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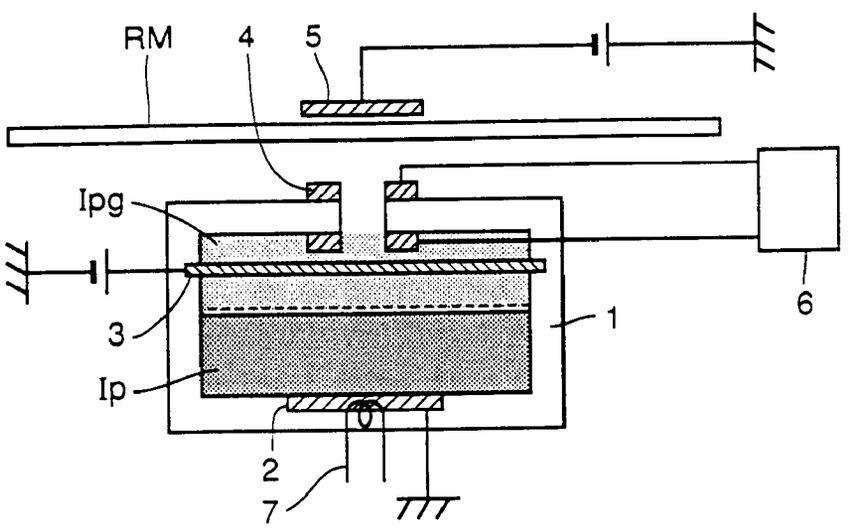
(54) Image recording method and apparatus using the same

(57) Powder ink (Ip) is heated and vaporized by a heating apparatus (2). The vaporized ink (Ipg) is charged by a charging electrode (3) and attracted toward a recording medium (RM) by a back electrode (5). An electric field shutter (4) controls passage of the gaseous ink (Ipg) through an ejection hole in accordance with an output signal of a control unit (6), and the gaseous ink (Ipg) is intermittently ejected to the recording medium (RM) in accordance with an electric signal corresponding to an image data to be recorded. As a result, the ink (Ipg) is efficiently utilized and running cost is reduced.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to image recording methods and apparatuses including a copying machine, a facsimile, and a printer, and more particularly to an image recording method and an apparatus for recording a predetermined image on a recording medium by using ink.

Description of the Background Art

As image recording apparatuses of an ejection type, image recording apparatuses employing an ink jet method or an electrostatic recording method have been proposed. According to the ink jet method, printing operation is carried out by pressurizing liquid ink contained in a tank by piezoelectric elements or the like in accordance with electric signals corresponding to image data and ejecting the pressurized ink from a nozzle. According to the electrostatic recording method, printing operation is carried out by charging powder or liquid (misty) ink, ejecting it from the nozzle by electrostatic suction force, and opening and closing a shutter provided at a tip of the nozzle in accordance with electric signals corresponding to image data.

However, the ink jet method gives rise to problems that printing operation cannot be achieved because sufficient pressurization in the ink tank is hindered by the air introduced into the tank, and that the nozzle is clogged up with ink and the recording medium is blurred with ink because liquid ink is employed, leading to degradation in image quality. The electrostatic recording method also gives rise to problems that the clogging is generated by the ink particles agglomerated by blocking if the ink used is powder, and that the image quality is degraded by the clogging and blur with ink similarly to the ink jet method.

As a method of solving the above-described problems, a method of ejecting the vaporized ink to be adhered onto the recording medium is proposed. According to this method, the clogging of the nozzle is less likely to occur because gas is ejected, and higher resolution as well as excellent gradation can be achieved because the pixel is recorded in the molecular state, thereby allowing high quality print with less blur. An image recording apparatus utilizing this method is disclosed in Japanese Patent Publication No. 56-2020. In the following, the above-mentioned conventional image recording apparatus will be described in detail with reference to Fig. 8. Fig. 8 is a block diagram showing the structure of the conventional image recording apparatus.

Referring to Fig. 8, the image recording apparatus includes a printing head 101, a heating apparatus 102, a charging electrode 103, electric field lenses 104 and 105, an electric field shutter 106, a back electrode 107, a power source 110 and a signal source 111. Heating apparatus 102 includes a power source 108, and an electric heater 109.

