

DESCRIPTION

IMAGE FORMING DEVICE AND PRINTED MATTER

TECHNICAL FIELD

5 This invention relates to an image forming device and a printed matter. More particularly, this invention relates to an image forming device including a liquid discharge head, and a printed matter on which an image is formed by the image forming device.

10 BACKGROUND ART

There is known an image forming device, such as a printer, a fax, a copier, a plotter or a multi-function peripheral having multiple image forming functions (including print, fax, copy, and the like functions), which uses a liquid discharge mechanism. The liquid discharge mechanism includes a recording head in which liquid discharge heads for discharging drops of recording liquid are arranged. With this recording head, image formation (which is inclusive of image recording and printing) is carried out by discharging drops of the recording fluid (ink) to a medium (recording sheet) while the medium (recording sheet) is transported.

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An image forming device hereinafter refers to a device which performs image formation by discharging liquid drops to a medium (which is inclusive of paper, yarns, fibers, textile, leather, metal, plastics, glass, wood, ceramics, etc.). Image formation hereinafter refers to not only formation of images with meaningful characters, figures, etc. but also formation of images with meaningless patterns, etc. Liquid hereinafter is not restricted to a recording fluid or ink, but refers to any fluid which is a liquid state when it is discharged. A liquid discharge device hereinafter refers to a device in which a liquid discharge head discharges liquid drops, and it is not limited to a device which performs image formation.

The image forming devices provided with liquid discharge heads are classified into two types: a serial type image forming device in which a recording head provided on a carriage is moved in a main scanning direction perpendicular to a sheet transport direction to perform recording or printing; and a full-line type image forming device which uses a full-line type

recording head in which a plurality of ejection holes (nozzles) for discharging liquid drops are arranged to cover the overall recording region.

5 A liquid discharge head for use in an image forming device is arranged to discharge liquid drops from ejection holes in order to perform recording or printing. If a non-discharge state of the liquid discharge head keeps on for a certain period, the viscosity of
10 the liquid in the ejection holes is increased by evaporation of the solvent, etc. If the discharge operation is started from the non-discharge state, the discharging state of the head is disturbed with the increased viscosity
15 and the liquid discharge head will be inoperable and the printing quality will deteriorate. To avoid this, idle discharge operation in which liquid drops (waste fluid) that are not used for image formation are discharged from the nozzles
20 is performed and the recording fluid remaining in the nozzles with the viscosity increased is eliminated.

Regarding idle discharge operation,
Japanese Laid-Open Patent Application No. 11-
25 105304 discloses an ink jet printer in which an

ink jet head is provided with a preliminary discharge unit which performs preliminary discharging of ink for preventing clogging of the nozzles in the ink jet head, in a position separated from a recording medium during the scanning of the ink jet head on the recording medium.

Japanese Laid-Open Patent Application No. 2001-026123 discloses an ink jet recorder in which data for ejecting flushing dots from a nozzle for ejecting a small amount of ink is generated based on print data for one path. A head driving unit performs a printing operation in accordance with the data wherein printing dots as well as flushing dots smaller than the printing dots are ejected to a recording medium during the scanning of a carriage. As a result, the flushing dots are suitably ejected from the small-amount ejecting nozzle during the period of one path as needed, and it is possible to assure that the normal printing operation is performed even by a recorder using a comparatively large sized recording medium. Moreover, Japanese Laid-Open Patent Application No. 2005-313624 discloses a liquid discharge

head which performs a preliminary discharge operation during a normal printing operation.

Japanese Laid-Open Patent Application No. 2005-007899 discloses a full-line ink-jet

5 recording device in which an idle discharge region for performing idle discharge of liquid drop is set up in a position separated from a recording region. An idle discharge recording liquid portion for receiving the liquid drops
10 when idle discharge is performed is arranged in the idle discharge region. A recording head unit including a full-line ink jet head is moved or rotated to the idle discharge region, and it is caused to perform idle discharge operation.
15 Thereafter, the recording head unit is returned to the recording region by performing a head returning operation.

Moreover, Japanese Laid-Open Patent Application No. 2001-105589 discloses a method
20 of driving a liquid discharge head. Japanese Laid-Open Patent Application No. 2002-248766 discloses an image forming device which uses an ink in which charged particles are distributed in a solvent.

25 However, it is difficult to apply the

idle discharge method which performs idle discharge (preliminary discharge) operation in a position separated from the recording medium during the print scanning, according to Japanese Laid-Open Patent Application No. 11-105304, to the full-line type image forming device in which the recording head is moved. Even if the application of the idle discharge method mentioned above is possible, the problem that the printing speed in such a case extremely falls remains unresolved.

The idle discharge method which generates the data for idle discharge (flushing) based on the print data for one path and performs idle discharge within one print path, according to Japanese Laid-Open Patent Application No. 2001-026123 and others, would require the analysis of data with little ink discharge, the generation of the data for idle discharge according to image data, and the switching of the drive circuits which generate a drive waveform for normal printing and a drive waveform for idle discharge. Therefore, the problem that the processing is complicated and the cost is increased remains unresolved.

DISCLOSURE OF THE INVENTION

According to one aspect of the invention,
there is disclosed an improved image forming
device in which the above-described problems are
5 eliminated.

According to one aspect of the invention
there is disclosed an image forming device which
carries out idle discharge operation of a liquid
discharge head using a simple, inexpensive
10 mechanism.

According to one aspect of the invention
there is disclosed a printed matter on which an
image is formed by the above-mentioned image
forming device.

15 In an embodiment of the invention which
solves or reduces one or more of the above-
mentioned problems, there is disclosed an image
forming device which forms an image on a medium
and includes a liquid discharge head in which a
20 plurality of nozzles for discharging liquid
drops are arranged side by side, the image
forming device comprising: a drive waveform
generating unit generating, within a single
drive cycle, a first drive waveform containing a
25 drive signal to discharge an amount of liquid

drop used for image formation, and a second drive waveform containing a drive signal to discharge an amount of liquid drop smaller than a minimum discharge drop amount used for image formation; and a head control unit causing the liquid discharge head to discharge the amount of liquid drop used for image formation in accordance with the first drive waveform for a region where an image is formed, and causing the liquid discharge head to discharge the amount of liquid drop smaller than the minimum discharge drop amount in accordance with the second drive waveform for a region where any image is not formed.

The above-mentioned image forming device may be configured so that the region where any image is not formed corresponds to a region of the medium in which the medium is transported in a transport direction.

The above-mentioned image forming device may be configured so that the region where any image is not formed corresponds to an end portion of the image-formation region of the medium in a direction perpendicular to a transporting direction in which the medium is

transported.

The above-mentioned image forming device may be configured so that each of the drive signal in the first drive waveform and the drive signal in the second drive waveform contains a pressing waveform element which makes a liquid drop discharge by shrinking a liquid chamber communicating with one of the plurality of nozzles of the liquid discharge head, and a voltage change of the pressing waveform element of the drive signal in the second drive waveform is smaller than a voltage change of the pressing waveform element of the drive signal in the first drive waveform.

The above-mentioned image forming device may be configured so that each of the drive signal in the first drive waveform and the drive signal in the second drive waveform contains a pressing waveform element which makes a liquid drop discharge by shrinking a liquid chamber communicating with one of the plurality of nozzles of the liquid discharge head, and a change time of the pressing waveform element of the drive signal in the second drive waveform is longer than a change time of the pressing

waveform element of the drive signal in the first drive waveform.

