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

(72) Inventor: **Kobayashi, Ryohei**
Tokyo, 100-7015 (JP)

(74) Representative: **Henkel, Breuer & Partner**
Patentanwälte
Maximiliansplatz 21
80333 München (DE)

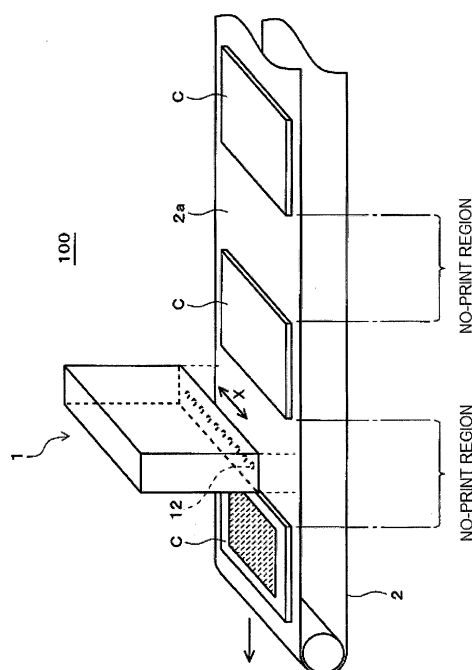
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(54) **Liquid droplet ejection apparatus and method for recovering nozzle of liquid droplet ejection apparatus**

(57) Sedimentation of solid particles in an ink is affectively eliminated, and liquid droplets can be stably ejected for a long time.

There is provided a liquid droplet ejection apparatus including: a head 1 that includes an ink chamber, a nozzle 12 provided in accordance with the ink chamber, and an energy giving device that gives energy to the ink in the ink chamber, the head performing printing on a print region of a recording medium C by ejecting liquid droplets from the nozzle 12; and a drive pulse generating device for generating, as the drive pulse, an ejection pulse that is used for ejecting the liquid droplets from the nozzle 12 and a micro-vibration pulse that micro-vibrates the ink in the ink chamber so as not to eject the liquid droplets from the nozzle 12, wherein the ink contains a dispersion medium and solid particles having higher specific gravity than that of a dispersion medium, and the liquid droplet ejection apparatus includes a refresh device for performing a micro-vibration operation for applying the plurality of micro-vibration pulses when the head is present in a non-print region, and an ejection operation for applying the plurality of rejection pulses after the micro-vibration operation and ejecting a liquid droplet amount equal to or greater than a capacity of the ink chamber from the nozzle 12.

FIG. 1



Description

Technical Field

[0001] The present invention relates to a liquid droplet ejection apparatus and a method for recovering a nozzle of the liquid droplet ejection apparatus, and more particularly to a liquid droplet ejection apparatus that can suppress sedimentation of solid particles contained in an ink and stably eject liquid droplets for a long time and a method for recovering a nozzle of the liquid droplet ejection apparatus.

Background

[0002] A liquid droplet ejection apparatus that performs printing by ejecting liquid droplets from a head is generally used for various industrial purposes as an inkjet printer. Applications of this industrial inkjet increases year by year, and the inkjet printer is used for not only performing printing on paper sheets, fabric, plastic sheets, and others but also performing printing a design on a surface of a ceramic tile in recent years. Accordingly, performance that enables stably ejecting various kinds of inks for a long time has been demanded with respect to the liquid droplet ejection apparatus.

[0003] However, in case of performing printing by using as an ink a ceramic ink containing solid particles of ceramics or a white ink containing solid particles of a titanium oxide or the like as a pigment and ejecting liquid droplets from a head, sedimentation of the solid particles in the ink occurs in an ink chamber when print data is not present or the head is present in a non-print region where the head does not perform printing. That is because these solid particles have specific gravity higher than that of dispersion medium in the ink. When the sedimentation of the solid particles occurs in the ink chamber, density of the solid particle near the nozzle rises, and nozzle clogging may be possibly caused. Further, when the solid particles having the high density are solidified, ejection cannot be performed on a permanent basis.

[0004] Even if the nozzle is arranged sideways, since a concentration distribution is produced in the ink in the ink chamber due to the sedimentation of the solid particles, the solid particles in liquid droplets do not have adequate concentration even though the liquid droplets were successfully ejected, and irregularity of an ejection rate or non-uniformity of images may occur.

[0005] According to the prior art, to reduce sedimentation of solid matters such as a pigment in an ink, a technology that circulates the ink by using a pressure difference between a head and an ink tank has been suggested (Patent Document 1). However, the ink on the ink side that is circulated by this technology is an ink in a common ink chamber that exclusively supplies the ink to respective ink chambers in common, and the ink supplied to the respective ink chamber cannot be circulated. Therefore, at a print pause time, the sedimentation of the

solid particles that occurs in the ink chambers cannot be suppressed.

[0006] As a countermeasure for nozzle clogging during the printing pause, there has been known a technology that applies a preliminary waveform to each ink chamber to vibrate a meniscus immediately before restarting ejection and allows the ink in the ink chambers to flow (Patent Document 2). However, this technology eliminates the nozzle clogging by an increase in viscosity based on evaporation of a volatile component in the ink. The flow of the ink caused by such meniscus vibration is very small, and hence the increase in viscosity is effective for elimination of the nozzle clogging, but just finely vibrating the meniscus cannot sufficiently eliminate a sedimentation state of the solid particles that has advanced to some extent in the ink chambers.

[0007] Furthermore, there has been also known detecting viscosity of an ink and adjusting intensity of micro-vibration and an amount of liquid droplets at the time of discharging an ink (Patent Document 3). However, this technology prevents nozzle clogging caused due to evaporation of a liquid and an increase in viscosity of the ink, and does not solve a problem caused by the sedimentation of the solid particles contained in the ink.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0008]

Patent Document 1: JP-A-2011-506152

Patent Document 2: JP-A-2000-203020

Patent Document 3: JP-A-2012-96423

SAMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0009] Therefore, it is an object of the present invention to provide a liquid droplet ejection apparatus that can effectively eliminate the sedimentation of solid particles contained in an ink and stably eject liquid droplets for a long time.

[0010] Further, it is another object of the present invention to provide a method for recovering a nozzle of a liquid droplet ejection apparatus that can effectively eliminate the sedimentation of solid particles contained in an ink and stably eject liquid droplets for a long time.

[0011] Furthermore, other objects of the present invention will become obvious from the following description.

MEANS FOR SOLVING PROBLEM

[0012]

1. A liquid droplet ejection apparatus comprising:

a head that includes an ink chamber into which an ink is supplied, a nozzle provided in accordance with the ink chamber, and an energy giving device that drives when a drive pulse is applied thereto and gives energy to the ink in the ink chamber, the head performing printing on a print region of a recording medium based on print data by ejecting liquid droplets from the nozzle; and a drive pulse generation device that generates, as the drive pulse, an ejection pulse that is used for ejecting the liquid droplets from the nozzle and a micro-vibration pulse that micro-vibrates the ink in the ink chamber so as not to eject the liquid droplets from the nozzle, wherein the ink contains a dispersion medium and solid particles having higher specific gravity than that of a dispersion medium, and the liquid droplet ejection apparatus comprises a refresh device that performs a micro-vibration operation for applying the plurality of micro-vibration pulses to the energy giving device and an ejection operation for applying the plurality of ejection pulses to the energy giving device after the micro-vibration operation and ejecting a liquid droplet amount equal to or greater than a capacity of the ink chamber from the nozzle, when the head is present in a non-print region where the printing is not performed.

2. The liquid droplet ejection apparatus according to 1, comprising a liquid droplet speed detection device that detects a speed of the liquid droplets ejected from the nozzle when the head is present in the non-print region where printing is not performed, wherein the refresh device is executed after detecting that a detection result of the liquid droplet speed detection device falls below a preset threshold value.
3. The liquid droplet ejection apparatus according to 1, comprising a pause period detection device that detects a period during which ejection of the liquid droplets from the nozzle pauses when the head is present in the print region where the printing is carried out, wherein the refresh device is executed after detecting that a detection result of the pause period detection device exceeds a preset threshold value.
4. A liquid droplet ejection apparatus comprising:

a head that includes an ink chamber into which an ink is supplied, a nozzle provided in accordance with the ink chamber, and an energy giving device that drives when a drive pulse is applied thereto and gives energy to the ink in the ink chamber, the head performing printing on a print-region of a recording medium based on print data by ejecting liquid droplets from the nozzle; and a drive pulse generation device that generates,

as the drive pulse, an ejection pulse that is used for ejecting the liquid droplets from the nozzle and a micro-vibration pulse that micro-vibrates the ink in the ink chamber so as not to eject the liquid droplets from the nozzle, wherein the ink contains a dispersion medium and solid particles having higher specific gravity than that of a dispersion medium, and the liquid droplet ejection apparatus comprises:

a micro-vibration device that exclusively performs a micro-vibration operation for applying the plurality of micro-vibration pulses to the energy giving device;
a refresh device that performs the micro-vibration operation for applying the plurality of micro-vibration pulses to the energy giving device and an ejection operation for applying the plurality of ejection pulses to the energy giving device after the micro-vibration operation and ejecting a liquid droplet amount equal to or greater than a capacity of the ink chamber from the nozzle; and
a selection device that selects and executes one of the micro-vibration device and the refresh device when the head is present in the non-print region where printing is not performed.

5. The liquid droplet ejection apparatus according to 4, comprising a liquid droplet speed detection device that detects a speed of the liquid droplets ejected from the nozzle when the head is present in the non-print region where the printing is not performed, wherein the selection device selects and executes one of the micro-vibration device and the refresh device in accordance with a detection result of the liquid droplet speed detection device after detecting that the detection result falls below a preset threshold value.
6. The liquid droplet ejection apparatus according to 4, comprising a pause period detection device that detects a period during which ejection of the liquid droplets from the nozzle pauses when the head is present in the print region where the printing is performed, wherein the selection device selects and executes one of the micro-vibration device and the refresh device in accordance with a detection result of the pause period detection device after detecting that the detection result exceeds a preset threshold value.
7. The liquid droplet ejection apparatus according to any one of 1 to 6, wherein, in the micro-vibration operation, an application frequency is raised as specific gravity of the solid particles relative to the dispersion medium increases in accordance with the specific gravity.

8. The liquid droplet ejection apparatus according to any one of 1 to 7, comprising:

an ink tank that stores the ink that is supplied to the head; and
a circulation device that circulates the ink between the head and the ink tank,
wherein the circulation device circulates the ink during a period that at least the refresh device is executed.

9. The liquid droplet ejection apparatus according to any one of 1 to 8, comprising a nozzle maintenance device that executes at least one of a wiping operation for wiping off stains on a nozzle surface in which the nozzle is opened and a removing operation for removing the ink on the nozzle surface when the head is present in the non-print region where the printing is not performed,

wherein both the micro-vibration device and the refresh device are not executed during a period that the nozzle maintenance device is executed.

10. The liquid droplet ejection apparatus according to any one of 1 to 9,

wherein a specific gravity difference between the dispersion medium and the solid particles in the ink is 0.2 or more.

11. The liquid droplet ejection apparatus according to any one of 1 to 10,

wherein the ink does not volatilize from the nozzle by drying.

12. A method for recovering a nozzle of a liquid droplet ejection apparatus comprising:

a head that includes an ink chamber into which an ink is supplied, a nozzle provided in accordance with the ink chamber, and an energy giving device that drives when a drive pulse is applied thereto and gives energy to the ink in the ink chamber, the head performing printing on a print-region of a recording medium based on print data by ejecting liquid droplets from the nozzle; and

a drive pulse generation device that generates, as the drive pulse, an ejection pulse that is used for ejecting the liquid droplets from the nozzle and a micro-vibration pulse that micro-vibrates the ink in the ink chamber so as not to eject the liquid droplets from the nozzle,

wherein the ink contains a dispersion medium and solid particles having higher specific gravity than that of a dispersion medium, and the method comprises a refresh process that performs a micro-vibration operation for applying the plurality of micro-vibration pulses to the energy giving device and an ejection operation for applying the plurality of ejection pulses to the energy giving device after the micro-vibration

operation and ejecting a liquid droplet amount equal to or greater than a capacity of the ink chamber from the nozzle, when the head is present in a non-print region where printing is not performed.

13. The method for recovering a nozzle of a liquid droplet ejection apparatus according to 12, comprising a liquid droplet speed detection process that detects a speed of the liquid droplets ejected from the nozzle when the head is present in the non-print region where printing is not performed, wherein the refresh process is executed after detecting that a detection result of the liquid droplet speed detection process falls below a preset threshold value.

14. The method for recovering a nozzle of a liquid droplet ejection apparatus according to 12, comprising a pause period detection process that detects a period during which ejection of the liquid droplets from the nozzle pauses when the head is present in the print region where the printing is carried out, wherein the refresh process is executed after detecting that a detection result of the pause period detection process exceeds a preset threshold value.

15. A method for recovering a nozzle of a liquid droplet ejection apparatus comprising:

a head that includes an ink chamber into which an ink is supplied, a nozzle provided in accordance with the ink chamber, and an energy giving device that drives when a drive pulse is applied thereto and gives energy to the ink in the ink chamber, the head performing printing on a print region of a recording medium based on print data by ejecting liquid droplets from the nozzle; and a drive pulse generation device that generates, as the drive pulse, an ejection pulse that is used for ejecting the liquid droplets from the nozzle and a micro-vibration pulse that micro-vibrates the ink in the ink chamber so as not to eject the liquid droplets from the nozzle, wherein the ink contains a dispersion medium and solid particles having higher specific gravity than that of a dispersion medium, and the method for recovering a nozzle comprises:

a micro-vibration process that exclusively performs a micro-vibration operation for applying the plurality of micro-vibration pulses to the energy giving device; and a refresh process that performs the micro-vibration operation for applying the plurality of micro-vibration pulses to the energy giving device and an ejection operation for applying the plurality of ejection pulses to the energy giving device after the micro-vibration operation and ejecting a liquid droplet

amount equal to or greater than a capacity of the ink chamber from the nozzle, one of the micro-vibration process or the refresh process is selected and executed when the head is present in the non-print region where printing is not performed.

