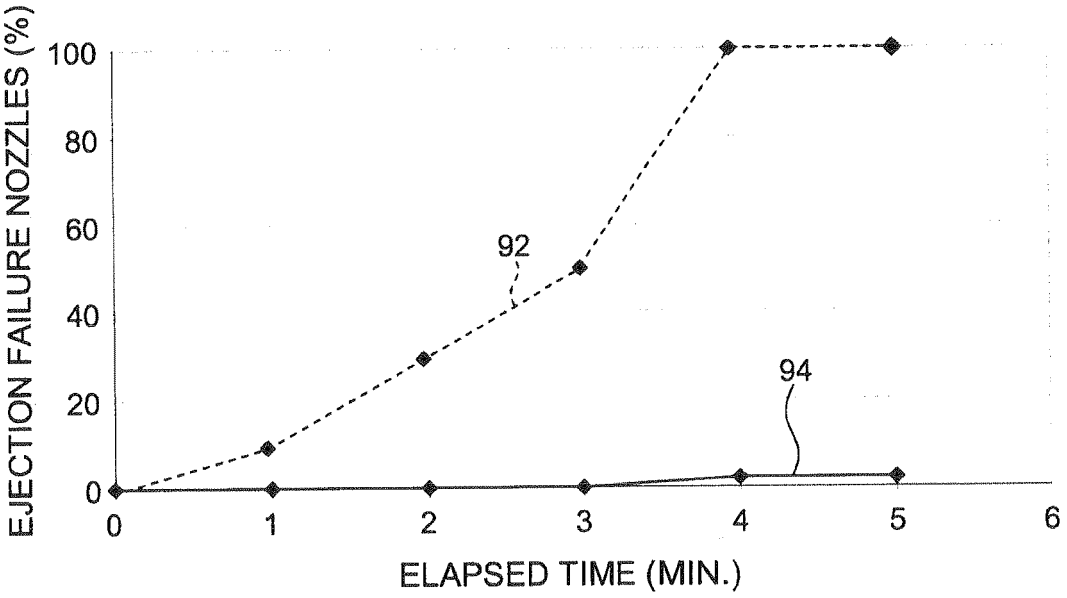

EJECTION FAILURE NOZZLES (%)
100
80
60
40
20
0
0
1
2
3
4
5
6
ELAPSED TIME (MIN.)
92
94

FIG.16A

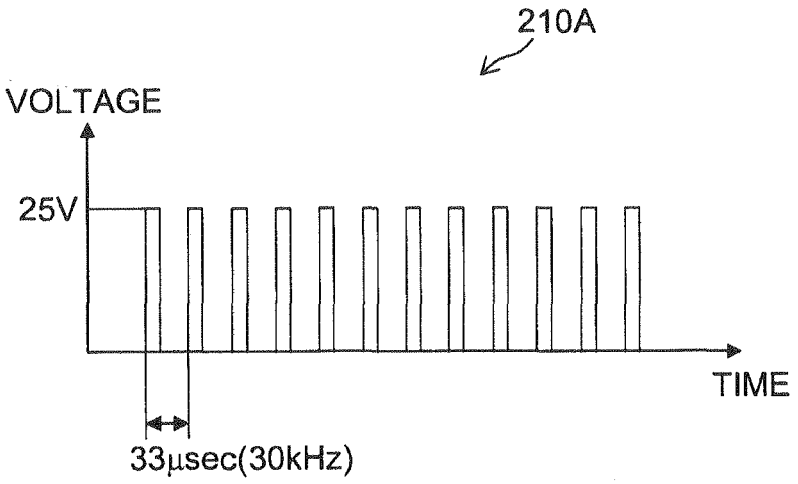


FIG.16B

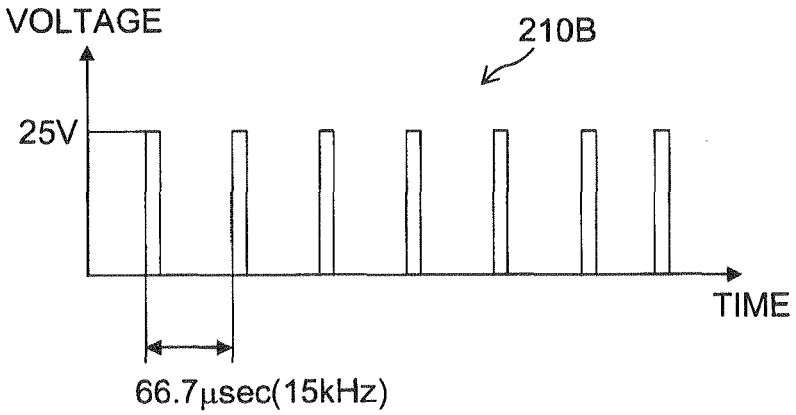


FIG.17

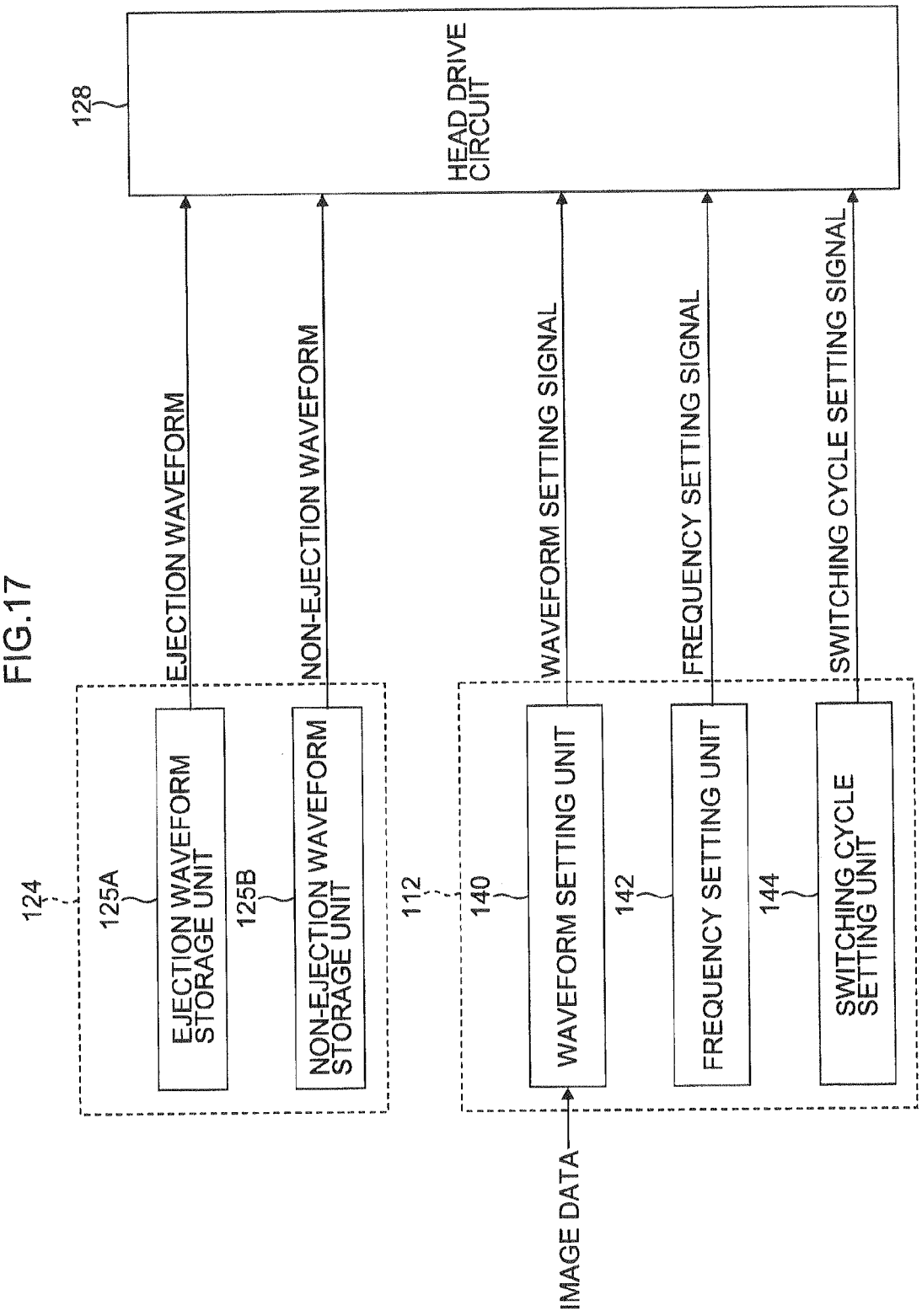

128
HEAD DRIVE CIRCUIT
EJECTION WAVEFORM
NON-EJECTION WAVEFORM
WAVEFORM SETTING SIGNAL
FREQUENCY SETTING SIGNAL
SWITCHING CYCLE SETTING SIGNAL
124
125A
EJECTION WAVEFORM STORAGE UNIT
125B
NON-EJECTION WAVEFORM STORAGE UNIT
112
140
WAVEFORM SETTING UNIT
142
FREQUENCY SETTING UNIT
144
SWITCHING CYCLE SETTING UNIT
IMAGE DATA