The above-mentioned image forming device may be configured so that each of the drive
5 signal in the first drive waveform and the drive signal in the second drive waveform contains a drawing waveform element which causes a liquid chamber communicating with one of the plurality of nozzles of the liquid discharge head to
10 expand, and a voltage change of the drawing waveform element of the drive signal in the second drive waveform is larger than a voltage change of the drawing waveform element of the drive signal in the first drive waveform.

15 The above-mentioned image forming device may be configured so that each of the drive signal in the first drive waveform and the drive signal in the second drive waveform contains a drawing waveform element which causes a liquid
20 chamber communicating with one of the plurality of nozzles of the liquid discharge head to expand, and a change time of the drawing waveform element of the drive signal in the second drive waveform is shorter than a change
25 time of the drawing waveform element of the

drive signal in the first drive waveform.

The above-mentioned image forming device may be configured so that the liquid discharge head is a full-line type recording head.

5 The above-mentioned image forming device may be configured so that the medium is a rolled-form medium.

 The above-mentioned image forming device may be configured so that, when an idle
10 discharge operation is performed to discharge liquid drops which do not contribute to image formation, the liquid discharge head discharges, over an entire image formable region of the medium in a width direction of the medium, the
15 amount of liquid drop smaller than the minimum discharge drop amount.

 In an embodiment of the invention which solves or reduces one or more of the above-mentioned problems, there is disclosed a printed
20 matter on which an image is formed by the above-mentioned image forming device through discharging of liquid drops to the medium.

 In an embodiment of the invention which solves or reduces one or more of the above-mentioned problems, there is disclosed an image
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forming device which forms an image on a medium and includes a liquid discharge head in which a plurality of nozzles for discharging liquid drop are arranged side by side, the image forming
5 device comprising: a drive waveform generating unit generating, within a single drive cycle, a first drive waveform containing a first drive signal to discharge an amount of liquid drop used for image formation, and a second drive
10 waveform containing a second drive signal to discharge an amount of liquid drop smaller than a minimum discharge drop amount used for image formation; and a selecting unit selecting at least one of the first drive signal in the first
15 drive waveform and the second drive signal in the second drive waveform in response to a control signal, to output the selected drive signal to the liquid discharge head.

The above-mentioned image forming device
20 may be configured so that the drive waveform generating unit is arranged to generate a plurality of the first drive signals in time series, and the second drive signal being interposed between two of the plurality of the
25 first drive signals.

The above-mentioned image forming device may be configured so that the selecting unit is arranged to select the second drive signal concurrently with the first drive signal when forming an image.

The above-mentioned image forming device may be configured so that the drive waveform generating unit is arranged to generate the second drive waveform having a waveform element adapted to tear off a part of a liquid drop discharged from the liquid discharge head.

The above-mentioned image forming device may be configured so that the drive waveform generating unit is arranged so that a discharge drop speed of the amount of liquid drop smaller than the minimum discharge drop amount used for image formation is slower than a discharge drop speed of the minimum discharge drop amount used for image formation.

According to the embodiments of the image forming device of the invention, it is possible to perform idle discharge operation using a simple, inexpensive mechanism.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features and advantages

of the present invention will be apparent from the following detailed description when reading in conjunction with the accompanying drawings.

FIG. 1 is a diagram showing the composition of an image forming device in an embodiment of the invention.

FIG. 2 is a diagram showing the composition of a recording head in the image forming device of FIG. 1.

FIG. 3 is a cross-sectional view of a liquid discharge head, which constitutes a part of the recording head of FIG. 2, taken along a longitudinal direction of a liquid chamber of the liquid discharge head.

FIG. 4 is a cross-sectional view of the liquid discharge head, which constitutes a part of the recording head of FIG. 2, taken along a lateral direction of the liquid chamber.

FIG. 5 is a block diagram showing the composition of a control system of the image forming device of FIG. 1.

FIG. 6 is a block diagram showing the composition of a printing control part and a head drive circuit in the control system of FIG. 5.

FIG. 7 is a diagram showing an example of a drive waveform which is generated by the control system of FIG. 5.

FIG. 8A is a diagram showing an example of a drive signal P1 which is included in a first drive waveform which constitutes a part of the drive waveform of FIG. 7.

FIG. 8B is a diagram showing an example of a drive signal Pk which is included in a second drive waveform that constitutes a part of the drive waveform of FIG. 7.

FIG. 9A is a diagram showing an example of a drive signal P1 which is included in a first drive waveform which constitutes a part of the drive waveform of FIG. 7.

FIG. 9B is a diagram showing an example of a drive signal Pk which is included in a second drive waveform that constitutes a part of the drive waveform of FIG. 7.

FIG. 10 is a flowchart for explaining a liquid drop discharge control which is performed by the image forming device of FIG. 1.

FIG. 11 is a diagram showing an example of the image forming device in which image formation is performed by the recording head

using a roll sheet.

FIG. 12 is a diagram for explaining an example of a region where an image is formed, and a region where any image is not formed.

5 FIG. 13 is a diagram for explaining an example of a region where an image is formed, and a region where any image is not formed.

FIG. 14 is a diagram for explaining an example of a region where an image is formed,
10 and a region where any image is not formed.

FIG. 15 is a diagram showing an example of a drive waveform which is generated by a control system of an image forming device in an embodiment of the invention.

15 FIG. 16 is a diagram showing the relationship between a drop control signal and a discharge drop amount in the embodiment of FIG. 15.

FIG. 17 is a diagram showing an example of a drive waveform which is generated by a control system of an image forming device in an embodiment of the invention.

FIG. 18 is a diagram showing the relationship between a drop control signal and a
25 discharge drop amount in the embodiment of FIG.

17.

FIG. 19 is a diagram showing an example of a second discharge drive signal to cause the recording head to perform idle discharge.

5 FIG. 20 is a diagram showing the composition of an image forming device in an embodiment of the invention.

FIG. 21 is a diagram showing the composition of an image forming device in an
10 embodiment of the invention.

BEST MODE FOR CARRYING OUT THE INVENTION

A description will be given of embodiments of the invention with reference to the accompanying drawings.

15 FIG. 1 is a diagram showing the composition of the mechanical part of an image forming device in an embodiment of the invention.

The image forming device 1 of this embodiment is a full-line type image forming
20 device wherein a recording head is constituted by a full-line type liquid discharge head having rows of nozzles (in which plural nozzles are arrayed in each row) and having a longitudinal length larger than the width of a recording
25 region of a recording sheet (medium).

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The image forming device 1 includes an image formation part 2 inside the image forming device 1 and a transport mechanism 3 which transports a recording sheet. A medium tray 4 which accommodates several recording sheets 5 is attached to one side of the image forming device 1. Alternatively, a roll-sheet supply mechanism (which is not illustrated) which supplies a roll sheet (rolled-form medium) to the image formation part 2 may be attached to one side of the image forming device 1.

In the image forming device 1, a recording sheet 5 (or roll sheet) from the medium tray 4 is supplied to the transport mechanism 3, and an image is formed on the recording sheet 5 by the image formation part 2 while the recording sheet 5 (or roll sheet) is transported. The recording sheet 5 after the image formation is completed is delivered to a sheet output tray 6 which is attached to the other side of the image forming device 1.

As shown in FIG. 2, the image forming device 1 includes the recording heads 11k, 11c, 11m and 11y (which may be called collectively recording head 11) which discharge liquid drops

of the color of black (K), cyan (C), magenta (M) and yellow (Y), respectively. The recording heads 11k, 11c, 11m and 11y are constituted by four full-line type liquid discharge heads, and the respective recording heads 11 are attached to a head holder (which is not illustrated) with the nozzle surface 104N (nozzles 104 are formed therein) faced down.