16. The method for recovering a nozzle of a liquid droplet ejection apparatus according to 15, comprising a liquid droplet speed detection process that detects a speed of liquid droplets ejected from the nozzle when the head is present in the non-print region where the printing is not performed, wherein one of the micro-vibration process and the refresh process is selected and executed in accordance with a detection result of the liquid droplet speed detection process after detecting that the detection result falls below a preset threshold value.

17. The method for recovering a nozzle of a liquid droplet ejection apparatus according to 15, comprising a pause period detection process that detects a period during which ejection of the liquid droplets from the nozzle pauses when the head is present in the print region where the printing is performed, wherein one of the micro-vibration process and the refresh process is selected and executed in accordance with a detection result of the pause period detection process after detecting that the detection result exceeds a preset threshold value.

18. The method for recovering a nozzle of a liquid droplet ejection apparatus according to any one of 12 to 17,

wherein, in the micro-vibration operation, an application frequency is raised as specific gravity of the solid particles relative to the dispersion medium increases in accordance with the specific gravity.

19. The method for recovering a nozzle of a liquid droplet ejection apparatus according to any one of 12 to 18, comprising an ink tank that stores the ink that is supplied to the head,

wherein the ink is circulated between the head and the ink tank during a period that at least the refresh process is executed.

20. The method for recovering a nozzle of a liquid droplet ejection apparatus according to any one of 12 to 19, comprising a nozzle maintenance process that executes at least one of a wiping process for wiping off stains on a nozzle surface in which the nozzle is opened and a removing process for removing the ink on the nozzle surface when the head is present in the non-print region where the printing is not performed,

wherein both the micro-vibration process and the refresh process are not executed during a period that the nozzle maintenance process is executed.

21. The method for recovering a nozzle of a liquid droplet ejection apparatus according to any one of 12 to 20,

wherein a specific gravity difference between the dispersion medium and the solid particles in the ink is 0.2 or more.

22. The method for recovering a nozzle of a liquid droplet ejection apparatus according to any of 12 to 21, wherein the ink does not volatilize from the nozzle by drying.

10 EFFECT OF THE INVENTION

[0013] According to the present invention, it is possible to provide the liquid droplet ejection apparatus that can effectively eliminate the sedimentation of solid particles contained in an ink and stably eject liquid droplets for a long time.

[0014] Moreover, according to the present invention, it is possible to provide the method for recovering a nozzle of a liquid droplet ejection apparatus that can effectively eliminate the sedimentation of solid particles contained in an ink and stably eject liquid droplets for a long time.

Brief Description of Drawings

25 [0015]

FIG. 1 is a perspective view showing an example of a line type liquid droplet ejection apparatus;

FIG. 2 is a cross-sectional view of a head in the liquid droplet ejection apparatus;

FIG. 3 is a block diagram showing an outline configuration of the liquid droplet ejection apparatus;

FIG. 4(a) is a view showing an example of an ejection pulse and FIG. 4(b) is a view showing an example of a micro-vibration pulse;

FIG. 5 is a view for explaining a capacity of an ink chamber;

FIG. 6 is a view showing an application pattern of the micro-vibration pulse and the ejection pulse at the time of refresh;

FIG. 7 is a view for explaining an example of detecting means for detecting a sedimentation state of solid particles;

FIG. 8 is a view showing an example of a flow for detecting a speed of liquid droplets by a liquid droplet speed detection apparatus prior to refresh;

FIG. 9 is a view showing an example of a flow for detecting an ejection pause period of liquid droplets prior to refresh;

FIGS. 10(a) and (b) are views showing examples of an application pattern of the micro-vibration pulse in case of performing a micro-vibration operation alone, respectively;

FIG. 11 is a view showing an example of a flow of selecting the micro-vibration operation and the refresh by using a detection result of the liquid droplet speed detection apparatus as a trigger;

FIG. 12 is a view showing an example of a flow for

selecting the micro-vibration operation and the refresh by using a detection result of a liquid droplet ejection pause period as a trigger;

FIG. 13 is a view showing an example of a table specifying a relationship between a ratio of specific gravity difference of solid particles relative to specific gravity of a dispersion medium and a micro-vibration pulse applying frequency;

FIG. 14 is a view for explaining an example of a structure that enables an ink to circulate; and

FIG. 15 is an exterior view showing an example of a scan type liquid droplet ejection apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] An embodiment according to the present invention will now be described hereinafter in detail.

[0017] FIG. 1 is a perspective view showing an example of a liquid droplet ejection apparatus, and FIG. 2 is a cross-sectional view showing an example of a head. In the drawings, reference numeral 100 denotes a liquid droplets ejection apparatus; 1, a head; and 2, a conveyance belt.

[0018] In the liquid droplet ejection apparatus 100, ceramic tiles C as recording mediums are mounted at intervals on a conveyance surface 2a of a conveyance belt 2 that is driven to rotate in one direction, and they are conveyed in an arrow direction in the drawing. In the head 1, a plurality of nozzles 12 are aligned along an X direction in the drawing parallel to a width direction of the conveyance belt 2, and nozzle surfaces are arranged to be vertically downward directed so that they face the conveyance surface 2a. Further, a ceramic ink containing, e.g., ceramic particles having specific gravity higher than that of dispersion medium is ejected as solid particles from the respective nozzles 12 to a print region on a front surface of each ceramic tile C that is conveyed at a fixed speed by the conveyance belt 2 based on print data, thereby forming a predetermined image.

[0019] In the head 1, as shown in FIG. 2, a plurality of ink chambers 11 are aligned along the X direction. Here, although an example where 20 ink chambers 11 are aligned in line along the X direction is shown, the number of the ink chambers 11 and the number of columns are out of the question. In this head 1, all the ink chambers 11 are ink chambers that can eject liquid droplets from the nozzles 12 provided in accordance with the respective ink chambers 11 when the ink in a common ink chamber 13 provided to communicate with the respective ink chambers 11 is supplied thereto.

[0020] In this head 1, each partition wall 14 that separates the neighboring ink chambers 11, 11 from each other is formed of a piezoelectric element. Drive electrodes (not shown) are formed on surfaces of the partition walls 14 facing the inside of the ink chambers 11. In the head 1, when a drive pulse of a predetermined voltage is applied to each drive electrode from a later-described head driver, each partition wall 14 deforms, and a capac-

ity of each ink chamber 11 changes. When this change in capacity increases to eject the ink in each ink chamber 11 from each nozzle 12 formed on a nozzle plate 15, ejection energy is given to the ink in each ink chamber 11, and liquid droplets are ejected from each nozzle 12. It is to be noted that, in this head 1, the partition walls 14 having the drive electrodes formed thereon constitute energy giving means for giving the ink in the ink chambers 11 the energy.

[0021] Here, the ink to be used in the present invention contains dispersion medium as well as solid particles having higher specific gravity than that of the dispersion medium. The dispersion medium is out of the question. As the solid particles, there are ceramic particles in the ceramic ink, pigment particles of a titanium oxide, and others.

[0022] When a specific gravity difference of the solid particles relative to the dispersion medium is high, a sedimentation speed increases, the solid particles are apt to settle out in the ink chambers, and a problem of the present invention becomes prominent. It is preferable for the specific gravity difference between the dispersion medium and the solid particles in the present invention to be 0.2 or more since an effect of the present invention can be considerably provided, which is preferable.

[0023] In the present invention, the ink that does not volatilize by drying at an ordinary temperature under an ordinary pressure is used. Here, "the ink that does not volatilize" means an ink in which the content of a material, whose steam pressure at an ordinary temperature is higher than that of water, is 10% or less or preferably 5% or less. Such an ink does not have a problem of an increase in viscosity due to evaporation of a volatile component that can be observed when a volatile ink such as an aqueous ink is used at the time of use. As such an ink, for example, there are a UV ink, an oil ink, and others.

[0024] FIG. 3 is a block diagram showing an outline configuration of the inside of the liquid droplet ejection apparatus 100.

[0025] Reference numeral 101 denotes a CPU that controls the entire liquid droplet ejection apparatus 100; 102, a print data memory that stores print data to be formed in a print region on the surface of each ceramic tile C; 103, an encoder that detects a moving length of the conveyance belt 2; 104, a belt conveyance motor that drives the conveyance belt 2 to rotate; 105, a head driver that gives a pulse to the drive electrodes of the head 1 to deform the partition walls 14; 106, a drive pulse generation unit that is provided in the head driver 105 and generates a drive pulse as a drive signal to be supplied to the head 1; 107, a micro-vibration control unit that is provided in the CPU 101 and controls a micro-vibration operation for micro-vibrating the ink in the ink chambers 11; and 108, an ejection control unit that is provided in the CPU 101 and controls an ejection operation of ejecting the ink in the ink chambers 11.

[0026] When the head 1 is present in a non-print region where printing based on print data is not performed, the

micro-vibration control unit 107 controls drive of the head 1 through the head driver 105 so as to perform a micro-vibration operation for micro-vibrating the ink in the ink chambers 11 and providing the solid particles with kinetic energy to facilitate dispersion. In the present invention, this micro-vibration control unit 107 constitutes micro-vibrating means.

[0027] When the head 1 is present in a non-print region where printing based on print data is not performed, the ejection control unit 108 controls drive of the head 1 through the head driver 105 so as to perform an ejection operation for forcibly ejecting the ink in the ink chambers 11 and replacing the ink in the ink chambers 11 with a new ink. In the present invention, the micro-vibration control unit 107 and the ejection control unit 108 constitute refreshing means.

[0028] A pulse generated by the drive pulse generating unit 106 includes an ejection pulse P1 for ejecting liquid droplets from the nozzles 12 like an example shown in FIG. 4 (a) and a micro-vibration pulse P2 for micro-vibrating the ink in the ink chambers 11 so as not to eject liquid droplets from the nozzles 12 like an example shown in FIG. 4(b). The drive pulse generating unit 106 selects one of these drive pulses in accordance with an instruction from the CPU 101 and applies the drive pulse to the drive electrodes formed on the partition walls 104 of the head 1.

[0029] In case of ejecting the ink containing the solid particles having higher specific gravity than that of the dispersion medium from the nozzles 12 in accordance with print data, sedimentation of the solid particles may possibly cause an ejection failure such as nozzle clogging if a period during which ejection from the nozzle 12 pauses when the head 1 is in the print region or a small period during which ejection pauses when the head 1 is in the non-print region has been passed. Thus, in the present invention, when the head 1 is in this non-print region, refresh for ejecting liquid droplets from the respective nozzles 12 to eject the ink is performed under control of the CPU 101, thereby stabilizing the ejection.

[0030] It is to be noted that, in the present invention, as different from the print region where the liquid droplets are ejected from the nozzles 12 based on print data and printing is carried out with respect to a recording medium, the non-print region is a region which deviates from the recording medium has no print data and in which printing based on this print data is not performed. As seen from the head 1, print regions and non-print regions alternately fed. In this liquid droplet ejection apparatus 100, a space between the ceramic tiles C, C continuously mounted on the conveyance surface 2a at an interval is the non-print region where printing based on print data is not carried out. Arrival of the head 1 at the non-print region is detected by a moving length of the conveyance belt 2 detected by the encoder 103.

[0031] The refresh of the head 1 executed by the CPU 101 is performed by the micro-vibration operation under control of the micro-vibration control unit 107 and the

ejection operation performed after this micro-vibration operation under control of the ejection control unit 108. That is, when the head 1 is present in the non-print region during a period from passage of one ceramic tile C through a position immediately below the head 1 to arrival of the subsequent ceramic tile C at the position immediately below the head 1, the refresh is constituted of the micro-vibration operation for applying the plurality of micro-vibration pulses P2 to the drive electrodes of the partition walls 14 and micro-vibrating the ink in the ink chambers 11 so as not to eject the liquid droplets from the nozzles 12 under control of the micro-vibration control unit 107 and the ejection operation for applying the plurality of ejection pulses P1 to the drive electrodes of the partition walls 14 after effecting the micro-vibration operation and ejects the liquid droplets from the nozzles 12 to provide a liquid droplet amount that is equal to or above the capacity of the ink chamber 11 under control of the ejection control unit 108.

[0032] The capacity of the ink chamber 11 means a capacity of an ink channel between a boundary relative to the common ink chamber 13 and an end opening portion of each nozzle 12. Therefore, this capacity does not include a capacity in the common ink chamber 13. In the head 1 according to this embodiment, as shown in FIG. 5, this capacity is a capacity of a space with a distance D that serves as an ink channel from an opening portion 11a of the ink chamber 11 that is a boundary relative to the common ink chamber 13 between both the partition walls 14 defining each ink chamber 11 to an end opening portion 12a of the nozzle 12 that is opened in a surface (a nozzle surface) of the nozzle plate 15.

[0033] Since a liquid droplet volume of droplet ejected by one ejection pulse P1 is known in advance, the liquid droplet amount that is equal to or greater than the capacity of the ink chamber 11 can be defined by the total number of times of applying the ejection pulses P1.

[0034] When the refresh is performed while the head 1 is present in the non-print region, a total amount of the ink stored in the ink chambers 11 is forcibly ejected from the nozzles 12. Therefore, even if sedimentation of the solid particles advances in the ink chambers 11, all of the ink in the ink chambers 11 is replaced with an ink newly supplied from the common ink chamber 13, and the solid particles do not keep settling out in the ink chambers 11. As a result, concentration of the solid particles in the ink in the ink chambers 11 can be maintained constant, occurrence of nozzle clogging is suppressed, and stable ejection can be performed for a long time.