FIG.18

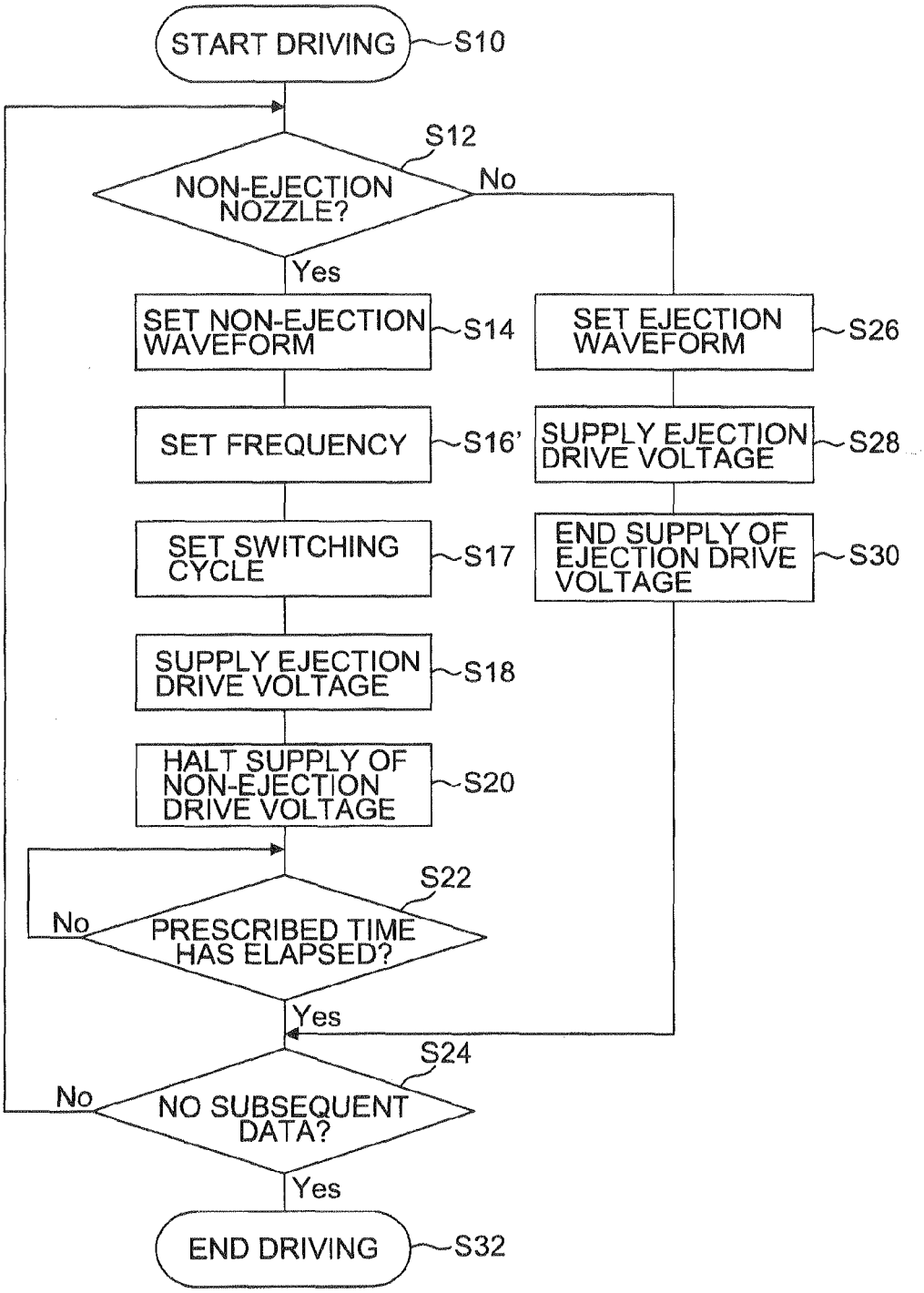

START DRIVING
S10
S12
NON-EJECTION NOZZLE?
No
Yes
SET NON-EJECTION WAVEFORM
S14
SET EJECTION WAVEFORM
S26
SET FREQUENCY
S16'
SUPPLY EJECTION DRIVE VOLTAGE
S28
SET SWITCHING CYCLE
S17
END SUPPLY OF EJECTION DRIVE VOLTAGE
S30
SUPPLY EJECTION DRIVE VOLTAGE
S18
HALT SUPPLY OF NON-EJECTION DRIVE VOLTAGE
S20
S22
No
PRESCRIBED TIME HAS ELAPSED?
Yes
S24
No
NO SUBSEQUENT DATA?
Yes
END DRIVING
S32