Ink Il in printing head 101 is heated and vaporized by heating apparatus 102 formed by electric heater 109 and power source 108. Gaseous ink Ig thus vaporized is jetted from printing head 101. At the same time, gaseous ink Ig is charged by power source 110 inserted between charging electrode 103 and printing head 101 as it passes through charging electrode 103. Gaseous ink Ig thus charged is converged by electric field lenses 104 and 105. Gaseous ink Ig thus converged is controlled to a predetermined ejection amount by electric field shutter 106 operation of which is controlled by signal source 111 and sprayed toward back electrode 107, whereby an image is formed on a recording medium RM.

In the conventional image recording apparatus above, however, the vaporized ink Ig is constantly ejected from printing head 101, thereby wasting ink which is not actually used for recording, leading to an increase in running cost. In addition, an apparatus for collecting the unused gaseous ink and an apparatus (not shown) for cleaning electric field shutter 106 and the surrounding elements are required, preventing reduction in size of the entire apparatus. Gaseous ink Ig is moved from printing head 101 to charging electrode 103 by increased pressure in printing head 101 due to volume expansion by vaporization of ink Il to cause gaseous ink Ig to jet out. Therefore, response in ejecting operation of gaseous ink Ig is poor and such operation is affected by the amount of ink Il in printing head 101, leading to an undesirable deterioration in quality of printing such as unequal density.

SUMMARY OF THE INVENTION

Therefore, an object of the present invention is to provide an image recording method and apparatus which allows effective use of ink and reduction in running cost.

Another object of the present invention is to provide an image recording apparatus which allows improvement in adherence of ink and printing with high resolution and excellent gradation of density.

Still another object of the present invention is to provide an image recording apparatus allowing improvement in fixing properties of ink method to enhance preservability.

The image method recording according to the present invention relates to an image recording method for recording a predetermined image on a recording medium with ink which includes the steps of intermittently ejecting vaporized ink in accordance with image data corresponding to an image, causing vaporized ink to adhere or permeate onto the recording medium, and recording the image on the recording medium. The step of intermittently ejecting vaporized ink includes the

steps of charging ink, vaporizing the charged ink by heat, and ejecting the vaporized ink with use of a back electrode disposed at a rear surface of the recording medium.

Since the vaporized ink is intermittently ejected in accordance with the image data corresponding to the image to adhere or permeate onto the recording medium so that the image is recorded on the recording medium, only the ink necessary for printing can be intermittently ejected without using unnecessary ink, whereby an image recording method allowing efficient use of the ink and reducing running cost can be provided.

According to another aspect of the present invention, an image recording apparatus for recording a predetermined image on the recording medium with ink includes a heater for vaporizing ink by heat, an ejector for ejecting vaporized ink to the recording medium, and a controller for controlling the vaporized ink so that the heated ink is intermittently ejected in accordance with image data corresponding to the image.

Since the heated ink is intermittently ejected in accordance with the image data corresponding to the image, only the ink necessary for printing can be ejected, thereby providing an image recording apparatus which can achieve efficient use of the ink and reduction in running cost.

The foregoing and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing a structure of an image recording apparatus according to a first embodiment of the present invention.

Fig. 2 is a perspective view of the image recording apparatus shown in Fig. 1.

Fig. 3 is a block diagram showing a structure of an image recording apparatus according to a second embodiment of the present invention.

Fig. 4 is a perspective view of the image recording apparatus shown in Fig. 3.

Figs. 5 to 7 are block diagrams showing structures of image recording apparatuses according to third through fifth embodiments of the present invention, respectively.

Fig. 8 is a block diagram showing a structure of a conventional image recording apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Now, the image recording apparatus according to the first embodiment of the present invention will be described below with reference to the drawings.

Referring to Fig. 1, the image recording apparatus includes a printing head 1, a heating apparatus 2 including an electric heater 7, a charging electrode 3, an electric field shutter 4, a back electrode 5, and a control unit 6.