[0035] Further, in the refresh, not only simple ejection of the liquid droplets is performed, but also the ink in the ink chambers 11 is micro-vibrated before ejecting the liquid droplets, the solid particles is provided with kinetic energy, and hence the settled and aggregated solid particles in the ink before ejection are apt to be dispersed, thereby smoothly discharging the ink from the nozzles 12 by the energy given at the time of subsequent ejection. Therefore, the settled solid particles do not remain in the

ink chambers 11, and a total amount of the ink in the ink chambers 11 can be efficiently replaced. When ejection of the liquid droplets alone is performed without micro-vibrating the ink in a state that the sedimentation of the solid particles has advanced, the solid particles settled out in the ink chambers 11 cannot be smoothly discharged from the nozzles 12, and the solid particles might remain, or nozzle clogging might possibly occur by the aggregated solid particles.

[0036] Fig. 6 shows an example of an application pattern of the ejection pulse P1 and the micro-vibration pulse P2 at the time of performing the refresh. Here, when the head 1 enters the non-print region, a micro-vibration pulse applying operation for continuously applying the plurality of micro-vibration pulses P2 is first continued for a predetermined time t1, and then an ejection pulse applying operation for continuously applying the plurality of ejection pulses P1 is continued for a predetermined time t2. Furthermore, the micro-vibration pulse applying operation of the time t1 and the ejection pulse applying operation of the time t2 are continuously alternately repeated three times.

[0037] To equalize a liquid droplet amount ejected from the nozzles 12 with an amount that is equal to or higher than the capacity of each ink chamber in one non-print region, as shown in FIG. 6, in case of performing the ejection pulse applying operation in one segment that is the time t2 more than once in one non-print region, the liquid droplets can be ejected so that a total liquid droplet amount of the liquid droplets ejected by the ejection pulse applying operation performed more than once can be a liquid droplet amount equal to or above the capacity of the ink chamber 11. According to this configuration, since the ink containing the solid particles settled out in each ink chamber 11 is ejected little by little while being dispersed little by little by provision of the micro-vibration, a total amount of the ink in each ink chamber 11 can be effectively replaced even if sedimentation of the solid particles advances and the ink is hard to be discharged from the nozzles 12.

[0038] Further, the liquid droplets can be ejected so as to provide an amount of liquid droplets that is equal to or greater than the capacity of each ink chamber 11 in accordance with each single ejection pulse applying operation in one non-print region. In this case, a total amount of the ink is replaced more than once in one non-print region. According to this operation, since a flowing amount of the ink around the ink chambers 1 including the common ink chamber 13 in the head 1 increases, an effect for enabling supply of the ink in which the solid particles are uniformly dispersed into the ink chambers 11 can be improved.

[0039] The number of times of occurrence of the micro-vibration pulse applying operation of the time t1 and the ejection pulse applying operation of the time t2 in one non-print region is out of the question as long as the micro-vibration pulse applying operation is carried out immediately before the ejection pulse applying operation.

Furthermore, in FIG. 6, three sets of the time t1 of the micro-vibration pulse P2 are all uniform and three sets of the time t2 of the respective ejection pulse P1 are also uniform, but the time t1 and the time t2 may be set to be non-uniform in each applying operation. That is, the number of times of applying the ejection pulse P1 or the micro-vibration pulse P2 in each applying operation may differ in accordance with each applying operation.

[0040] Although the refresh that the micro-vibration operation and the ejection operation are carried out can be effected every time the head 1 reaches the non-print region, there might be a case that sedimentation of the solid particles in the ink in the ink chambers 11 does not substantially advance like a situation where a large amount of liquid droplets are continuously ejected from the nozzle 12 in the print region or where a specific gravity difference of the dispersion medium and the solid particles is relatively small depending on a type of ink. In such a case, when the ink ejection operation is carried out every time the head 1 reaches the non-print region, the ink is wastefully consumed. Moreover, since the liquid droplets containing the solid particles is apt to produce a satellite, there is concern that the generated satellite turns to mist and scatters at the time of ejection, leading to contamination of the periphery. To suppress the waste of the ink or the contamination of the periphery due to the satellite, it is desirable to restrict the liquid droplets that are ejected by the ejection operation to the minimum requirement.

[0041] Therefore, it is also preferable for the CPU 101 to select whether the refresh is to be carried out in accordance with a sedimentation state, i.e., a state of progress of sedimentation of the solid particles in the ink in the ink chambers 11 when the head 1 is present in the non-print region. As a result, the unnecessary ejection operation can be prevented from being performed, and the wasteful consumption of the ink and the contamination of the periphery due to the satellite can be suppressed.

[0042] In general, an ejection speed of the liquid droplets ejected from the nozzles 12 is lowered as a quantity of the solid particles contained in the liquid droplets increases. Therefore, it is possible to estimate of a state of progress of sedimentation of the solid particles in the ink near the nozzles 12 in the ink chamber 11.

[0043] FIG. 7 shows a liquid droplet speed detection apparatus 3 which is an example of detecting means for detecting an ejection speed of the liquid droplets. This liquid droplet speed detection apparatus 3 is configured to operate in response to an instruction from the CPU 101 and transmit a result to the CPU 101 as shown in FIG. 3.

[0044] The liquid droplet speed detection apparatus 3 has a light projection unit 31 formed of an LED or a laser that emits detection light L and a light receiving unit 32 formed of a photosensor or the like that receives this detection light L, and the liquid droplet speed detection apparatus 3 is arranged near a position immediately be-

low nozzles 12 in such a manner that an optical axis of the detection light L becomes parallel to the X direction as an alignment direction of the nozzles 12 and also becomes parallel to the nozzle surface. As a result, the liquid droplet ejected from each nozzle 12 crosses the detection light L, and a shade when the liquid droplet a passes is captured by the light receiving unit 32. Additionally, when the ejection pulse P is applied to any one of ink chambers 11 and the liquid droplet a is ejected from the nozzle 12, the liquid droplet speed detection apparatus 3 calculates an ejection speed of the liquid droplet a from a time required to capture a shade of the liquid droplet a from application of the ejection pulse P1 and a distance to the optical axis of the detection light L from the nozzle 12.

[0045] A threshold value indicative of a lower limit of a preferred ejection speed of the liquid droplet a is preset to one of the CPU 101 and the liquid droplet speed detection apparatus 3. When the ejection speed of the liquid droplet a detected in a case where the head 1 is present in the non-print region falls below this threshold value, sedimentation of the solid particles in the ink in the corresponding ink chamber 11 is progressing, and it is possible to determine that the refresh should be carried out.

[0046] FIG. 8 shows an example of a flow for detecting a speed of the liquid droplet a by the liquid droplet speed detection apparatus 3 prior to the refresh when the head 1 reaches the non-print region. When the head 1 reaches the non-print region, the liquid droplet a is first ejected from each nozzle 12 in the head 1, and the liquid droplet speed detection apparatus 3 detects an ejection speed of the liquid droplet a (S1). A detection result is transmitted to the CPU 101, and the CPU 101 determines whether the ejection speed of the liquid droplet a is lower than the threshold value and sedimentation of the solid particles is advancing from this result (S2) and then starts the refresh constituted of the micro-vibration operation and the ejection operation if the ejection speed was determined to be lower than the threshold value (S3). On the other hand, when the ejection speed of the liquid droplet a is not lower than the threshold value, it is determined that sedimentation of the solid particles in the ink chamber 11 has not advanced and ejection is not required, and the refresh in the non-print region is not carried out. Therefore, the unnecessary consumption of the ink and the contamination of the periphery due to the satellite can be suppressed.

[0047] The refresh after detecting the liquid droplet speed may be performed with respect to all the ink chambers 11 in the head 1 or individually performed with respect to the ink chamber 11 that has ejected the liquid droplet a whose ejection speed was lower than the threshold value when it was determined that the ejection speed of the liquid droplet a ejected from any nozzle 12 in the head 1 fell below the threshold value. In the latter case, the unnecessary consumption of the ink and the contamination of the periphery due to the satellite can be further suppressed.

[0048] Moreover, if the plurality of heads 1 are provided in accordance with respective colors, detecting an ejection speed of the liquid droplet in accordance with each head 1 and determining whether the refresh is to be performed enables carrying out an appropriate nozzle recovery operation in accordance with each head 1.

[0049] The sedimentation of the solid particles in the ink in each ink chamber 11 advances when a period that no print data is provided continues for a long time even in the print region. If the plurality of heads 1 are provided in accordance with the respective colors, a head that ejects a white ink that is often used as a base may not be used for a long time. Therefore, it is also possible to estimate how the sedimentation of the solid particles in the ink has advanced near the nozzle 12 in the ink chamber 11 from a liquid droplet ejection pause period of the ink chamber 11 in the print region. Therefore, it is also preferable to select whether the ejection operation is to be performed in accordance with a pause period of ejection of the ink droplets from the nozzle 12 when the head 1 is present in the print region where printing is carried out. As a result, the unnecessary refresh can be prevented from being effected, and the wasteful consumption of the ink and the contamination of the periphery due to the satellite can be suppressed.

[0050] FIG. 9 shows an example of a flow of selecting whether the refresh is to be performed in accordance with a liquid droplet ejection pause period. When the head 1 reaches the non-print region, a liquid droplet ejection pause period of each nozzle 12 in the print region is first detected (S10). The ejection pause period of the liquid droplets from each nozzle 12 can be obtained by analyzing print data stored in the print data memory 102 in the CPU 101, for example. A detection result is transmitted to the CPU 101.

[0051] A threshold value indicative of an upper limit of the ejection pause period is preset in the CPU 101. The CPU 101 determines from the detection result whether the sedimentation of the solid particles has advanced so that the refresh should be carried out since the ejection pause period is long beyond the threshold value (S11). Additionally, if the ejection pause period was determined to exceed the threshold value, then the refresh constituted of the micro-vibration operation and the ejection operation is started (S12). On the other hand, if the ejection pause period is lower than the threshold value, it is determined that the sedimentation of the solid particles in the ink chamber 11 has not advanced and the refresh is not required, and the refresh in the non-print region is not carried out. Therefore, the wasteful consumption of the ink and the contamination of the periphery due to the satellite can be suppressed.

[0052] The refresh after detecting the ejection pause period may be performed with respect to all the ink chambers 11 in the head 1 or may be individually performed with respect to the ink chamber 11 having the ejection pause period exceeding the threshold value when the ejection pause period of any nozzle 12 in the head 1 was

determined to exceed the threshold value. In the latter case, the wasteful consumption of the ink and the contamination of the periphery due to the satellite can be further suppressed.

[0053] Further, when the plurality of heads 1 are provided in accordance with the respective colors, an appropriate nozzle recovery operation can be executed in accordance with each head 1 by detecting the ejection pause period in accordance with each head 1 and determining whether the refresh is to be performed.

[0054] In the above-described conformation, when the head 1 is present in the non-print region, the CPU 101 controls the micro-vibration control unit 107 and the ejection control unit 108 to perform the refresh. However, since the refresh involves ejection of the liquid droplets, the consumption of the ink increase. Therefore, it is also preferable to configure the liquid droplet ejection apparatus 100 to select one of a case where the refresh constituted of the micro-vibration operation and the ejection operation is performed and a case where the micro-vibration operation alone is performed without effecting liquid droplet ejecting operation by applying the plurality of micro-vibration pulses P2 to the drive electrodes on the partition walls 14 of the ink chambers 11.

[0055] The refresh in this conformation is as described above, thereby omitting a description thereof. On the other hand, in case of selecting and executing the micro-vibration operation alone, as a pulse applied to the drive electrodes formed on the partition walls 14 of the head 1 from the head driver 105 the micro-vibration pulse P2 shown in FIG. 4(b) alone in pulses generated by the drive pulse generation unit 106 is used.

[0056] FIG. 10 shows examples of an application pattern of the micro-vibration pulse P2 when the micro-vibration operation alone is performed. In the application pattern shown in (a), a micro-vibration pulse applying operation for continuously applying the plurality of micro-vibration pulses P2 is continued during a period that the head 1 is present in the non-print region. On the other hand, in the application pattern shown in (b), the micro-vibration pulse applying operation is continued for a predetermined time alone, and the micro-vibration pulse applying operation that is one segment in this predetermined time is repeated more than once at intervals. A continuation time of the micro-vibration pulse applying operation as one segment may be uniformly set in one non-print region or may be non-uniformly set.

[0057] When the head 1 is present in the non-print region, selecting execution of the micro-vibration operation alone or execution of the refresh constituted of the micro-vibration operation and the ejection operation may be manually set by an operator using, e.g., a changeover switch in advance, but it is preferable to automatically select and execute the operation by the CPU 101 with a progression of sedimentation of the solid particles in each ink chamber 11 when the head 1 reaches the non-print region being used as a trigger. The progression of sedimentation of the solid particles in the ink in each ink

chamber 11 can be detected by setting a predetermined threshold value and detecting an ejection speed of liquid droplets with the use of the liquid droplet detection apparatus 3 depicted in FIG. 7.

[0058] FIG. 11 shows an example of a flow that uses a detection result of the liquid droplet speed detection apparatus 3 as a trigger at the time of selecting the micro-vibration operation or the refresh to be performed. When the head 1 reaches the non-print region, the liquid droplet speed detection apparatus 3 first ejects the liquid droplet a from each nozzle 12 in the head and detects an ejection speed (S20). A detection result is transmitted to the CPU 101.