The image forming device 1 as shown in FIG. 1 includes maintenance/recovery devices 12k, 12c, 12m and 12y (which may be called collectively maintenance/recovery device 12) which perform maintenance and recovery of the performance of the respective recording heads 11.

At the time of performance maintenance operation of the respective recording heads, such as a purging process and a wiping process, the recording head 11 and the maintenance/recovery device 12 are moved relative to each other, and the capping member which constitutes a part of the maintenance/recovery device 12 is made to face the nozzle surface 104N of the recording head 11.

In this embodiment, the black, cyan, magenta and yellow recording heads 11 are

arranged in this order in a sequence from the upstream side of the recording sheet transporting direction to discharge the liquid drops of each color to the recording sheet.

5 However, the arrangement and the number of colors of the recording heads according to the invention are not limited to this embodiment.

One or a plurality of full-line type recording heads in which a plurality of nozzle
10 rows are arranged at given intervals may also be used instead. The recording head and the recording fluid cartridge which supplies the recording fluid to the recording head may be formed into an integral component or they are
15 formed as separate components.

The image forming device 1 includes a sheet supply roller 21 which separates one sheet from the recording sheets 5 of the medium tray 4 and supplies the sheet to the image forming
20 device 1 at a time, and sheet supply rollers 22 which deliver the sheet to the transport mechanism 3. When the image forming device 1 is provided with the roll-sheet supply mechanism, a roll sheet is continuously delivered to the
25 transport mechanism 3 by means of the sheet

supply rollers 22.

The transport mechanism 3 includes the following elements. A transporting belt 25 of endless type is wound between a drive roller (transport roller) 23 which is rotated by the drive motor (not illustrated) and a driven roller 24. A charging roller 26 is provided to charge the transporting belt 25 electrically. A guide member (platen plate) 27 is provided to guide the transporting belt 25 in the portion which faces the image formation part 2. A retaining roller 28 is arranged opposite to the driving roller 23 to retain the recording sheet 5 (or roll sheet), sent from the sheet supply part, against the drive roller 23. A recording fluid wiping member (or cleaning blade) 29 which is made of a porous material is a cleaning unit provided to remove the recording fluid (ink) adhering to the transporting belt 25. And an electric discharge roller 30 is provided to electrically discharge the transporting belt 25.

In addition, delivery rollers 31 are provided at the downstream portion of the transport mechanism 3 to deliver the recording sheet 5 (or roll sheet) on which the image is

formed, to the sheet output tray 6.

In the full-line type image forming device described above, the transporting belt 25 is electrically charged and the recording sheet 5 (or roll sheet) is delivered to the transporting belt 25, so that the recording sheet 5 (or roll sheet) is attracted by the electrostatic force of the transporting belt 25 and it is transported by the rotating movement of the transporting belt 25. An image is formed on the recording sheet by the liquid drops of the respective colors discharged from the recording heads 11k, 11c, 11m and 11y of the image formation part 2. The recording sheet on which the image is formed is delivered to the sheet output tray 6.

A description will be given of an example of a liquid discharge head which constitutes a part of the recording head 11 with reference to FIG. 3 and FIG. 4.

FIG. 3 is a cross-sectional view of the liquid discharge head taken along the line A-A indicated in FIG. 2 in a longitudinal direction of a liquid chamber of the liquid discharge head (which direction is perpendicular to the

direction of the nozzle row). FIG. 4 is a cross-sectional view of the liquid discharge head taken along a lateral direction of the liquid chamber (which direction is parallel to the direction of the nozzle row).

The liquid discharge head includes the following elements: a channel plate (liquid chamber substrate) 101; a diaphragm plate 102 which is bonded to the undersurface of the channel plate (liquid chamber substrate) 101 and this channel plate 101; and a nozzle plate 103 which is bonded to the upper surface of the channel plate 101 (or formed integrally with the channel plate 101).

Moreover, the channel plate 101, the diaphragm plate 102 and the nozzle plate 103 constitute the following elements: a pressurized liquid chamber which is provided as an individual passage to communicate with nozzles 104 for discharging liquid drops; a fluid resistance part 107 which is provided as a liquid supply passage which supplies the ink (recording fluid) to the pressurized liquid chamber 106; and a damper chamber 118 which is provided adjacent to a common liquid chamber 108.

In this embodiment, the channel plate 101 is produced from an SUS substrate through machining, punching or etching using an acid etching solution, and the channel plate 101
5 forms various openings of the pressurized liquid chamber 106, the fluid resistance part 107 and the damper chamber 118, respectively.

As mentioned above, the channel plate 101 and the nozzle plate 103 or the diaphragm
10 plate 102 may be formed together through electrocasting. The channel plate 101 may be formed by performing anisotropic etching of a single crystal silicon substrate of crystal face orientation (110) using alkaline etching
15 solution, such as a potassium hydroxide solution (KOH). Alternatively, the channel plate 101 may be formed using a photosensitive resin.

As shown in FIG. 3, the diaphragm plate 102 is formed from a three-layered nickel plate
20 including a first layer 102a, a second layer 102b and a third layer 102c which are laminated from the liquid chamber 106 side, and the diaphragm plate 102 is produced through electrocasting, for example. Alternatively, the
25 diaphragm plate 102 may be formed from a

laminated member made of a resin, such as polyimide, and a metal plate, such as an SUS substrate, or formed from a resin member, for example.

5 The nozzle plate 103 forms various nozzles 104 corresponding to the respective pressurized liquid chambers 106, and this nozzle plate 103 is bonded to the channel plate 101 by an adhesive agent.

10 The source materials suitable for forming the nozzle plate 103 may include a metal material, such as stainless steel and nickel, a resin material, such as a polyimide resin, silicon, and their combination.

15 The internal shape of the nozzle 104 is a horn-like shape (or a generally cylindrical shape or truncated cone shape may be used), and the inside diameter of the nozzle 104 is in a range of 20-35 micrometers as the diameter on
20 the side of an ink drop outlet. The pitch of nozzles of each row is set to 150 dpi.

 A water-repellent-finish layer (not illustrated) which is subjected a water-repellent surface treatment is provided on the
25 nozzle surface 104N (the surface in the

discharge direction) of the nozzle plate 103.

The water-repellent-finish layer may be formed through PTFE-Ni eutectic plating or electrodeposition of fluororesin, vapor

5 deposition of fluororesin with evaporativity, or baking after solvent spreading of silicon-based resin or fluorine-based resin etc.

In the diaphragm plate 102, as shown in FIG. 3, a diaphragm part 102A corresponding to each pressurized liquid chamber 106 is formed by
10 the first layer 102a, and a projection part 102B of two-layer structure is formed in the middle of the diaphragm part 102A by the second layer 102b and the third layer 102c. Each of the
15 piezoelectric elements 112 which constitute the energy generating unit (actuator unit) is bonded to the projection part 102B, respectively.

Corresponding to a partition 106A of each pressurized liquid chamber 106, the support
20 part 113 is bonded to the three-layer structured portion (thick portion 102B).

The piezoelectric elements 112 and the support parts 113 are formed through slit processing by half-cut dicing of a laminated
25 piezoelectric element member 114. The support

parts 113 are also piezoelectric elements, but no drive voltage is applied to the support parts 13 and they serve as a support for the diaphragm plate 102. The laminated piezoelectric element member 114 is bonded to the base member 115.

For example, the piezoelectric elements 112 (piezoelectric element member 114) are made by laminating alternately a piezoelectric layer of lead titanate zirconate (PZT) whose thickness per layer is in a range of 10-50 micrometers, and an internal electrode layer of silver/palladium (AgPd) whose thickness per layer is several micrometers. The internal electrodes are electrically connected to the individual electrode and the common electrode, and a drive signal is supplied to these electrodes via an FPC cable 116.