Powder ink Ip is stored in printing head 1. At a lower part of printing head 1, heating apparatus 2 is provided for heating ink Ip. In the upper half portion of printing head 1, a thin wire electrode of 50-80 μm is provided as charging electrode 3 for charging the heated and vaporized ink Ipg. An ejection hole for ejecting vaporized ink Ipg is provided at the upper portion of printing head 1, and electric field shutter 4 controlling an amount of vaporized ink Ipg to be ejected is provided to surround the ejection hole. Electric field shutter 4 is formed by two electrode plates to sandwich the wall at the upper portion of printing head 1. Operation of electric field shutter 4 is controlled by control unit 6. A recording medium RM is disposed over electric field shutter 4, and back electrode 5 is provided over recording medium RM.

Fig. 2 is a perspective view of the image recording apparatus shown in Fig. 1. Referring to Fig. 2, at the upper portion of printing head 1, a plurality of ejection holes are provided, each corresponding to one pixel and provided with electric field shutter 4. When record density is 150 dpi, the distance between ejection holes is 169 μm and the hole has a diameter of 55 μm.

Next, operation of the image recording apparatus thus structured will be described. Upon printing, ink Ip is heated and vaporized by heating apparatus 2. As coloring material for the ink, anthraisothiazole family, quinophtalon family, pyrazolonazo family, pyridonazo family, styryl family or the like can be used for yellow; anthraquinone family, dicyanoimidazole family, thiadiazoleazo family, tricyanovinyl family or the like can be used for magenta; azo family, anthraquinone family, naphthoquinone family, indoaniline family or the like can be used for cyan. The same applies to the embodiments described later.

Ink Ip is vaporized to gaseous ink Ipg and a voltage of +2 - 5 kV is applied to charging electrode 3, whereby corona discharge occurs toward heating apparatus 2 connected to the ground. As a result, gaseous ink Ipg is charged to + ions. Next, a voltage of -0.5 to -2 kV is applied to back electrode 5 disposed at the rear surface with respect to the printing surface of printing medium RM, thereby attracting gaseous ink Ipg thus charged toward recording medium RM. At electric field shutter 4, a voltage of 50 V - 1 kV is applied to the electrode on the side of recording medium RM and the electrode inside printing head 1 in accordance with an output signal of control unit 6 corresponding to the electric signal of image data to be recorded. Consequently, gaseous ink Ipg is controlled to pass or to be prevented from passing through electric field shutter 4. Gaseous ink Ipg which has passed through electric field shutter 4 is attracted by back electrode 5 and adhered to recording medium RM to be printed. The voltage applied to electric field shutter 4 is set so that the potential difference between

electric field shutter 4 and back electrode 5 is large, taking into consideration the amount of increase in pressure in printing head 1 due to volume expansion caused by vaporization of ink Ip besides the Coulomb force of gaseous ink Ipg.

Through the operation above, ink Ip is vaporized to be gaseous ink Ipg, intermittently ejected from electric field shutter 4 in accordance with the electric signal corresponding to the image data to be recorded, and adhered or permeated to recording medium RM, so that the desired image can be formed. Therefore, ejection operation of gaseous ink Ipg is controlled in printing head 1 in accordance with the image data, without ejecting ink Ipg more than necessary, thereby allowing efficient printing and reduction in running cost. In addition, since heating apparatus 2, charging electrode 3, and electric field shutter 4 are integrally formed with printing head 1, ink Ipg blocked at electric field shutter 4 does not adhere to the inside of shutter 4. As a result, generation of the clogging is diminished, eliminating the need for an apparatus for collecting the adhered ink Ipg or a cleaning apparatus. Furthermore, printing response can be improved by attracting only the charged gaseous ink Ipg.

Although ink Ip before heated is powder in the embodiment above, liquid ink can also be employed, which excels in transportability and requires less amount of energy for evaporation. Since gaseous ink Ipg is charged, even the ink formed of insulating material can be charged, less susceptible to the environmental influences.

While gaseous ink Ipg is charged to be positive in the embodiment above, the ink can be charged to be negative by applying a negative voltage to charging electrode 3. In this case, countermeasures should be taken to prevent generation of toxic substances since it causes more toxic substances including ozone to generate than positive charging.

Although electric field shutter 4 is employed for controlling the ejection amount of gaseous ink Ipg in the present embodiment, an electromagnetic shutter, or a shutter physically opened and closed by piezoelectric elements and the like can also be employed. The same applies to the embodiments described in the following.