[0059] Two threshold values of the ejection speed corresponding to a progression of sedimentation of the solid particles are set in the CPU 101 in advance. A first threshold value is a threshold value that is used for determining whether the micro-vibration operation is to be performed or whether nothing has to be performed. A second threshold value is a threshold value that is set to a value lower than the first threshold value, indicative of a state that sedimentation of the solid particles has advanced to some extent, and used for determining whether the micro-vibration operation alone is to be performed or whether the refresh is to be performed.

[0060] The CPU 101 first compares a detection result of the liquid droplet speed detection apparatus 3 with the first threshold value and determines whether the detection result is lower than the first threshold value so that sedimentation of the solid particles has advanced and hence the micro-vibration operation should be performed (S21). As a result, when the detection result is not lower than the first threshold value, it is determined that sedimentation of the solid particles in the ink chambers 11 has not advanced and hence the nozzle recovery operation is not required, and the nozzle recovery operation is not carried out in the non-print region. Therefore, the wasteful consumption of the ink and the contamination of the periphery due to the satellite can be suppressed.

[0061] On the other hand, if it was determined that the detection result was lower than the first threshold value, the detection result is then compared with the second threshold value (S22). As a result, if it was determined that the detection result was lower than the second threshold value, then the refresh constituted of the micro-vibration operation and the ejection operation is started (S23). Furthermore, if it was determined that the detection result was not lower than the second threshold value, it is determined that sedimentation of the solid particles has advanced to some extent but the refresh does not have to be carried out, and then the micro-vibration operation alone is performed (S24).

[0062] As a result, it is possible to take an appropriate action in accordance with a state of the ink in the ink chambers 11. If performing the micro-vibration operation alone is selected, since the liquid droplets are not ejected, and hence the wasteful consumption of the ink and the contamination of the periphery due to the satellite can be

suppressed.

[0063] Moreover, in place of the detection result of the liquid droplet speed detection apparatus 3, as shown in FIG. 12, a detection result of the liquid droplet ejection pause period can be used as a trigger. That is, when the head 1 first reaches the non-print region, a liquid droplet ejection pause period of each nozzle 12 in the print region is first detected based on print data (S30). The detection result is transmitted to the CPU 101.

[0064] Additionally, the CPU 101 first compares the detection result of the ejection pause period with the first threshold value and determines whether the detection result exceeds the first threshold value and sedimentation of the solid particles has advanced so that the micro-vibration operation should be performed (S31). As a result, when the detection result is lower than the first threshold value, it is determined that sedimentation of the solid particles in each ink chamber 11 has not advanced so that the nozzle recovery operation does not have to be performed, and the nozzle recovery operation is not performed in the non-print region. Therefore, the wasteful consumption of the ink and the contamination of the periphery due to the satellite can be suppressed.

[0065] On the other hand, if the detection result was determined to exceed the first threshold value, the detection result is compared with the second threshold value set to a value higher than the first threshold value (S32). As a result, if the detection result was determined to likewise exceed the second threshold value, then the refresh constituted of the micro-vibration operation and the ejection operation is started (S33). Further, if it was determined that the detection result was yet to exceed the second threshold value, the solid particles are determined to settle out to some extent, but the refresh does not have to be carried out, and then the micro-vibration operation alone is carried out (S34). As a result, the same effect as that in case of detecting an ejection speed of the liquid droplets can be provided.

[0066] In such cases, if the plurality of heads 1 are provided in accordance with the respective colors, an ejection speed or an ejection pause period of the liquid droplets is detected in accordance with each head, and whether the micro-vibration operation alone is performed or whether the refresh is performed is determined, thereby executing an appropriate nozzle recovery operation in accordance with each head 1.

[0067] Furthermore, in each flow shown in FIG. 11 and FIG. 12, when the head 1 reaches the non-print region, the micro-vibration operation may be always carried out. In this case, one set value can suffice as a threshold value, and whether the micro-vibration operation alone is to be performed or whether the refresh constituted of the micro-vibration operation and the ejection operation is to be performed may be determined based on comparison with this threshold value.

[0068] Besides, whether the micro-vibration operation alone is to be performed or whether the refresh is to be performed may be selected and executed in accordance

with a preset sequence. For example, a selection trigger may be set by the number of times that the head 1 reaches the non-print region, the micro-vibration operation may be always performed every time the head 1 is present in the non-print region, and the refresh constituted of the micro-vibration operation and the ejection operation may be performed every time the head 1 reaches the non-print region for the third time. Moreover, the selection trigger may be set by a time, the micro-vibration operation may be performed in a regular situation, and the refresh constituted of the micro-vibration operation and the ejection operation alone may be effected at start of printing or every time a predetermined time passes after execution of the previous refresh.

[0069] Meanwhile, a sedimentation speed of the solid particles rises as specific gravity of the solid particles relative to the dispersion medium increases, and hence sedimentation is facilitated. For example, even if the same head is used, when types of inks to be used differ, specific gravity of the solid particles relative to the dispersion medium may differ in levels in cases. Furthermore, in case of using a plurality of heads 1, types of the solid particles contained in the ink differ depending on types (colors) of the inks for the respective heads 1, and hence the specific gravity of the solid particles relative to the dispersion medium may differ in levels. In such a case, when the uniformed micro-vibration operation is performed irrespective of a level difference in specific gravity of the solid particles relative to the dispersion medium, a situation where the solid particles cannot be sufficiently dispersed depending on levels of specific gravity can be expected.

[0070] Therefore, at the time of micro-vibrating the ink in each ink chamber 11 by using the micro-vibration pulse P2, it is preferable to raise an application frequency as the specific gravity increases in accordance with a level of the specific gravity of the solid particles relative to the dispersion medium. When the application frequency of the micro-vibration pulse P2 is raised as the specific gravity increases, the ink in each ink chamber 11 can be efficiently micro-vibrated, and dispersion of the solid particles can be effectively facilitated.

[0071] A level of the specific gravity of the solid particles relative to the dispersion medium can be manually set by, e.g., providing a non-illustrated input switch to the liquid droplet ejection apparatus 100 and performing an input operation by an operator in accordance with a type of the ink at the time of setting an ink tank or an ink cartridge storing the ink to the apparatus, or it may be automatically set by recognizing identifying information of the type of the ink provided on the ink tank or the ink cartridge with the use of non-illustrated recognizing means provided to the liquid droplet ejection apparatus 100. The input result or the identification result is transmitted to the CPU 101, and the micro-vibration control unit 107 controls the micro-vibration operation based on the input result or the identification result.

[0072] FIG. 13 shows an example of a table that is

preferably used at the time of adjusting an application frequency in accordance with a level of the specific gravity of the solid particles relative to the dispersion medium. This table, a relationship between a level of the specific gravity of the solid particles relative to the dispersion medium (a ratio of a specific gravity difference of the solid particles relative to specific gravity of the dispersion medium) and an application frequency of the micro-vibration pulse, and it is stored in, e.g., the CPU 101. Moreover, when an input or identified level of the specific gravity of the solid particles relative to the dispersion medium is relatively small, a sedimentation speed of the solid particles is relatively slow, and hence the application frequency is reduced, the application frequency is raised as the level or specific gravity increases. As a result, it is possible to execute the fine micro-vibration operation according to a difference in level of the sedimentation speed of the solid particles, thereby further efficiently recovering the nozzles.

[0073] As shown in FIG. 14, the ink in the common ink chamber 13 in the head 1 can be circulated between the common ink chamber 13 and the ink tank 4 storing the ink. A supply pipe 41 and a return pipe 42 are connected between the common ink chamber 13 of the head 1 and the ink tank 4, a circulation pump 43 is provided to the return pipe 42, and the supply pipe 41, the return pipe 42, and the circulation pump 43 constitute circulating means. Further, the ink is circulated between the ink tank 4 and the common ink chamber 13 of the head 1 by drive of the circulation pump 43. As a result, since the solid particles of the ink stored in the common ink chamber 13 can have uniform concentration, the ink in which the solid particles having the uniform concentration can be supplied to the ink chambers 11. As a result, sedimentation of the solid particles in the ink in the ink chambers 11 can be further suppressed, and an ink replacement effect based on the refresh can be improved.

[0074] Although it is desirable to constantly perform this ink circulating operation based on drive of the circulation pump 43 irrespective of a case where the head 1 is present in the print region and a case where it is present in the non-print region, the ink in each ink chamber 11 can be replaced with an ink having uniform concentration at the time of refresh, and hence it is preferable to carry out the ink circulating operation at least during a period that the refresh constituted of the micro-vibration operation and the ejection operation is performed.

[0075] As nozzle maintenance means (a nozzle maintenance process) that performs maintenance for recovery of the nozzles 12, there are known means that perform a wiping operation (a wiping process) for wiping off stains on each nozzle surface with the use of a blade, a removing operation (a removing process) for pressing a water-absorptive member such as cloth against each nozzle surface and removing the ink, and others when the head 1 is present in the non-print region, any one or more of these means may be provided in the liquid droplet ejection apparatus 100 carried out. In this case, it is pref-

erable to prevent both the micro-vibration operation and the ejection operation from being performed during a period where the nozzle maintenance means (the nozzle maintenance process) is carried out. In particular, when the micro-vibration operation alone is performed as the nozzle recovery operation, since a meniscus in the nozzle 12 vibrates by micro-vibration, and hence the meniscus may be destroyed at the time of the wiping operation or the removing operation.

[0076] As the above-described liquid droplet ejection apparatus 100, the line type liquid droplet ejection apparatus that performs printing on a surface of a recording medium in one pass has been described, but the liquid droplet ejection apparatus may be a scan type liquid droplet ejection apparatus that performs printing by reciprocating the head 1 in a main scan direction.

[0077] FIG. 15 shows an example of such a scan type liquid droplet ejection apparatus.

[0078] In a liquid droplet ejection apparatus 200, a recording medium W is sandwiched between a pair of conveyance rollers 201 and conveyed in a direction indicated by an arrow (a sub-scan direction) by a conveyance roller 203 that is driven to rotate by a conveyance motor 202.

[0079] A head 1 is provided between the conveyance roller 203 and the pair of conveyance rollers 201 so as to face a surface of the recording medium W. The head 1 is arranged and mounted on a carriage 204 in such a manner that a nozzle surface side faces the recording medium W. The carriage 204 is provided to enable its reciprocating motion along a left-and-right direction in the drawing (the main scan direction) substantially orthogonal to a conveyance direction (the sub-scan direction) of the recording medium W by non-illustrated driving means along guide rails 205 installed along a width direction of the recording medium W.

[0080] The head 1 horizontally scans and moves on the surface of the recording medium W with movement of the carriage 204 in the main scan direction, and ejecting the liquid droplets from the nozzles 12 in this scanning and moving process enables performing desired printing.

[0081] In this liquid droplet ejection apparatus 200, both lateral sides of the recording medium W are non-print regions in which no print data is provided and printing based on the print data is not performed. In the non-print regions, ink receivers 206 are arranged at positions facing the nozzle surfaces of the head 1. Therefore, at the time of performing refresh when the head 1 reaches the non-print region, the liquid droplets are ejected toward the ink receivers 206. In case of installing the liquid droplet speed detection apparatus 3 shown in FIG. 7, this apparatus can be arranged in each of the non-print regions on both sides of the recording medium W.

[0082] In the head 1 explained above, the energy giving means in which each partition wall 14 between the neighboring ink chambers 11 and 11 is formed of a piezoelectric partition wall 14 and which ejects the ink in the ink chambers 11 as liquid droplets from the nozzles 12 by a deforming operation of each partition wall 14 has

been described as the example, but a specific structure of the energy giving means for giving energy to the ink in the ink chamber is out of the question. For example, a heater may be provided in the ink chambers as the energy giving means, air bubbles may be generated in the ink by energizing the heater, and the liquid droplets may be ejected from the nozzles by a breaking function of the air bubbles, or one wall surface of the ink chamber may be formed of a diaphragm as the energy giving means, this diaphragm may be vibrated by a deforming operation of the piezoelectric element, the ink in the ink chamber may be given energy, and the liquid droplets may be ejected from the nozzles.

[0083] Moreover, the head 1 is not restricted to a head in which nozzle surfaces are arranged to be vertically downward directed, and nozzle surfaces may be arranged in a horizontal direction or an oblique direction.

Examples

(Example 1)

[0084] As shown in FIG. 15, a scan type liquid droplet ejection apparatus having ink receivers arranged in non-print regions on both lateral sides of a recording medium was used, predetermined printing was performed in a print region of the recording medium from a head using a UV ink containing a dispersion medium and a titanium oxide in which solid particles have specific gravity higher than that of the dispersion medium (a specific gravity difference between the dispersion medium and the solid particles: 0.25, the content of a material having a steam pressure higher than that of wafer at an ordinary temperature: 5%), a micro-vibration pulse having a frequency that is a half of a liquid droplet ejection frequency at the time of printing was applied every time the head reached the non-print region in order to turn back at an end portion in a main scan direction, and then liquid droplets having the same frequency as the ejection frequency were ejected into each ink receiver.

[0085] As a result, even though the operation was continuously performed for 120 hours or more, nozzle clogging did not occur, and the stable operation was possible.

(Comparative Example 1)

[0086] The continuous operation was performed under the same conditions as those in Example 1 except that the micro-vibration pulse was not applied in each non-print region and the ejection operation alone was performed.

[0087] As a result, nozzle clogging occurred in an ink chamber at the end portion when five hours passed from the operation.

(Comparative Example 2)

[0088] The continuous operation was performed under

the same conditions as those in Example 1 except that the micro-vibration pulse alone was applied in each non-print region and the ejection operation was not performed.

[0089] As a result, nozzle clogging occurred in an ink chamber at the end portion when five hours passed from the operation.