The recording head may be configured so that the recording fluid in the liquid chamber 106 is pressurized using a piezoelectric displacement of the piezoelectric element 112 in d33 direction. Alternatively, the recording head may be configured so that the recording fluid in the liquid chamber 106 is pressurized using a piezoelectric displacement of the piezoelectric

element 112 in d31 direction.

The recording head in this embodiment employs the configuration which utilizes the displacement of the piezoelectric element 112 in
5 d33 direction.

It is preferred that the base member 115 is formed using a metallic material. When the material of the base member 115 is metal, it is possible to prevent the heat accumulation of the
10 piezoelectric element 112 by the self-heating thereof. Bonding of the piezoelectric element 112 and the base member 115 may be performed using an adhesive agent. However, when the number of channels increases as in the full-line
15 type recording head, the temperature rises to about 100 degrees C by the self-heating of the piezoelectric element 112 and the bonding strength falls remarkably.

The temperature rise inside the
20 recording head occurs by the self-heating and the ink temperature rises, and if the temperature of ink rises, ink viscosity will fall and it will have significant influences on discharging properties.

25 Therefore, the base member 115 is formed

using a metallic material, to prevent the heat accumulation by the self-heating of the piezoelectric element 112. Furthermore, this allows the degradation of the jetting properties due to the fall of such bonding strength and the fall of recording fluid viscosity to be prevented.

Moreover, a frame member 117 which is formed through injection molding of an epoxy-based resin or polyphenylene sulfite is bonded to the circumference of the diaphragm plate 102 by an adhesive agent.

A common liquid chamber 108 which supplies the recording fluid to each pressurized liquid chamber 106 is formed in the frame member 117. The recording fluid from the common liquid chamber 108 is supplied to the pressurized liquid chamber 106 via the feed hole 109 formed in the diaphragm plate 102, the passage 110 formed in the upstream of the fluid resistance part 107, and the fluid resistance part 107. A recording fluid feed hole 119 for supplying the recording fluid to the common liquid chamber 108 externally is also formed in the frame member 17.

A portion of the wall surface of the

common liquid chamber 108 is formed by the diaphragm plate 102 which forms the wall surface of the liquid chamber 106. The portion which forms the wall surface of the common liquid chamber 108 is formed into a damper part 124. The damper part 124 forms the wall part of the adjoining damper chamber 118 to absorb the pressure fluctuation arising in the common liquid chamber 108. The damper chamber 118 is open to the atmosphere through the air opening which is not illustrated.

In the liquid discharge head mentioned above, when the voltage applied to the piezoelectric element 112 falls from the reference voltage V_e , the piezoelectric element 112 is caused to contract, the diaphragm 2 is caused to descend, so that the capacity of pressurized liquid chamber 106 is expanded and the ink flows into the liquid chamber 106. After that, when the voltage applied to the piezoelectric element 112 rises, the piezoelectric element 112 is caused to expand in the lamination direction. The diaphragm plate 102 is deformed in the nozzle 104 direction, and the capacity/volume of the liquid chamber 106 is

decreased, so that the recording fluid in the liquid chamber 106 is pressurized, and a drop of the recording fluid is discharged (ejected) from the nozzle 104.

5 Subsequently, when the voltage applied to the piezoelectric element 112 is returned to the reference voltage, the diaphragm plate 102 is returned to the initial position, and the liquid chamber 106 is caused to expand. At this
10 time, negative pressure arises in the liquid chamber 106, and the liquid chamber 106 is refilled with recording fluid from the common liquid chamber 108.

 After oscillation of the meniscus of the
15 nozzle 104 is declined and the nozzle meniscus is stabilized, the liquid discharge head is shifted to subsequent operation for discharging a liquid drop from the nozzle 104.

 In this embodiment, the piezoelectric
20 type liquid discharge head which uses piezoelectric elements as the energy generating unit (actuator unit) will be described. Alternatively, a liquid discharge head using another actuator unit, such as a thermal head
25 which uses an exothermic resistor for an

actuator unit, and an electrostatic head which uses as the actuator unit a diaphragm and an electrode which generate electrostatic force, may also be used as the recording head 11.

5 Next, a control system of the image forming device of this embodiment will be described with reference to FIG. 5.

 As shown in FIG. 5, the control system includes a main control part 301 constituted by
10 a microcomputer which controls the entire image forming device and includes a control unit which controls idle discharge operation according to the invention, and a printing control part 302
constituted by a microcomputer which performs
15 printing control.

 In order to form an image on a recording sheet based on print processing information received from a communication circuit 300, the main control part 301 carries out various
20 controls including a drive control of the driving roller 23, a drive control of a sheet feed motor (which is not illustrated) through the sheet feed motor drive circuit 304, and a print control of outputting image data and print
25 control data to the printing control part 302.

The main control part 301 receives a detection signal from the feed amount detecting circuit 306 which detects the amount of movement of the driving roller 23. The main control part 301 controls the amount of movement and rotating speed of the driving roller 23 based on the received detection signal.

For example, the feed amount detecting circuit 306 detects the amount of movement of the driving roller 23 by reading the number of slits of a rotary encoder sheet attached to the rotating shaft of the driving roller 23, using a photosensor, and measuring the amount of movement.

The sheet feed motor drive circuit 304 rotates the sheet feed motor in accordance with the amount of feed received from the main control part 301, so that the driving roller 23 is rotated and a recording sheet is transported to a predetermined position at a predetermined speed.

The main control part 301 performs one revolution of the sheet supply roller 21 by outputting a sheet-supply motor drive command to the sheet-supply motor drive circuit 307. The

main control part 301 performs the maintenance
recovery action of the recording head 11 by
driving the drive source of the head holder (not
illustrated) and driving the maintenance/
5 recovery device 12 through the maintenance/
recovery-device drive circuit 308.

The printing control part 302 generates,
based on the amount of sheet feed from the feed
amount detecting circuit 306 and the control
10 signal from the main control part 301, the drive
waveform data for driving the energy generating
unit (piezoelectric elements) of the recording
head 11 to discharge liquid drops, and transmits
the drive waveform data to the head drive
15 circuit 310. The printing control part 302
outputs various signals required for
transmission of image data and acknowledgement
of the transmission, to the head drive circuit
310.

20 The printing control part 302 includes a
drive waveform generating part which is
constituted by a D-A converter for D/A
conversion of the drive signal pattern data
stored in ROM, a voltage amplifier, a current
25 amplifier etc., and a drive waveform selecting

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unit which selects a drive signal to be supplied to the head drive circuit 310. The printing control part 302 generates a drive waveform containing one or a plurality of drive pulses (drive signals), and outputs the drive waveform to the head drive circuit 310.

The head drive circuit 310 selects the drive signal from the drive waveform received from the printing control part 302 in accordance with the image data, and supplies the drive signal to the energy generating unit (piezoelectric elements) of the recording head 11, so that the energy generating unit (piezoelectric elements) of the recording head 11 is driven to generate energy to discharge liquid drops.

Next, a description will be given of the printing control part 302 and the head drive circuit 310 with reference to FIG. 6.

As shown in FIG. 6, the printing control part 302 includes: a drive waveform generating part 401 which generates the drive waveform (common drive waveform) containing a plurality of drive pulses (drive signals) within one printing cycle; and a data transfer part 402

which outputs, to the head drive circuit 310, 2-bit image data (gradation signals 0 and 1) according to the print image, a clock signal, a latch signal (LAT), and drop control signals M0-M3.