FIG.19

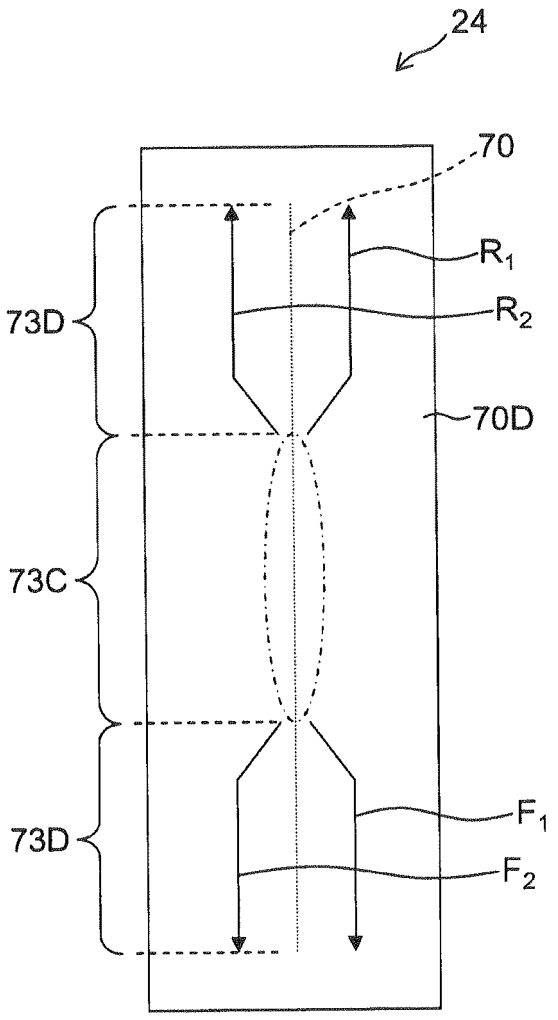
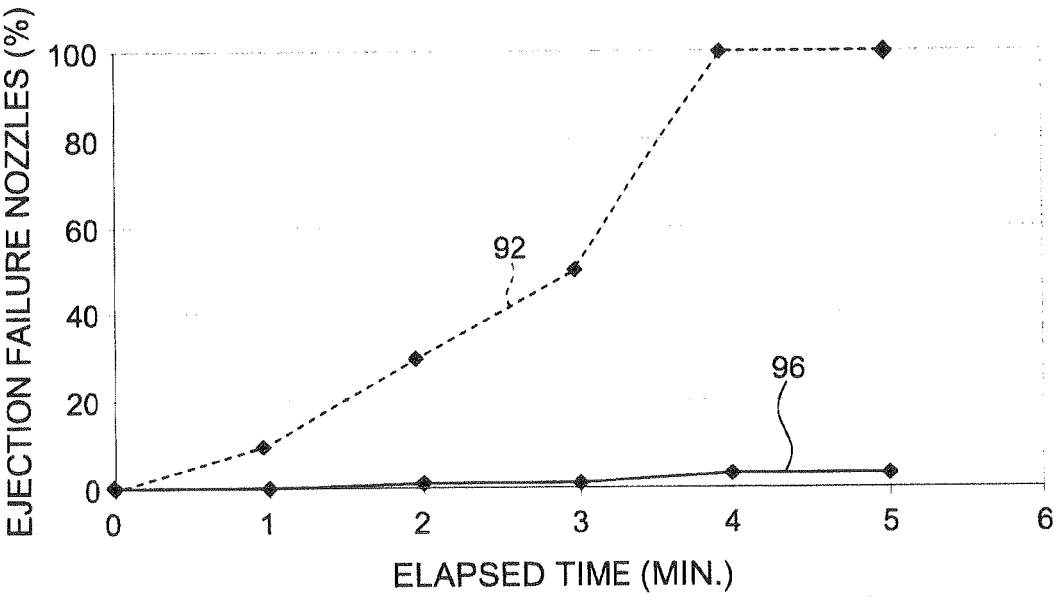


FIG.20


EJECTION FAILURE NOZZLES (%)
100
80
60
40
20
0
0
1
2
3
4
5
6
ELAPSED TIME (MIN.)
92
96

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EUROPEAN SEARCH REPORT

Application Number
EP 13 15 9425

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2010/066787 A1 (YOKOUCHI TSUTOMU [JP] ET AL) 18 March 2010 (2010-03-18) * paragraphs [0037] - [0042], [0081], [0088], [0108] * * figure 2 *	1,10	INV. B41J2/155 B41J2/045 B41J2/14
A	US 2002/041315 A1 (KUBOTA ATSUSHI [JP] ET AL) 11 April 2002 (2002-04-11) * paragraphs [0034] - [0041] * * figure 6c *	1,10	
A	US 2006/028503 A1 (YAMAZAKI SHUNPEI [JP] ET AL) 9 February 2006 (2006-02-09) * paragraphs [0035] - [0044], [0050], [0055] *	1,10	

TECHNICAL FIELDS SEARCHED (IPC)

B41J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	3 July 2013	Bonnin, David

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03-07-2013

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		US 2006028503 A1	09-02-2006

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- JP 7137252 A **[0004] [0005] [0008]**
- JP 2004306617 A **[0074]**