(Example 2)

[0090] As shown in FIG. 1, a line type liquid droplet ejection apparatus that performs printing on a surface of each ceramic tile conveyed by a conveyance belt in one pass from a head was used, and predetermined printing was performed in a print region on the ceramic tile surface from the head using an oil ink containing a dispersion medium and pigment particles of yellow as solid particles (a specific gravity difference between the dispersion medium and the solid particles: 0.30, the content of a material having a steam pressure higher than that of water at an ordinary temperature: 3%). Since the oil ink for the ceramic tile has high density and the pigment particles are apt to settle out, the micro-vibration pulse having the same frequency as a liquid droplet ejection frequency at the time of printing was applied, and then liquid droplets having the same frequency as the ejection frequency were ejected into each ink receiver.

[0091] As a result, even though the operation was continuously performed for 120 hours or more, nozzle clogging did not occur, and the stable operation was possible.

(Comparative Example 3)

[0092] The continuous operation was performed under the same conditions as those in Example 2 except that the ejection operation alone was performed without applying a micro-vibration pulse in each non-print region.

[0093] As a result, nozzle clogging occurred in the ink chamber at the end portion when five hours passed from the operation.

EXPLANATIONS OF LETTERS OR NUMERALS

[0094]

1: head

11: ink chamber

12 : nozzle

13 : common ink chamber

14 partition wall

15 : nozzle plate

2 : conveyance belt

2a : conveyance surface

3 : liquid droplet speed detection apparatus

31 : light projection unit	
32 : light receiving unit	
4 : ink tank	
41 : supply pipe	5
42 : return pipe	
43 : circulation pump	
100 : liquid droplet ejection apparatus	10
101 : CPU	
102 : print data memory	
103 : encoder	
104 : belt conveyance motor	15
105 : head driver	
106 : drive pulse generation unit	
107 : micro-vibration control unit	
108 : ejection control unit	20
200 : liquid droplet ejection apparatus	
201 : pair of conveyance rollers	
202 : conveyance motor	
203 : conveyance roller	25
204 : carriage	
205 : guide rail	
206 : ink receivers	
P1 : ejection pulse	
P2 : micro-vibration pulses	30
C : ceramic tile	
L : detection light	
W : recording medium	
a : liquid droplet	35

Claims

1. A liquid droplet ejection apparatus comprising:

a head that includes an ink chamber into which an ink is supplied, a nozzle provided in accordance with the ink chamber, and an energy giving device that drives when a drive pulse is applied thereto and gives energy to the ink in the ink chamber, the head performing printing on a print region of a recording medium based on print data by ejecting liquid droplets from the nozzle; and a drive pulse generation device that generates, as the drive pulse, an ejection pulse that is used for ejecting the liquid droplets from the nozzle and a micro-vibration pulse that micro-vibrates the ink in the ink chamber so as not to eject the liquid droplets from the nozzle, wherein the ink contains a dispersion medium and solid particles having higher specific gravity than that of a dispersion medium, and the liquid droplet ejection apparatus comprises

a refresh device that performs a micro-vibration operation for applying the plurality of micro-vibration pulses to the energy giving device and an ejection operation for applying the plurality of ejection pulses to the energy giving device after the micro-vibration operation and ejecting a liquid droplet amount equal to or greater than a capacity of the ink chamber from the nozzle, when the head is present in a non-print region where the printing is not performed.

2. The liquid droplet ejection apparatus according to claim 1, comprising a liquid droplet speed detection device that detects a speed of the liquid droplets ejected from the nozzle when the head is present in the non-print region where printing is not performed, wherein the refresh device is executed after detecting that a detection result of the liquid droplet speed detection device falls below a preset threshold value.

3. The liquid droplet ejection apparatus according to claim 1, comprising a pause period detection device that detects a period during which ejection of the liquid droplets from the nozzle pauses when the head is present in the print region where the printing is carried out, wherein the refresh device is executed after detecting that a detection result of the pause period detection device exceeds a preset threshold value.

4. A liquid droplet ejection apparatus comprising:

a head that includes an ink chamber into which an ink is supplied, a nozzle provided in accordance with the ink chamber, and an energy giving device that drives when a drive pulse is applied thereto and gives energy to the ink in the ink chamber, the head performing printing on a print-region of a recording medium based on print data by ejecting liquid droplets from the nozzle; and

a drive pulse generation device that generates, as the drive pulse, an ejection pulse that is used for ejecting the liquid droplets from the nozzle and a micro-vibration pulse that micro-vibrates the ink in the ink chamber so as not to eject the liquid droplets from the nozzle, wherein the ink contains a dispersion medium and solid particles having higher specific gravity than that of a dispersion medium, and the liquid droplet ejection apparatus comprises:

a micro-vibration device that exclusively performs a micro-vibration operation for applying the plurality of micro-vibration pulses to the energy giving device; a refresh device that performs the micro-vibration operation for applying the plurality

- of micro-vibration pulses to the energy giving device and an ejection operation for applying the plurality of ejection pulses to the energy giving device after the micro-vibration operation and ejecting a liquid droplet amount equal to or greater than a capacity of the ink chamber from the nozzle; and a selection device that selects and executes one of the micro-vibration device and the refresh device when the head is present in the non-print region where printing is not performed.
5. The liquid droplet ejection apparatus according to claim 4, comprising a liquid droplet speed detection device that detects a speed of the liquid droplets ejected from the nozzle when the head is present in the non-print region where the printing is not performed, wherein the selection device selects and executes one of the micro-vibration device and the refresh device in accordance with a detection result of the liquid droplet speed detection device after detecting that the detection result falls below a preset threshold value.
 6. The liquid droplet ejection apparatus according to claim 4, comprising a pause period detection device that detects a period during which ejection of the liquid droplets from the nozzle pauses when the head is present in the print region where the printing is performed, wherein the selection device selects and executes one of the micro-vibration device and the refresh device in accordance with a detection result of the pause period detection device after detecting that the detection result exceeds a preset threshold value.
 7. The liquid droplet ejection apparatus according to any one of claims 1 to 6, wherein, in the micro-vibration operation, an application frequency is raised as specific gravity of the solid particles relative to the dispersion medium increases in accordance with the specific gravity.
 8. The liquid droplet ejection apparatus according to any one of claims 1 to 7, comprising:
 - an ink tank that stores the ink that is supplied to the head; and
 - a circulation device that circulates the ink between the head and the ink tank, wherein the circulation device circulates the ink during a period that at least the refresh device is executed.
 9. The liquid droplet ejection apparatus according to any one of claims 1 to 8, comprising a nozzle maintenance device that executes at least one of a wiping operation for wiping off stains on a nozzle surface in which the nozzle is opened and a removing operation for removing the ink on the nozzle surface when the head is present in the non-print region, where the printing is not performed, wherein both the micro-vibration device and the refresh device are not executed during a period that the nozzle maintenance device is executed,
 10. The liquid droplet ejection apparatus according to any one of claims 1 to 9, wherein a specific gravity difference between the dispersion medium and the solid particles in the ink is 0.2 or more.
 11. The liquid droplet ejection apparatus according to any one of claims 1 to 10, wherein the ink does not volatilize from the nozzle by drying.
 12. A method for recovering a nozzle of a liquid droplet ejection apparatus comprising:
 - a head that includes an ink chamber into which an ink is supplied, a nozzle provided in accordance with the ink chamber, and an energy giving device that drives when a drive pulse is applied thereto and gives energy to the ink in the ink chamber, the head performing printing on a print-region of a recording medium based on print data by ejecting liquid droplets from the nozzle; and
 - a drive pulse generation device that generates, as the drive pulse, an ejection pulse that is used for ejecting the liquid droplets from the nozzle and a micro-vibration pulse that micro-vibrates the ink in the ink chamber so as not to eject the liquid droplets from the nozzle, wherein the ink contains a dispersion medium and solid particles having higher specific gravity than that of a dispersion medium, and the method comprises a refresh process that performs a micro-vibration operation for applying the plurality of micro-vibration pulses to the energy giving device and an ejection operation for applying the plurality of ejection pulses to the energy giving device after the micro-vibration operation and ejecting a liquid droplet amount equal to or greater than a capacity of the ink chamber from the nozzle, when the head is present in a non-print region where printing is not performed.
 13. The method for recovering a nozzle of a liquid droplet ejection apparatus according to claim 12, comprising a liquid droplet speed detection process that detects

a speed of the liquid droplets ejected from the nozzle when the head is present in the non-print region where printing is not performed, wherein the refresh process is executed after detecting that a detection result of the liquid droplet speed detection process falls below a preset threshold value.

14. The method for recovering a nozzle of a liquid droplet ejection apparatus according to claim 12, comprising a pause period detection process that detects a period during which ejection of the liquid droplets from the nozzle pauses when the head is present in the print region where the printing is carried out, wherein the refresh process is executed after detecting that a detection result of the pause period detection process exceeds a preset threshold value.
15. A method for recovering a nozzle of a liquid droplet ejection apparatus comprising:

a head that includes an ink chamber into which an ink is supplied, a nozzle provided in accordance with the ink chamber, and an energy giving device that drives when a drive pulse is applied thereto and gives energy to the ink in the ink chamber, the head performing printing on a print region of a recording medium based on print data by ejecting liquid droplets from the nozzle; and a drive pulse generation device that generates, as the drive pulse, an ejection pulse that is used for ejecting the liquid droplets from the nozzle and a micro-vibration pulse that micro-vibrates the ink in the ink chamber so as not to eject the liquid droplets from the nozzle, wherein the ink contains a dispersion medium and solid particles having higher specific gravity than that of a dispersion medium, and the method for recovering a nozzle comprises:

a micro-vibration process that exclusively performs a micro-vibration operation for applying the plurality of micro-vibration pulses to the energy giving device; and a refresh process that performs the micro-vibration operation for applying the plurality of micro-vibration pulses to the energy giving device and an ejection operation for applying the plurality of ejection pulses to the energy giving device after the micro-vibration operation and ejecting a liquid droplet amount equal to or greater than a capacity of the ink chamber from the nozzle, one of the micro-vibration process or the refresh process is selected and executed when the head is present in the non-print region where printing is not performed.

16. The method for recovering a nozzle of a liquid droplet ejection apparatus according to claim 15, comprising a liquid droplet speed detection process that detects a speed of liquid droplets ejected from the nozzle when the head is present in the non-print region where the printing is not performed, wherein one of the micro-vibration process and the refresh process is selected and executed in accordance with a detection result of the liquid droplet speed detection process after detecting that the detection result falls below a preset threshold value.

17. The method for recovering a nozzle of a liquid droplet ejection apparatus according to claim 15, comprising a pause period detection process that detects a period during which ejection of the liquid droplets from the nozzle pauses when the head is present in the print region where the printing is performed, wherein one of the micro-vibration process and the refresh process is selected and executed in accordance with a detection result of the pause period detection process after detecting that the detection result exceeds a preset threshold value.

18. The method for recovering a nozzle of a liquid droplet ejection apparatus according to any one of claims 12 to 17, wherein, in the micro-vibration operation, an application frequency is raised as specific gravity of the solid particles relative to the dispersion medium increases in accordance with the specific gravity.

19. The method for recovering a nozzle of a liquid droplet ejection apparatus according to any one of claims 12 to 18, comprising an ink tank that stores the ink that is supplied to the head, wherein the ink is circulated between the head and the ink tank during a period that at least the refresh process is executed.

20. The method for recovering a nozzle of a liquid droplet ejection apparatus according to any one of claims 12 to 19, comprising a nozzle maintenance process that executes at least one of a wiping process for wiping off stains on a nozzle surface in which the nozzle is opened and a removing process for removing the ink on the nozzle surface when the head is present in the non-print region where the printing is not performed, wherein both the micro-vibration process and the refresh process are not executed during a period that the nozzle maintenance process is executed.

21. The method for recovering a nozzle of a liquid droplet ejection apparatus according to any one of claims 12 to 20, wherein a specific gravity difference between the dispersion medium and the solid particles in the ink is

0.2 or more.

- 22.** The method for recovering a nozzle of a liquid droplet ejection apparatus according to any one of claims 12 to 21, wherein the ink does not volatilize from the nozzle by drying.