The drop control signals M0-M3 are supplied to the head drive circuit 310 for requesting, for every drop, switching ON and OFF of the analog switch 415 (which is a switching unit in the head drive circuit 310). The state of each drop control signal is shifted to H level (ON) in accordance with the printing cycle of the common drive waveform when any portion of the waveform should not be selected, and the state of each drop control signal is shifted to L level (OFF) when a portion of the waveform should be selected.

The head drive circuit 310 includes the following elements: a shift register 411 which receives a transfer clock (shift clock) and serial image data (gradation data: 2 bits per channel) from the data transfer part 402; a latch circuit 412 for latching each registration value of the shift register 411 using the latch signal from the data transfer part 402; a

decoder 413 which decodes the gradation data and the drop control signal M0-M3 and outputs the resulting data; a level shifter 414 which converts the logic-level voltage signal of the decoder 413 into the level on which an analog switch 415 can operate; and an analog switch 415 which is switched on and off in accordance with the output of the decoder 413 received via the level shifter 414.

The analog switch 415 is connected to a selection electrode (individual electrode) 154 of each piezoelectric element 121, and the common drive waveform from the drive waveform generating part 401 is supplied to the analog switch 415.

When the analog switch 415 is switched ON based on the image data (gradation data) transferred serially and the resulting data of the control signals M0-M3 from the decoder 413, the drive signal which is selected from the common drive waveform is supplied to the piezoelectric element 121.

Next, the drive waveform in an embodiment of the invention will be described with reference to FIG. 7.

As shown in FIG. 7 (a), the drive waveform generating part 401 generates, within one drive cycle (one printing cycle) that is determined by the pixel density and the recording sheet transport speed, a drive waveform containing a first drive waveform Pd and a second drive waveform Pk in time series.

The first drive waveform Pd includes a non-discharge drive signal P0 for oscillating the meniscus of the nozzle which is not used for image formation, and a plurality of first discharge drive signals (drive pulses) P1-P3 for discharging the amount of liquid drop used for image formation. The second discharge drive signal (the second drive waveform) Pk is to discharge the amount of liquid drop smaller than the minimum discharge drop amount used for image formation.

Alternatively, the second drive waveform may be arranged to include a plurality of second discharge drive signals similar to the first drive waveform.

Each of the drive signals P0-P3 and Pk includes a waveform element whose voltage falls from the reference voltage V_e , and a waveform

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element whose voltage rises from the low potential to which the voltage has fallen.

5 The waveform element in which the voltage V of the drive signal falls from the reference voltage V_e is called a drawing waveform element, and this waveform element causes the piezoelectric element 121 to contract and causes the capacity of the liquid chamber 106 to expand.

10 The waveform element whose voltage rises from the low potential to which the voltage has fallen is called a pressing waveform element, and this waveform element causes the piezoelectric element 121 to elongate and causes
15 the capacity of the liquid chamber 106 to contract.

The drive signal P_0 included in the first drive waveform P_d is a drive waveform which oscillates the meniscus of the nozzle
20 without making liquid drop discharge. Each of the drive signals P_1 - P_3 and P_k included in the first and second drive waveforms is a drive waveform for discharging a liquid drop by expanded the liquid chamber communicating with
25 the nozzle of the liquid discharge head, and

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thereafter shrinking the liquid chamber.

One of the drop control signals M0-M3 shown in FIG. 7 (b) is supplied from the data transfer part 402 to the head drive circuit 310.

5 The head drive circuit 310 performs the drive signal selection to select at least one of the drive signal in the first drive waveform and the drive signal in the second drive waveform in the received drop control signal.

10 For example, when performing a fine drive, the drive signal P0 is selected in response to the drop control signal M0 (selection is done by the L level state of the drop control signal). When discharging a small
15 drop, the drive signal P1 is selected in response to the drop control signal M1. When discharging a large drop, the drive signals P1-P3 are selected in response to the drop control signal M2. When performing idle discharge, the
20 drive signal Pk is selected in response to the drop control signal M3. The selected drive signal is supplied to the piezoelectric element 121 of the recording head 11, respectively.

In this example, one of the two drop
25 sizes: small drop and large drop is selected.

Alternatively, one of three drop sizes: small drop, middle drop, and large drop may be selected to discharge the selected drop.

5 An example of the first discharge drive signal P1 for discharging a small drop, and the second discharge drive signal Pk for performing idle discharge will be described with reference to FIG. 8A and FIG. 8B.

10 FIG. 8A shows an example of the first discharge drive signal P1 in the first drive waveform Pd for discharging a small drop (a minimum liquid drop used for image formation).

15 FIG. 8B shows an example of the second discharge drive signal Pk in the second drive waveform for discharging the amount of liquid drop smaller than the minimum discharge drop amount.

20 The drive signal P1 includes a drawing waveform element a1 whose voltage falls from the reference voltage Ve by a voltage change Vfa, causing the liquid chamber 106 to expand, and causing the meniscus of the nozzle to be drawn.

25 After a predetermined hold time, the drive signal P1 includes a pressing waveform element b1 whose voltage rises by a voltage

change V_{ra} , shrinking the liquid chamber 106 and discharging a liquid drop from the nozzle.

After a predetermined hold time, the voltage of the drive signal P_1 rises to the reference

5 voltage V_e .

The drive signal P_k includes a drawing waveform element a_k whose voltage falls from the reference voltage V_e by a voltage change V_{fb} , causing the liquid chamber 106 to expand and

10 causing the meniscus of the nozzle to be drawn.

After a predetermined hold time, the drive signal P_k includes a pressing waveform element b_k whose voltage rises by a voltage change V_{rb} , shrinking the liquid chamber 106 and

15 discharging a liquid drop from the nozzle.

After a predetermined hold time, the voltage of the drive signal P_k rises to the reference voltage V_e .

It is preferred that the timing of

20 shrinking the liquid chamber 106 by the rising edges of the pressing waveform elements b_1 and b_k accords with the timing of the period of natural resonance arising when expanding the liquid chamber 106 by the falling edges of the

25 drawing waveform elements a_1 and a_k .

In this embodiment, a change time (falling time) T_{fa} of the drawing waveform element $a1$ of the drive signal $P1$ is equal to a change time (falling time) T_{fb} of the drawing waveform element ak of the drive signal Pk , and a change time (rising time) T_{ra} of the pressing waveform element $b1$ of the drive signal $P1$ is equal to a change time (rising time) T_{rb} of the pressing waveform element bk of the drive signal Pk .

In this embodiment, the rising voltage (voltage change) V_{rb} of the pressing waveform element bk of the drive signal Pk is set up to be smaller than the rising voltage (voltage change) V_{ra} of the pressing waveform element $b1$ of the drive signal $P1$. Thereby, the amount of the liquid drop discharged by the drive signal Pk is smaller than the discharge of the liquid drop (small drop) discharged by the drive signal $P1$.

Moreover, in this embodiment, the falling voltage (voltage change) V_{fb} of the drawing waveform element ak of the drive signal Pk is set up to be larger than the falling voltage (voltage change) V_{fa} of the drawing

waveform element a1 of the drive signal P1.

Thereby, the drop speed by the drive signal Pk is increased, and it is possible to discharge a liquid drop from the nozzle certainly.

5 Discharge bending of the liquid drop discharged by the drive signal Pk may arise if a high frequency drive is performed, and the drive signal Pk is not suitably used as a drive signal for discharging a liquid drop used for image
10 formation.

 In this embodiment, each of the first and second drive waveforms contains the pressing waveform element which discharges a liquid drop by shrinking the liquid chamber communicating
15 with the nozzle of the liquid discharge head. The voltage change of the pressing waveform element of the drive signal included in the second drive waveform is set up to be smaller than the voltage change of the pressing waveform
20 element of the drive signal included in the first drive waveform, thereby discharging the amount of liquid drop smaller than the minimum discharge drop amount used for image formation.