Now, an image recording apparatus according to a second embodiment of the present invention will be described with reference to the drawings. Fig. 3 is a block diagram showing a structure of the image recording apparatus according to the second embodiment of the present invention.

Referring to Fig. 3, the image recording apparatus includes a printing head 1a, heating apparatus 2 including electric heater 7, a charging electrode 3a, an electric field shutter 4a, back electrode 5, and control unit 6a. Liquid ink Il is stored in printing head 1a. At the lower portion of printing head 1a, heating apparatus 2 is provided formed of a radiation plate and electric heater 7 for heating up ink Il as described above. At the side surfaces of the lower portion of printing head 1a, two electrodes for introduction of electric charges are provided to sandwich the stored ink Il as charging electrodes 3a for charging ink Il. Electric field shutter 4a is provided at the upper portion of the printing head 1a. Operation of shutter 4a is controlled by control unit 6a. Recording medium RM is disposed over electric field shutter 4a, and back electrode 5 is disposed over recording medium RM.

Fig. 4 is a perspective view of the image recording apparatus shown in Fig. 3. Referring to Fig. 4a, a slit is formed as an ejection hole of gaseous ink Ilg at the upper portion of printing head 1a. Electric field shutters 4a and 4b are provided on both sides of the longer side of the slit. The slit has a length corresponding to the printing width; the width of the slit is set at 200 μm when the printing density is 150 dpi. One side 4a of the electric field shutter is connected to ground, while the other side 4b is provided with a plurality of electrodes in a comb-like shape spaced apart by the distance of 169 μm corresponding to the printing density.

Next, operation of the image recording apparatus structured as such will be described. Upon printing, the potential difference between the two charging electrodes 3a is set at 2-5 kV, thereby introducing electric charges to ink Il and charging the ink to + ions. The charged ink Il is vaporized by heating apparatus 2 to turn into gaseous ink Ilg while maintaining the charged state. Electric charges of -1 kV are applied to back electrode 5 disposed at the rear surface with respect to the printing surface of recording medium RM, thereby attracting gaseous ink Ilg to recording medium RM. It should be noted that shutter 4a usually receives a voltage of 50 V - 1 kV and prevents passage of gaseous ink Ilg and permits passage of gaseous ink Ilg by controlling the potential of electrode 4b corresponding to each pixel in accordance with an output signal of control unit 6 corresponding to the electric signal of the image data to be recorded. Gaseous ink Ilg passed through electric field shutter 4a is attracted by back electrode 5, adhered and printed on recording medium RM.

As described above, the second embodiment enjoys the effects similar to the first embodiment. Ejection of gaseous ink Ilg is controlled in printing head 1a in accordance with the image data, so that only the required amount of ink is ejected to achieve efficient printing. Since heating apparatus 2, charging electrode 3a, and electric field shutter 4a are integrally formed with printing head 1a, ink prevented from passing through electric field shutter 4 does not adhere to shutter 4a, thereby diminishing generation of the clogging. The apparatuses for cleaning and collecting the ink stuck to the shutter are not needed, whereby allowing reduction in size and weight of the apparatus.

According to the second embodiment, charging operation can be performed without generating toxic substances including ozone because solid or liquid ink is charged and then heated and vaporized. Since the ejection hole for ink Ilg is formed as a slit, the clogging is suppressed and the need for providing an ejection

hole for each pixel is eliminated, thereby simplifying the structure of printing head 1a.

While ink Il before heated is liquid in the embodiment above, powder ink can also be employed. In this case, a friction charging method can be adopted as well as the above-described charging method of introducing electric charges, and leakage from printing head 1a is reduced. Meanwhile, if the liquid ink is employed, inequality in charging is diminished as compared to powder ink, thereby achieving efficient charging.

Now, an image recording apparatus according to a third embodiment of the present invention will be described with reference to the drawings. Fig. 5 is a block diagram showing a structure of the image recording apparatus according to the third embodiment of the present invention.

Referring to Fig. 5, the image recording apparatus includes a printing head 1b, a first heating apparatus 2a including a first electric heater 7a, a second heating apparatus 2b including a second electric heater 7b, a charging electrode 3a, electric field shutter 4a, back electrode 5, and control unit 6a.