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FIG. 1

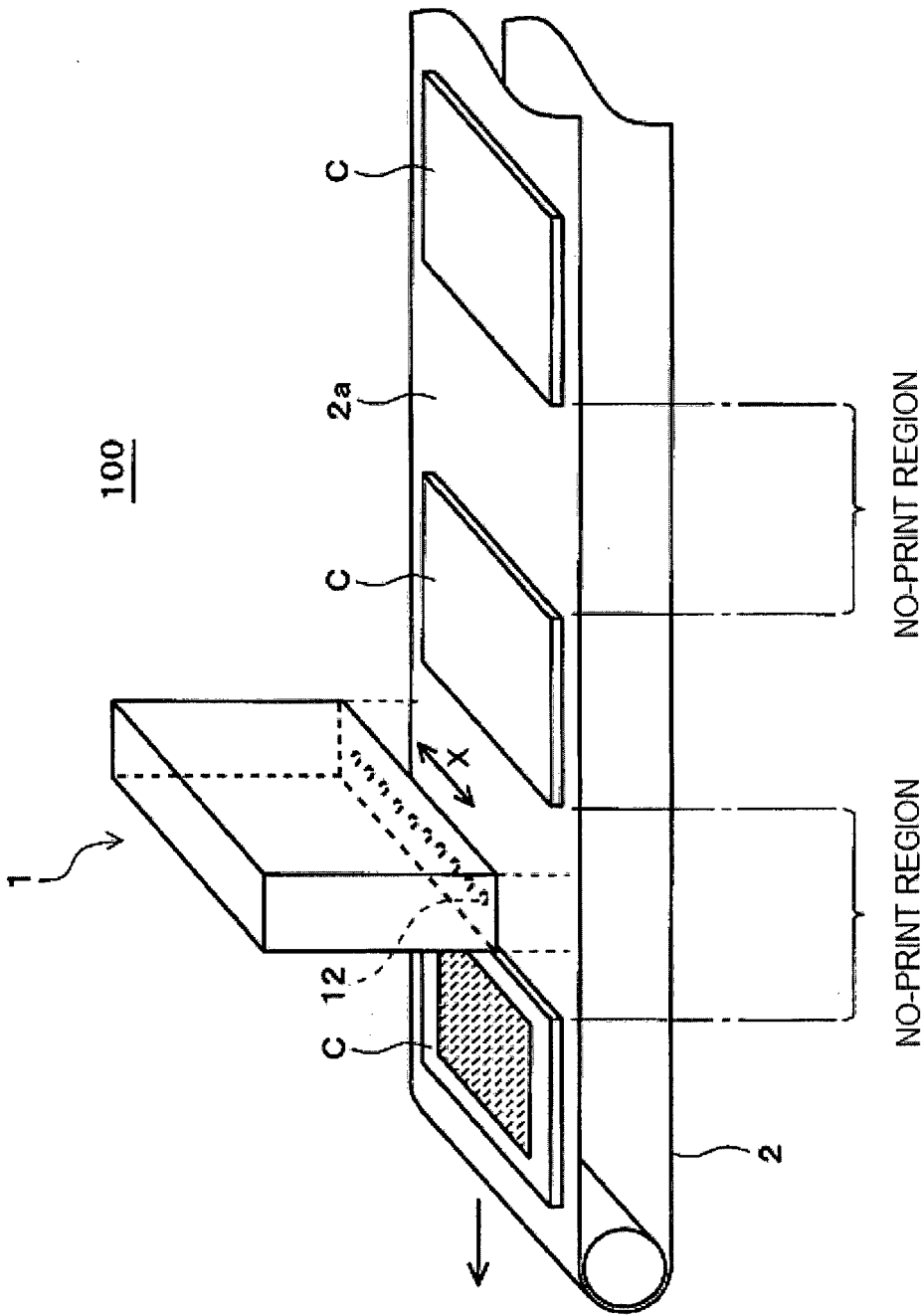


FIG. 2

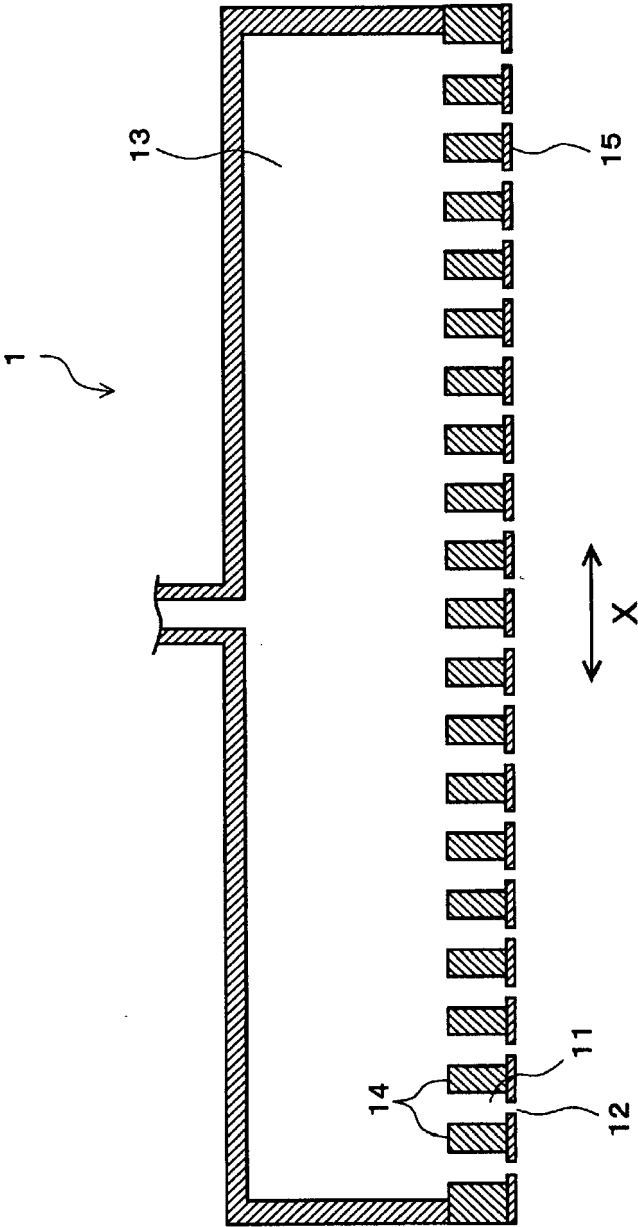


FIG. 3

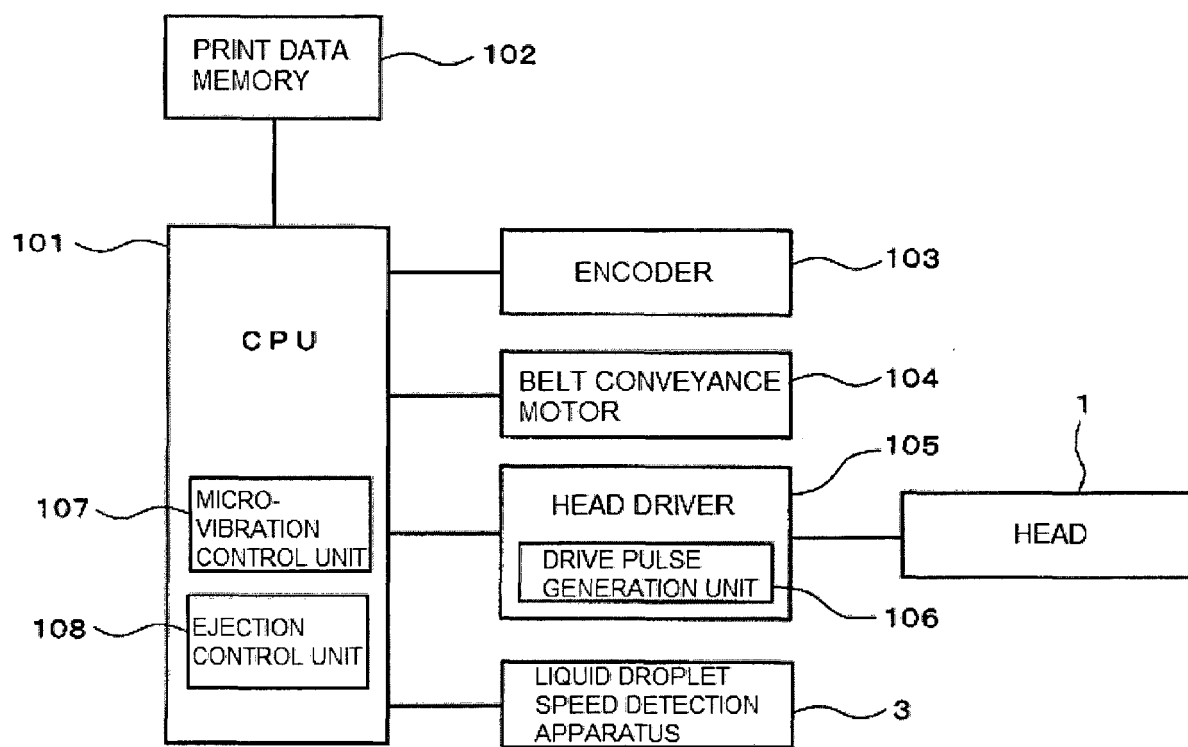


FIG. 4

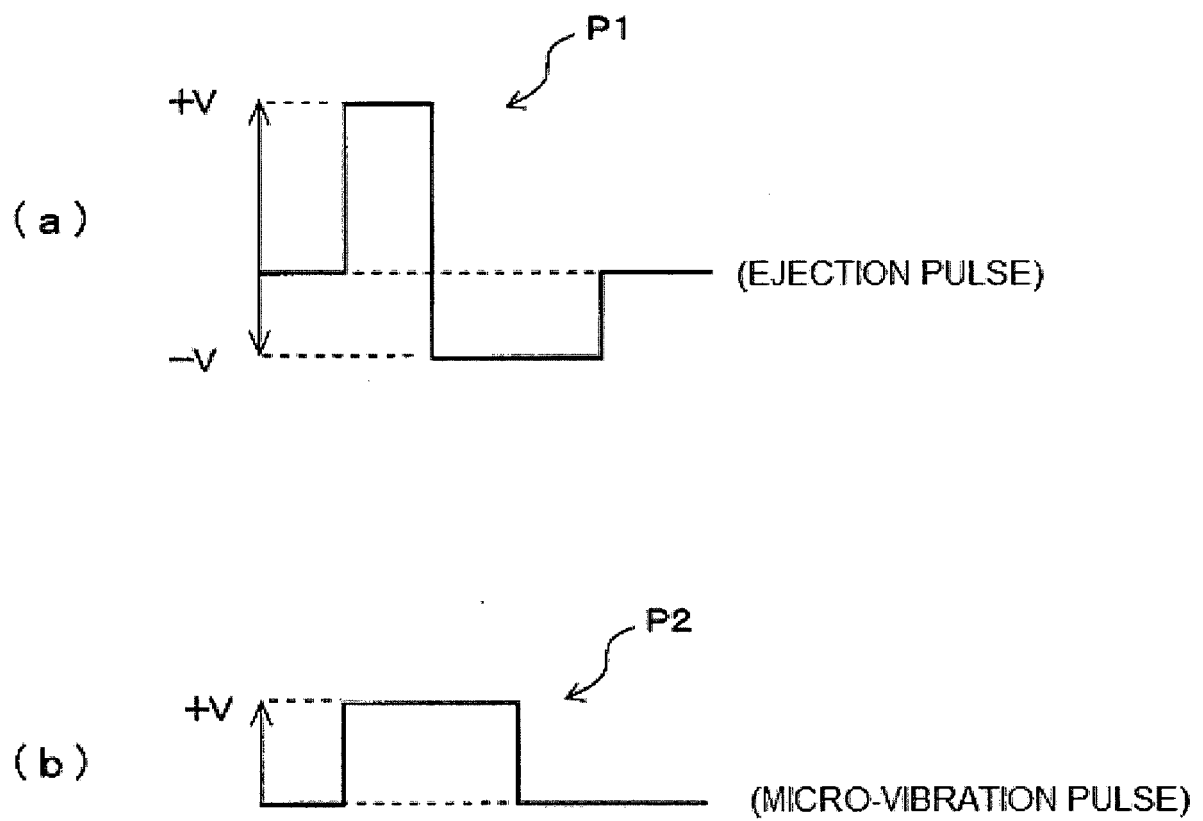


FIG. 5

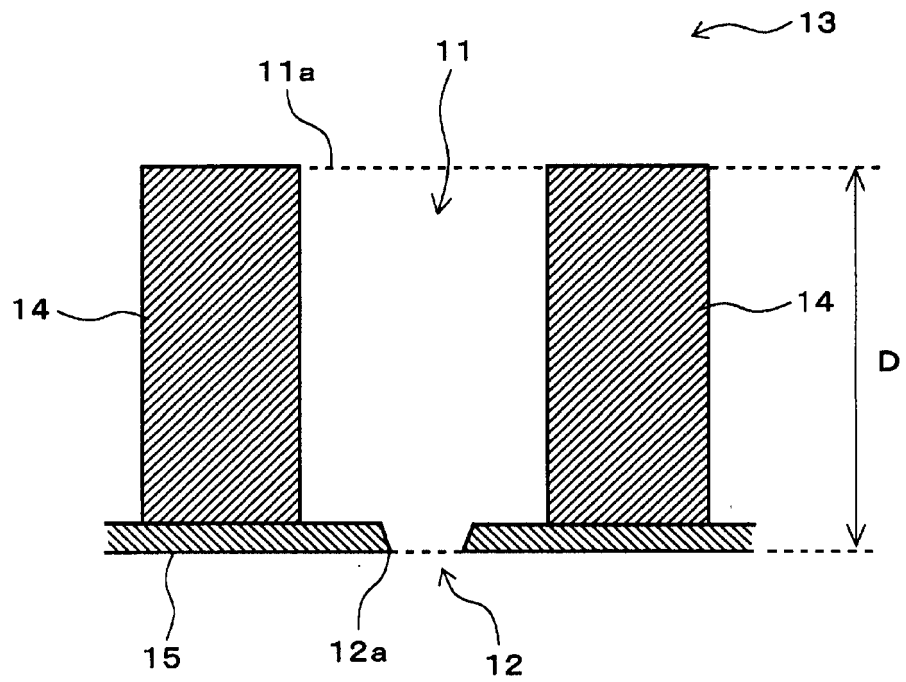


FIG. 6

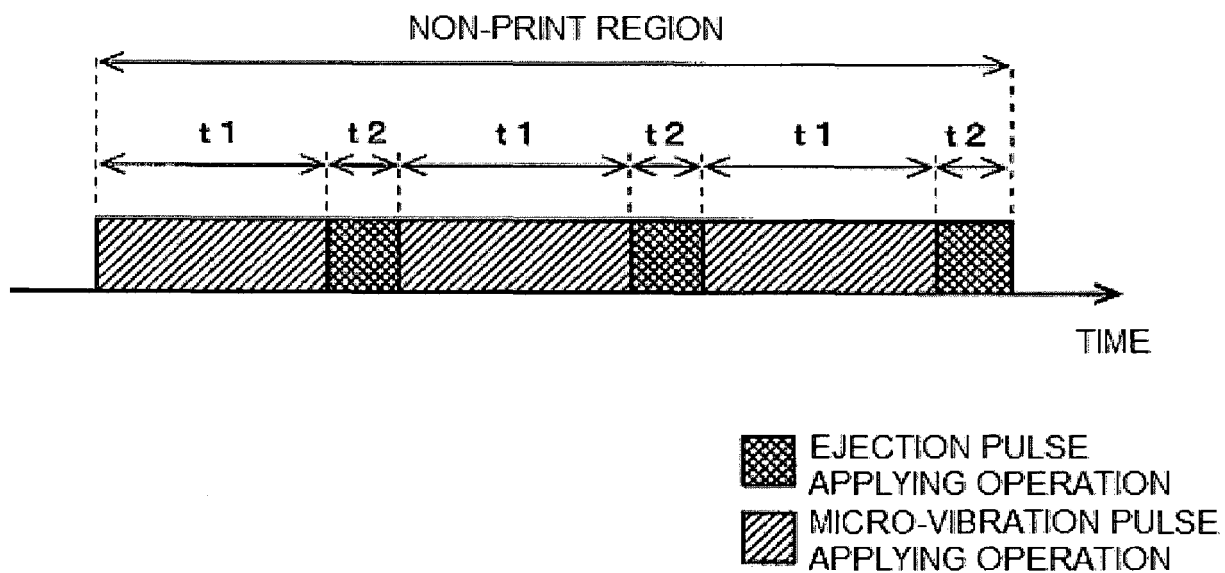


Fig. 7