 Moreover, in this embodiment, each of
25 the first and second drive waveform contains the

drawing waveform element which expands the liquid chamber communicating with the nozzle of the liquid discharge head. The voltage change of the drawing waveform element of the drive signal included in the second drive waveform is set up to be larger than the voltage change of the drawing waveform element of the drive signal included in the first drive waveform, thereby increasing the discharge drop speed and discharging certainly the amount of liquid drop smaller than the minimum discharge drop amount used for image formation.

Next, another example of the drive signal P1 for discharging a small drop, and the drive signal Pk for performing idle discharge will be described with reference to FIG. 9A and FIG. 9B.

FIG. 9A shows the waveform of a drive signal P1 in the first drive waveform Pd for discharging the minimum discharge drop amount (a small drop) used for image formation.

FIG. 9B shows the waveform of a drive signal Pk in the second drive waveform for discharging the amount of liquid drop (a very small drop) smaller than the minimum discharge

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drop amount.

As shown in FIGs. 9A and 9B, the drive signals P1 and Pk include drawing waveform elements a1 and ak whose voltage falls from the reference voltage Ve by a voltage change Vfa, respectively, causing the liquid chamber 106 to expand and causing the meniscus of the nozzle to be drawn. After a predetermined hold time, the drive signals P1 and Pk include pressing waveform elements b1 and bk whose voltage rises by a voltage change Vra, shrinking the liquid chamber 106 and discharging a liquid drop from the nozzle. After a predetermined hold time, the voltage of the drive signals P1 and Pk rises to the reference voltage Ve.

In this example, the falling times (change times) Tfa and Tfb of the drawing waveform elements a1 and ak are set up to be different from each other, and the rising times (change times) Tra and Trb of the pressing waveform elements b1 and bk are set up to be different from each other.

Specifically, the falling time Tfb of the drawing waveform element ak of the drive signal Pk is set up to be smaller than the

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falling time T_{fa} of the drawing waveform element
a1 of the drive signal P1. The rising time T_{rb}
of the pressing waveform element bk of the drive
signal Pk is set up to be larger than the rising
5 time T_{ra} of the pressing waveform element b1 of
the drive signal P1.

It is preferred that the timing of
shrinking the liquid chamber 106 by the rising
edges of the pressing waveform elements b1 and
10 bk accords with the timing of the period of
natural resonance arising when expanding the
liquid chamber 106 by the falling edges of the
drawing waveform elements a1 and ak.

In this example, the rising time (change
15 time) T_{rb} of the pressing waveform element bk of
the drive signal Pk is set up to be larger than
the rising time (change time) T_{ra} of the
pressing waveform element b1 of the drive signal
P1. Thereby, the amount of the liquid drop
20 discharged by the drive signal Pk is smaller
than the amount of the liquid drop (small drop)
discharged by the drive signal P1.

Moreover, in this example, the falling
time (change time) T_{fb} of the drawing waveform
25 element ak of the drive signal Pk is set up to

be smaller than the falling time (change time) Vfa of the drawing waveform element a1 of the drive signal P1. Thereby, the drop discharge speed by the drive signal Pk is increased, and
5 it is possible to discharge a liquid drop from the nozzle certainly.

Discharge bending of the liquid drop discharged by the drive signal Pk may arise if a high frequency drive is performed, and the drive
10 signal Pk is not suitably used as a drive signal for discharging a liquid drop used for image formation.

In this embodiment, each of the first and second drive waveform contains the pressing
15 waveform element which discharges a liquid drop by shrinking the liquid chamber communicating with the nozzle of the liquid discharge head. The change time of the pressing waveform element of the drive signal included in the second drive
20 waveform to discharge the amount of liquid drop smaller than the minimum discharge drop amount used for image formation is larger than the change time of the pressing waveform element of the drive signal included in the first drive
25 waveform to discharge the amount of liquid drop

used for image formation, and the amount of liquid drop smaller than the minimum discharge drop amount used for image formation is discharged from the nozzle.

5 Moreover, in this embodiment, each of the first and second drive waveforms contains the drawing waveform element which expands the liquid chamber communicating with the nozzle of the liquid discharge head. The change time of
10 the drawing waveform element of the drive signal included in the second drive waveform to discharge the amount of liquid drop smaller than the minimum discharge drop amount used for image formation is smaller than the change time of the
15 drawing waveform element of the drive signal included in the first drive waveform to discharge the amount of liquid drop used for image formation. Thus, the discharge drop speed during idle discharge is increased, and it is
20 possible to discharge certainly the amount of liquid drop smaller than the minimum discharge drop amount used for image formation.

 Moreover, in the example of FIG. 9B, the falling time T_{fb} of the drive signal P_k may be
25 set up to be the same as the falling time T_{fa} of

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the drive signal P1 by modifying the slope of the drawing waveform element ak to be gentle as indicated by the dotted line in FIG. 9B. In such a case, the discharge drop speed and the drop discharge amount by the drive signal Pk are smaller than those of the liquid drop (the minimum discharge drop amount used for image formation) by the drive signal P1.

If the discharge drop speed of the amount of liquid drop smaller than the minimum discharge drop amount used for image formation is smaller than that of the liquid drop of the minimum discharge used for image formation, the liquid drop by idle discharge may not reach the recording sheet. However, the purpose of idle discharge is to perform maintenance and recovery of the nozzle by discharging a liquid drop therefrom. It is not necessary that the liquid drop by idle discharge reaches the recording sheet.

Next, the idle discharge control performed by the image forming device of this embodiment will be described with reference to the flowchart of FIG. 10.

Upon start of the idle discharge control

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of FIG. 10, it is determined whether the current dot (pixel) is located in a region where an image is formed (S11).

When the result of the determination at
5 step S11 is affirmative (located in the region where an image is formed), necessary drive signals P1-P5 are selected from the first drive waveform Pd of the drive waveforms based on the image data so that an image is formed on the
10 medium by discharging liquid drops (large, middle, small) from the recording head (S12).

When the result of the determination at
step S11 is negative (not located in the region where an image is formed), the second drive
15 waveform (drive signal) Pk of the drive waveforms is selected based on the control data (for idle discharge) so that an idle discharge operation is performed by discharging very small drops, smaller than the minimum drop used for
20 image formation, from the recording head (S13).

After the step S12 or S13 is performed, the following process will be performed by the image forming device of this embodiment.

In a case in which a roll sheet 35 shown
25 in FIG. 11 is used as a medium, a recording

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region 36 where an image is formed and a non-recording region 37 where any image is not formed alternately appear along a recording sheet transporting direction (sheet feed direction) as shown in FIG. 12. In this case, the liquid discharge head forms a necessary image on the medium for the recording region 36 by discharging the liquid drops (large, middle, small) thereto, and the liquid discharge head performs idle discharge for the non-recording region 37 by discharging very small drops from the nozzle. In this way, it is possible to create a printed matter on which an image is formed by the image forming device of this embodiment. In this case, the non-recording region 37 where any image is not formed corresponds to a region of the medium in which the medium is transported in a transport direction.

Moreover, in this case, when an idle discharge operation is performed for the non-recording region 37 where any image is not formed, the recording head 11 discharges the amount of liquid drop smaller than the minimum discharge drop amount used for image formation,

from all of the nozzles of the recording head 11,
over an entire image formable region of the
medium in the width direction of the medium.
This facilitates creation of the idle discharge
5 control data, and it is possible for this
embodiment to perform idle discharge operation
using a simple, inexpensive mechanism, without
degrading the image quality.