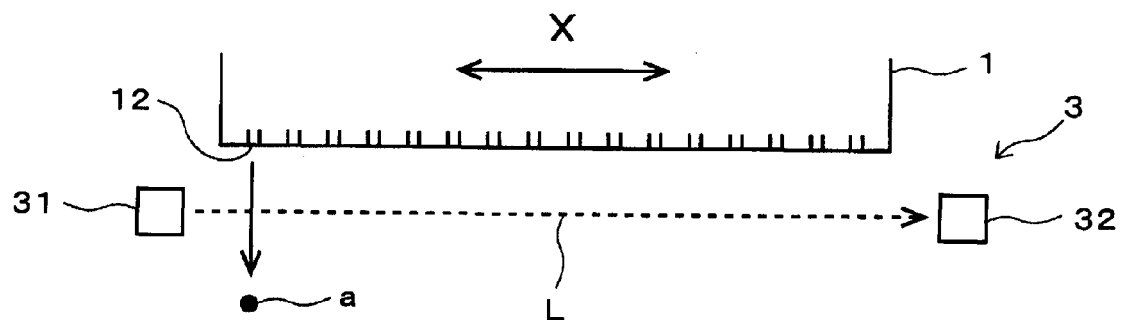


FIG. 8

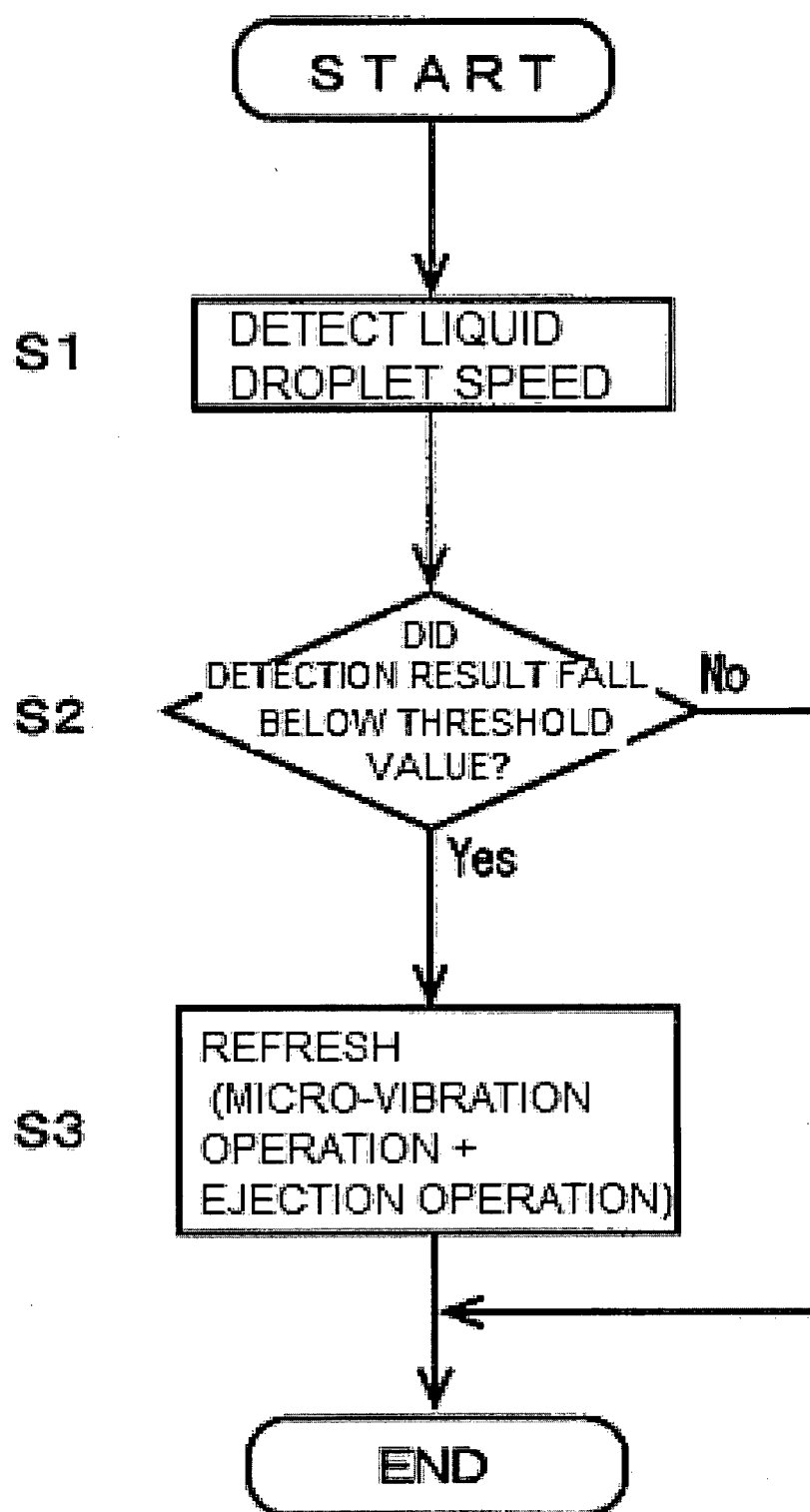


FIG. 9

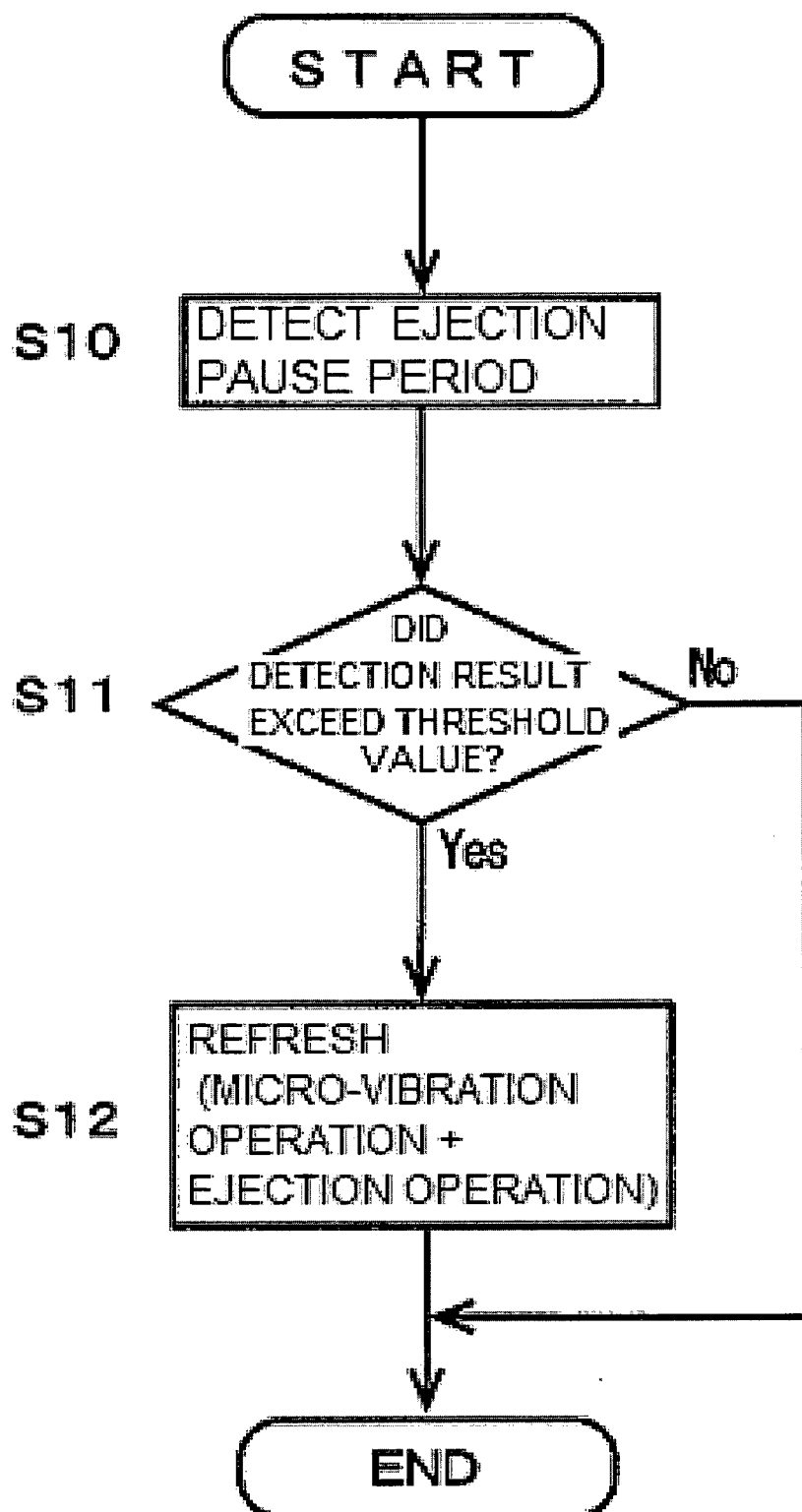


FIG. 10

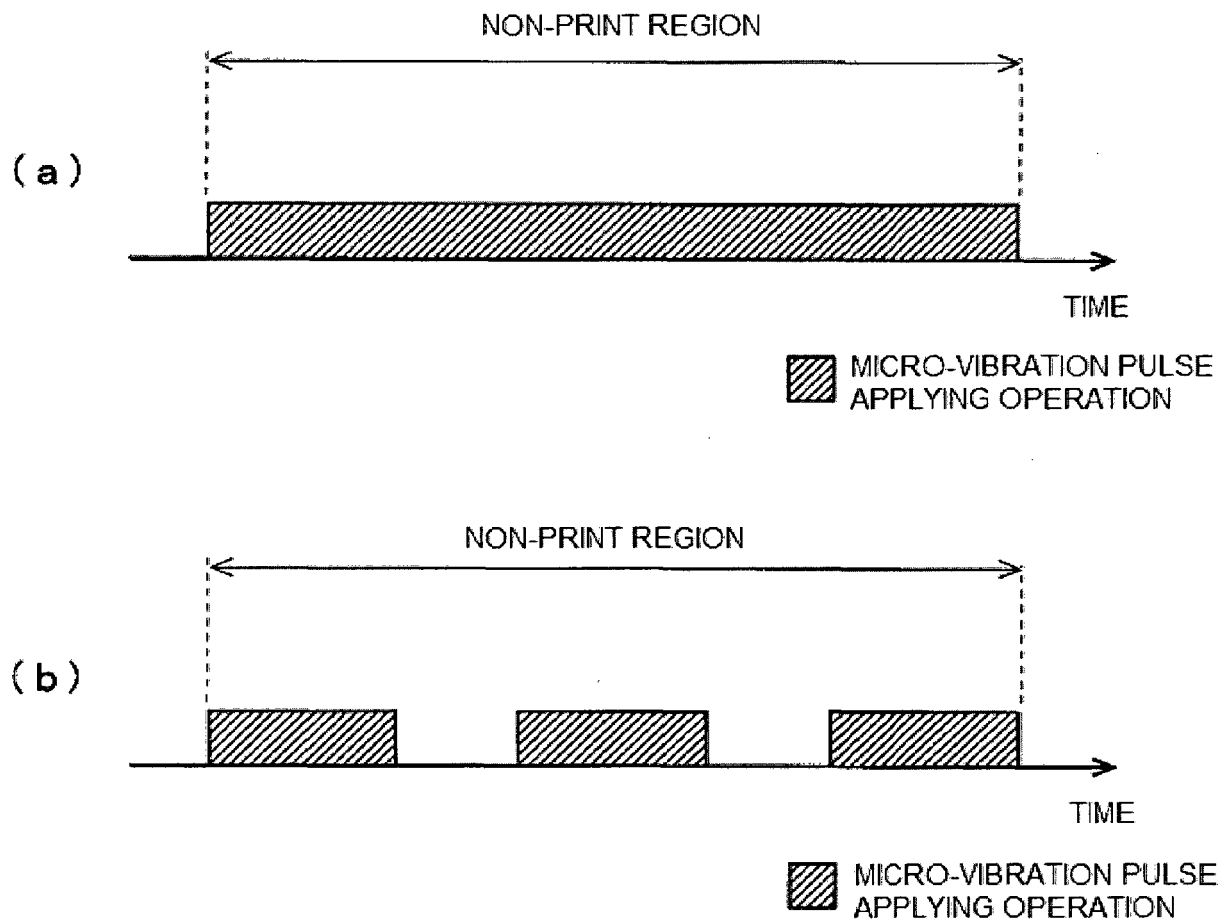


FIG. 11

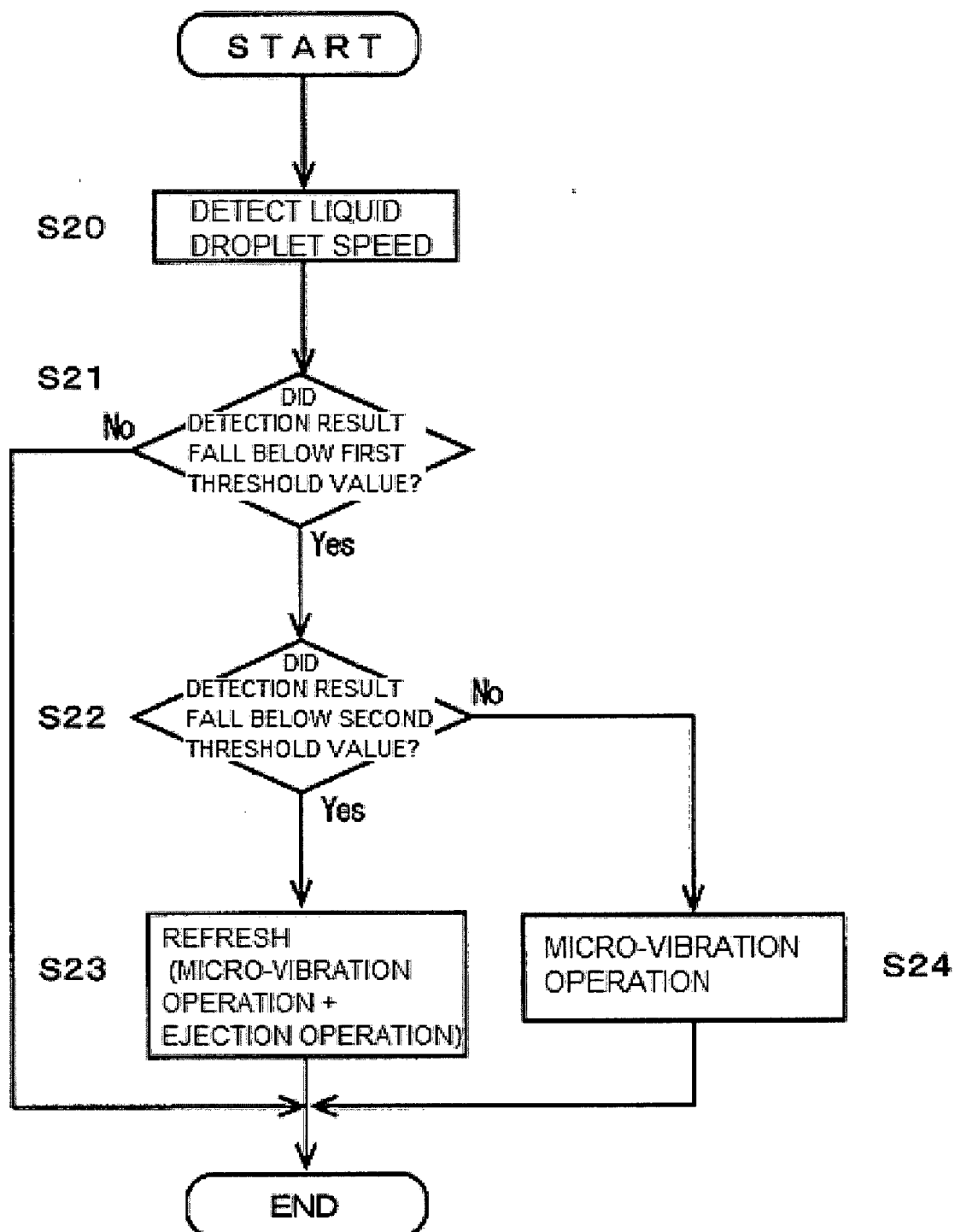


FIG. 12

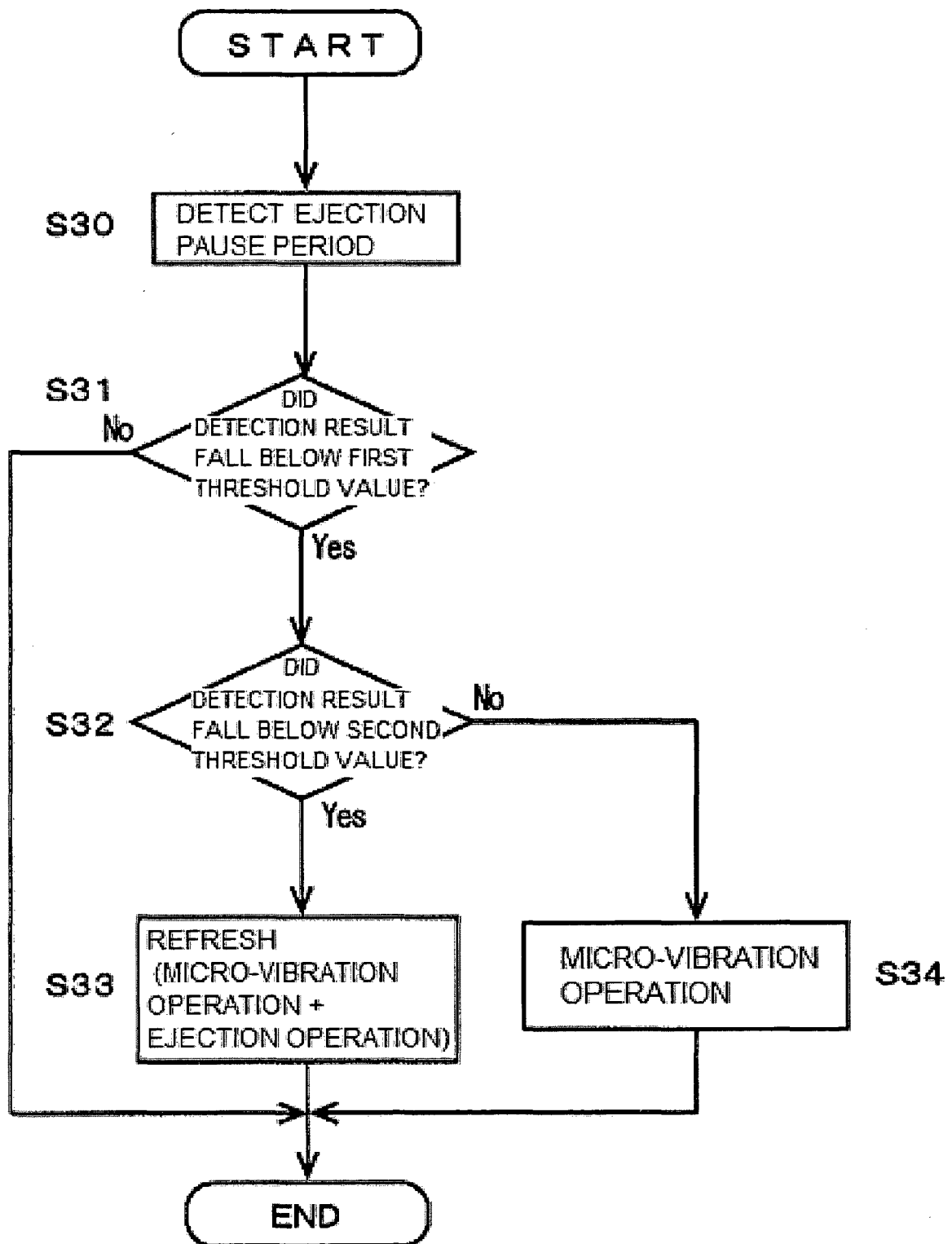


FIG. 13