Moreover, in the case in which the roll
10 sheet 35 is used as a medium (also in a case in
which a sheet-like recording medium is used),
non-recording regions 38 where any image is not
formed appear in both end portions of the
recording region 36 in a width direction of the
15 medium perpendicular to a transporting direction
in which the medium is transported, as shown in
FIG. 13. In this case, the liquid discharge
head forms a necessary image on the medium for
the recording region 36 by discharging the
20 liquid drops (large, middle, small) thereto, and
the liquid discharge head performs idle
discharge for the non-recording region 38 by
discharging very small drops from the nozzle.

In this case, the region where any image
25 is not formed corresponds to the end portion of

the image formation region of the medium in a direction perpendicular to the transporting direction in which the medium is transported.

However, in a case of the image forming device using the full-line type recording head, the nozzles for which idle discharge operation may be performed are restricted if the non-recording region corresponds to the end portion of the recording region in the direction perpendicular to the transporting direction in which the medium is transported. In such a case, idle discharge is no longer performed for the nozzles of the full-line type recording head which are used for image formation. Thus, the image forming device of this embodiment is suitably applied to the serial type image forming device in which the recording head is moved in the width direction perpendicular to the transporting direction.

Moreover, the recording head in the image forming device of this embodiment may be arranged so that the recording region where an image is formed is set to an actual image region where the image is actually formed by discharging liquid drops based on the image data,

and the peripheral region, surrounding the actual image region 41, is set to a non-recording region 42 where any image is not formed, as shown in FIG. 14. The recording head
5 in this case may be arranged to perform idle discharge operation for the non-recording region 42 by discharging very small drops 43 thereto.

As described above, it is possible for the image forming device of this embodiment to
10 perform idle discharge operation using a simple, inexpensive mechanism.

Next, the drive waveform in another embodiment of the invention will be described with reference to FIG. 15.

15 In this embodiment, the drive waveform shown in FIG. 15 (a) is generated and outputted by the drive waveform generating part 401, and any of the drop control signals MN0-MN3 shown in FIG. 15 (b) (which are the same as the drop
20 control signals M0-M3 in the previous embodiment) is outputted by the data transfer part 402, so that a necessary drive signal is selected from the drive waveform by the head drive circuit 310 in response to the drop
25 control signal.

The drive waveform shown in FIG. 15 (a) includes, within a single drive cycle, a first discharge drive signal P11 for discharging a liquid drop used for image formation, a second discharge drive signal P12 for discharging the amount of liquid drop smaller than the minimum discharge drop amount used for image formation, a non-discharge drive signal P13 for finely oscillating the meniscus of the nozzle without discharging a liquid drop, and a first discharge drive signal P14 for discharging a liquid drop used for image formation, which drive signals are generated in time series. That is, the plurality of the first discharge drive signals P11 and P14 are generated in time series, and the second discharge drive signal P13 is interposed between the first discharge drive signals P11 and P14.

When the drive waveform of FIG. 15 (a) is used, the drive signal P13 is selected in response to the drop control signals MN0, the drive signal P11 is selected in response to the drop control signal MN1, the drive signals P11, P13, P14 are selected in response to the drop control signal MN2, and the drive signal P12 is

selected in response to the drop control signal MN3.

FIG. 16 shows the relationship between the drop control signals MN0-MN3 and the discharge drop amount when the selected drive signal is supplied to the energy generating unit of the recording head.

As shown in FIG. 16, when performing a fine drive, the drive signal P13 is selected in response to the drop control signal MN0. When discharging a small dot, the drive signal P11 is selected in response to the drop control signal MN1. When discharging a large drop, the drive signals P11, P13, P14 are selected in response to the drop control signal MN2. When performing idle discharge, the drive signal P12 is selected in response to the drop control signal MN3. The selected drive signal is supplied to the piezoelectric element 121 of the recording head 11, respectively.

As described above, the plurality of the first discharge drive signals are generated in time series, and the second discharge drive signal is interposed between two of the plurality of the first discharge drive signals.

Next, the drive waveform in another embodiment of the invention will be described with reference to FIG. 17.

In the previously described embodiment, the second discharge drive signal (Pk, P12) is not selected when performing image formation. However, in this embodiment, the second discharge drive signal is selected concurrently with the first discharge drive signal when performing image formation.

As shown in FIG. 17 (b) and FIG. 18, the drop control signal MN2 for discharging a large drop is arranged so that the second discharge drive signal P12 is also selected and the selected drive signal is supplied to the piezoelectric element 121 of the recording head 11.

Although a liquid drop is discharged by the second discharge drive signal P12 at this time, the speed of a liquid drop subsequently discharged by the first drop discharge drive signal P14 is larger than the speed of the drop by the second discharge drive signal P12. The two dots are united during flight and the influence is not so large. This may be

considered that the amount of a large drop discharged in response to the drop control signal MN2 includes the amount of liquid drop discharged by the second discharge drive signal
5 P12.

According to this embodiment, the setting of the drop control signal can be made simple, and it is not necessary to repeat switching ON and OFF of the drop control signal
10 MN2.

Next, another example of the second discharge drive signal will be described with reference to FIG. 19.

As shown in FIG. 19, the second
15 discharge drive signal Pk includes a drawing waveform element ak1 whose voltage falls from the reference voltage V_e by a voltage change V_{fa} to expand the liquid chamber 106 and draw the meniscus of the nozzle. After a predetermined
20 hold time, the drive signal Pk includes a pressing waveform element bk1 whose voltage rises by a voltage change V_{rc} to shrink the liquid chamber 106 and discharge a liquid drop from the nozzle. The drive signal Pk includes a
25 drawing waveform element ak2 whose voltage falls

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again to expand the pressurized liquid chamber
106 and tear off a part of the discharged liquid
drop so as to be returned to the nozzle. After
a predetermined hold time, the drive signal Pk
5 includes a pressing waveform element bk2 whose
voltage rises to return the liquid chamber 106
to the original state. Since the slope of this
pressing waveform element bk2 is made gentle, no
further liquid drop is discharged from the
10 nozzle.

Next, another embodiment of the
invention will be described with reference to
FIG. 9B.

In this embodiment, the drive waveform
15 generating part 401 is arranged so that a
discharge drop speed of the amount of liquid
drop smaller than the minimum discharge drop
amount used for image formation is slower than
that of the liquid drop of the minimum discharge
20 drop amount used for image formation.

As shown in the example of the drive
waveform of FIG. 9B, the drive waveform
generating part 401 is arranged so that the
falling time Tfb of the second discharge drive
25 signal Pk is modified to be equal to the falling

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time Tfa of the first discharge drive signal P1. Specifically, the slope of the drawing waveform element ak is made gentle as indicated by the dotted line in FIG. 9B. Thereby, the discharge drop speed by the drive signal Pk is made slower while the discharge drop amount of the liquid drop discharged by the drive signal Pk is smaller than the minimum discharge drop amount used for image formation discharged by the drive signal P1.

If the discharge drop speed of the amount of liquid drop smaller than the minimum discharge drop amount used for image formation is smaller than that of the liquid drop of the minimum discharge used for image formation, the liquid drop by idle discharge may not reach the recording sheet. However, the purpose of idle discharge is to perform maintenance and recovery of the nozzle by discharging a liquid drop therefrom. It is not necessary that the liquid drop by idle discharge reaches the recording sheet.

According to this embodiment, the recording head is caused to discharge the amount of liquid drop smaller than the minimum

discharge drop amount used for image formation, at a slow drop speed, when performing idle discharge operation, and it is possible to avoid staining the recording sheet.