RATIO OF SPECIFIC GRAVITY DIFFERENCE OF SOLID PARTICLES FROM SPECIFIC GRAVITY OF DISPERSION MEDIUM	LESS THAN +15%	+15% OR MORE AND LESS THAN +30%	+30% OR MORE
APPLICATION FREQUENCY OF MICRO- VIBRATION PULSE	10kHz	15kHz	20kHz

FIG. 14

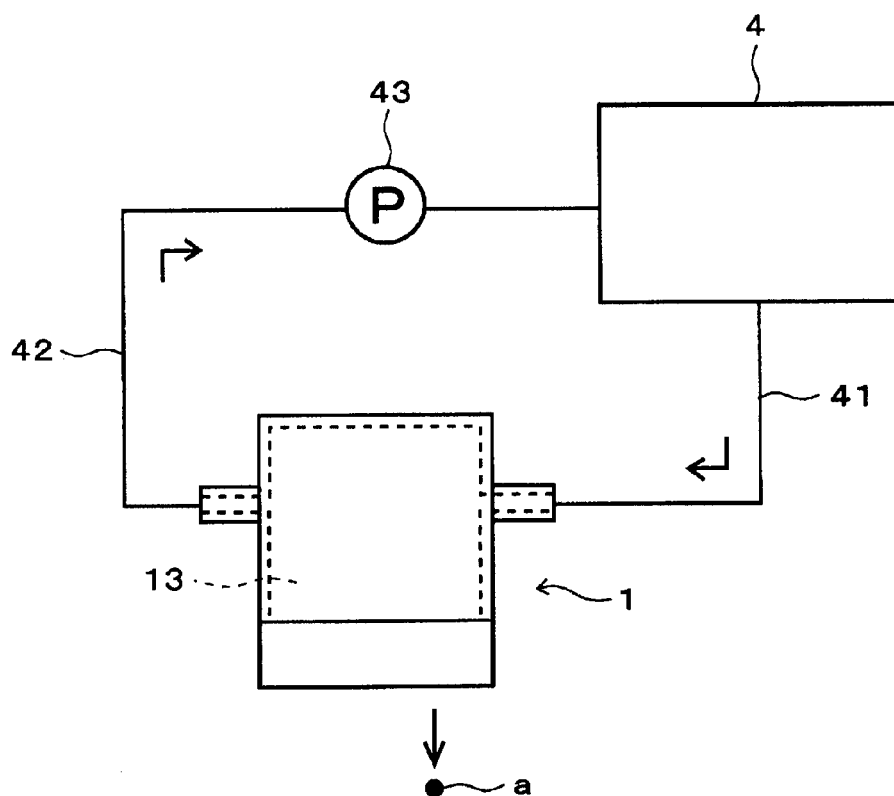
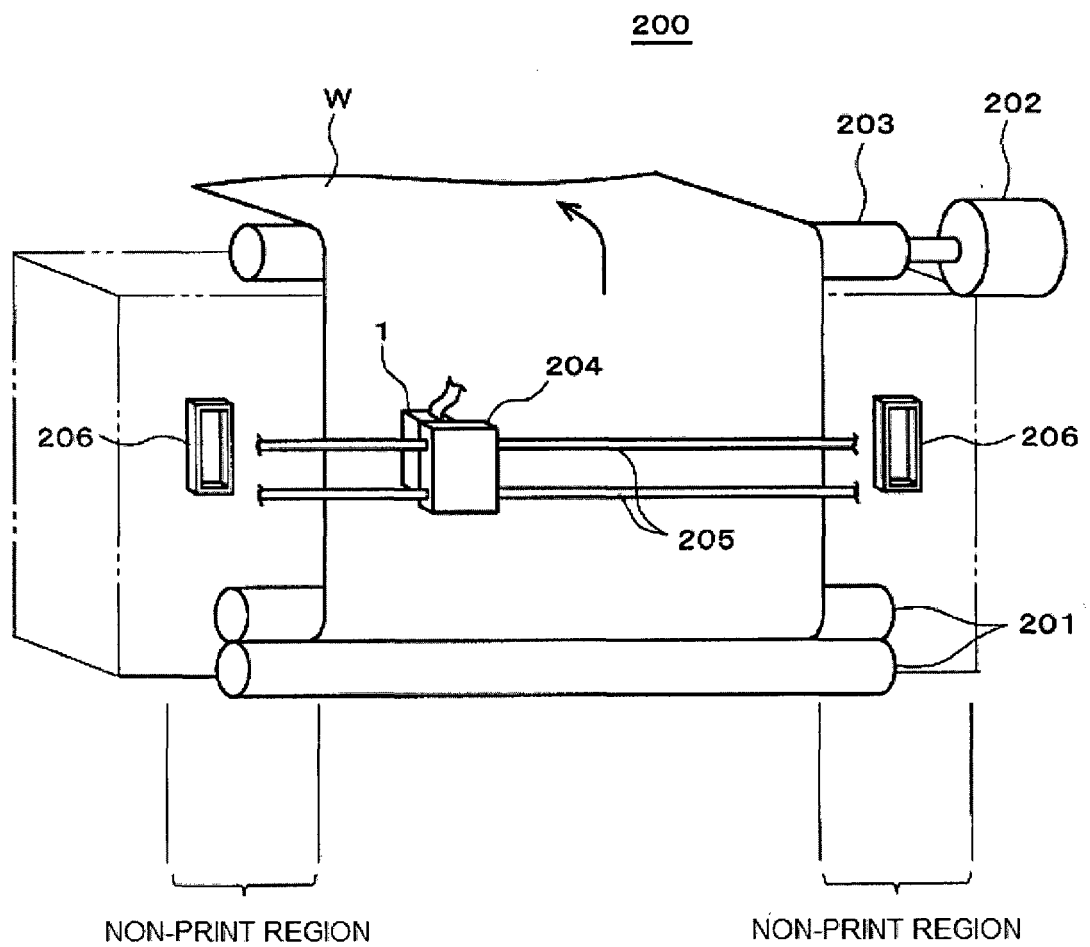


FIG. 15



REFERENCES CITED IN THE DESCRIPTION

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