5 Next, another embodiment of the invention will be described with reference to FIG. 20. FIG. 20 shows the composition of an image forming device in an embodiment of the invention.

10 In this embodiment, an electrode 500 is disposed in a vicinity of the side of the recording head 1, and a voltage applying unit 501 is arranged to apply a charging voltage for charging the electrode 500 to the electrode 500.

15 When idle discharge operation is performed in this embodiment, the electrode 500 is charged by the voltage applying unit 501. The electrode 500 has a length equivalent to the length of the nozzle row of the recording head 1 in the

20 longitudinal direction.

 When the amount of liquid drop smaller than the minimum discharge drop amount used for image formation is discharged without reaching the medium, or when idle discharge is performed,

25 the liquid drops generated by the idle discharge

operation float as in the previously described embodiment. If a transporting unit which is charged to perform electrostatic attraction of a recording sheet is used as the transporting belt 25, the liquid drops outputted by the recording head 1 are electrostatically charged by the charge of the transporting belt 25. In this case, the voltage applying unit 501 applies the charging voltage to the electrode 500 for charging the electrode 500 in the polarity opposite to the polarity of the charge of the liquid drops, so that the liquid drops are attracted by the charged electrode 500, and it is possible for the present embodiment to prevent scattering of the liquid drops.

Next, another embodiment of the invention will be described with reference to FIG. 21. FIG. 21 shows the composition of an image forming device in an embodiment of the invention.

In this embodiment, a suction passage 510 which has an opening to the recording head 1 is arranged in a vicinity of the side of the recording head 1, and a suction pump (suction unit) 511 is arranged to attract liquid drops

through the suction passage 510. When idle discharge operation is performed, the suction pump 511 is operated to attract the liquid drops generated by the idle discharge operation. When
5 idle discharge is performed, the liquid drops generated by the idle discharge operation float as in the previously described embodiment. It is possible for the present embodiment to prevent the scattering of the liquid drops by
10 driving the suction pump 511 to attract the liquid drops through the suction passage 510. The opening of the suction passage 510 has a length equivalent to the length of the nozzle row of the recording head 1 in the longitudinal
15 direction.

In the above-mentioned embodiments, the case in which the present invention is applied to the image forming device having the printer configuration has been described. Alternatively,
20 the present invention may be applied to any of image forming devices, including a fax, a copier, and a multi-function peripheral. The present invention may be applied also to an image forming device which uses a liquid other than
25 the printing ink.

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The present invention is not limited to the above-described embodiments, and variations and modifications may be made without departing from the scope of the present invention.

5 The present application is based on and claims the benefit of priority of Japanese patent application No. 2006-316381, filed on November 23, 2006, and Japanese patent application No. 2007-216336, filed on August 22,
10 2007, the entire contents of which are hereby incorporated by reference.

CLAIMS

1. An image forming device which forms
an image on a medium and includes a liquid
5 discharge head in which a plurality of nozzles
for discharging liquid drops are arranged side
by side, comprising:

a drive waveform generating unit
generating, within a single drive cycle, a first
10 drive waveform containing a drive signal to
discharge an amount of liquid drop used for
image formation, and a second drive waveform
containing a drive signal to discharge an amount
of liquid drop smaller than a minimum discharge
15 drop amount used for image formation; and

a head control unit causing the liquid
discharge head to discharge the amount of liquid
drop used for image formation in accordance with
the first drive waveform for a region where an
20 image is formed, and causing the liquid
discharge head to discharge the amount of liquid
drop smaller than the minimum discharge drop
amount in accordance with the second drive
waveform for a region where any image is not
25 formed.

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2. The image forming device according to claim 1, wherein the region where any image is not formed corresponds to a region of the medium in which the medium is transported in a transport direction.

3. The image forming device according to claim 1, wherein the region where any image is not formed corresponds to an end portion of the image-formation region of the medium in a direction perpendicular to a transporting direction in which the medium is transported.

4. The image forming device according to claim 1, wherein each of the drive signal in the first drive waveform and the drive signal in the second drive waveform contains a pressing waveform element which makes a liquid drop discharge by shrinking a liquid chamber communicating with one of the plurality of nozzles of the liquid discharge head, and a voltage change of the pressing waveform element of the drive signal in the second drive waveform is smaller than a voltage change of the pressing waveform element of the drive signal in the

first drive waveform.

5 5. The image forming device according to
claim 1, wherein each of the drive signal in the
first drive waveform and the drive signal in the
second drive waveform contains a pressing
waveform element which makes a liquid drop
discharge by shrinking a liquid chamber
communicating with one of the plurality of
10 nozzles of the liquid discharge head, and a
change time of the pressing waveform element of
the drive signal in the second drive waveform is
longer than a change time of the pressing
waveform element of the drive signal in the
15 first drive waveform.

20 6. The image forming device according to
claim 1, wherein each of the drive signal in the
first drive waveform and the drive signal in the
second drive waveform contains a drawing
waveform element which causes a liquid chamber
communicating with one of the plurality of
nozzles of the liquid discharge head to expand,
and a voltage change of the drawing waveform
25 element of the drive signal in the second drive

waveform is larger than a voltage change of the drawing waveform element of the drive signal in the first drive waveform.

5 7. The image forming device according to claim 1, wherein each of the drive signal in the first drive waveform and the drive signal in the second drive waveform contains a drawing
10 waveform element which causes a liquid chamber communicating with one of the plurality of nozzles of the liquid discharge head to expand, and a change time of the drawing waveform element of the drive signal in the second drive waveform is shorter than a change time of the
15 drawing waveform element of the drive signal in the first drive waveform.

8. The image forming device according to claim 1, wherein the liquid discharge head is a
20 full-line type recording head.

9. The image forming device according to claim 1, wherein the medium is a rolled-form medium.

10. The image forming device according to claim 1, wherein the image forming device is arranged so that when an idle discharge operation is performed to discharge liquid drops which do not contribute to image formation, the liquid discharge head discharges, over an entire image formable region of the medium in a width direction of the medium, the amount of liquid drop smaller than the minimum discharge drop amount.

11. A printed matter on which an image is formed by the image forming device of claim 1 through discharging of liquid drops to the medium.

12. An image forming device which forms an image on a medium and includes a liquid discharge head in which a plurality of nozzles for discharging liquid drop are arranged side by side, comprising:

a drive waveform generating unit generating, within a single drive cycle, a first drive waveform containing a first drive signal to discharge an amount of liquid drop used for

image formation, and a second drive waveform
containing a second drive signal to discharge an
amount of liquid drop smaller than a minimum
discharge drop amount used for image formation;
5 and

a selecting unit selecting at least one
of the first drive signal in the first drive
waveform and the second drive signal in the
second drive waveform in response to a control
10 signal, to output the selected drive signal to
the liquid discharge head.

13. The image forming device according
to claim 12, wherein the drive waveform
15 generating unit is arranged to generate a
plurality of the first drive signals in time
series, and the second drive signal being
interposed between two of the plurality of the
first drive signals.

20

14. The image forming device according
to claim 12, wherein the selecting unit is
arranged to select the second drive signal
concurrently with the first drive signal when
25 forming an image.

15. The image forming device according
to claim 12, wherein the drive waveform
generating unit is arranged to generate the
5 second drive waveform having a waveform element
adapted to tear off a part of a liquid drop
discharged from the liquid discharge head.

16. The image forming device according
10 to claim 12, wherein the drive waveform
generating unit is arranged so that a discharge
drop speed of the amount of liquid drop smaller
than the minimum discharge drop amount used for
image formation is slower than a discharge drop
15 speed of the minimum discharge drop amount used
for image formation.