Powder ink Ip is stored in printing head 1b. First and second heating apparatuses 2a and 2b are disposed at the lower portion of printing head 1b. First heating apparatus 2a is formed of a radiation plate and electric heater 7a for heating up ink Ip, and second heating apparatus 2b has the similar structure. First heating apparatus 2a heats up ink Ip, so that liquid ink Ipl flows along a slope having a predetermined inclination in printing head 1b to second printing apparatus 2b. Second heating apparatus 2b heats up liquid ink Ipl to turn into gaseous ink Ipg. More specifically, powder ink Ip is heated to 160°C and liquefied by first heating apparatus 2a. Liquid ink Ipl accumulates at the lower portion of printing head 1b and heated to 210°C to vaporize by second heating apparatus 2b provided at the lower portion.

Gaseous ink Ipg thus vaporized charges to + ions by applying a voltage of +2 - 5 kV to charging electrode 3a formed of a needle electrode to cause discharge toward second heating apparatus 2b which is connected to ground. Gaseous ink Ipg thus charged is attracted toward recording medium RM by applying a voltage of -0.5 to -2 kV to back electrode 5 disposed at the rear surface with respect to the printing surface of recording medium RM.

Electric field shutters 4a and 4b are arranged on both sides along the longer side of the slit serving as an ejection hole and provided at the upper portion of printing head 1b, similarly to the second embodiment described above. The slit has a length corresponding to the printing width, and a width of 200 μm if the printing density is 150 dpi. One side 4a of the electric field shutter is connected to ground while the other side 4b is provided with the electrodes in a comb-like shape spaced apart by a distance of 169 μm corresponding to the recording density. A voltage of normally 50 V - 1 kV is applied to shutter 4b to prevent passage of gaseous ink Ipg and permit passage of gaseous ink Ipg by controlling the potential of the electrodes corresponding to respective pixels in response to the output signal of control unit 6a corresponding to the electric signal of the image data to be recorded. The gaseous ink Ipg passed through electric field shutters 4a and 4b is attracted by back electrode 5, and adhered and printed on recording medium RM.

As described above, according to the third embodiment as well, ejection of gaseous ink Ipg can be controlled in printing head 1b in accordance with the image data, without ejecting ink more than necessary, thereby achieving efficient printing. Since the ejection hole of ink is formed as a slit, clogging is suppressed and the need for providing an ejection hole for each pixel is eliminated, thereby simplifying the structure of the printing head 1b. Since ink is heated in two stages, the temperature of ink is controlled more easily and ink is not vaporized more than necessary, thereby minimizing volume expansion in the printing head due to vaporization of ink. As a result, the ink does not flow from the ejection hole more than necessary, thereby achieving even more efficient printing.

Although the ejection hole is provided corresponding to each pixel in the first embodiment above, the ejection hole can be formed as a slit as in the second and third embodiments. In addition, the ejection hole can be provided for each pixel in the second and third embodiments.

In the embodiments above, the temperature of recording medium RM is not controlled and printing operation is performed at a temperature close to the room temperature. As a result, there is great difference in temperature between recording medium RM and vaporized ink Ipg, whereby vaporized ink Ipg may be liquefied or solidified before attaching to recording medium RM to deteriorate adhesion of the ink. Although the temperature of the vaporized ink may be raised to solve such a problem, too high a temperature destroys physical properties of the ink to affect the quality of printing. In addition, load is placed on the printing head, causing problems in terms of durability and efficiency. As another problem, some ink adheres only onto the surface of the recording medium RM and does not sink into recording medium RM. Therefore, such ink exhibits poor fixing properties and gives effects on the quality of printing, and also causes problems in terms of preservation. Especially when sublimation dye is employed as ink, sublimation dye sinks into the receptive layer on the recording medium to carry out printing, and therefore the ink adhered to the recording medium in the liquid or solid form is not fixed thereto.

Now, embodiments solving such problems as above will be described in detail. First, with reference to the drawings, description will be made of an image recording apparatus according to a fourth embodiment that can improve adherence properties of ink to the recording medium. Fig. 6 is a block diagram showing a

structure of an image recording apparatus according to the fourth embodiment of the present invention.

Referring to Fig. 6, the image recording apparatus includes printing head 1, heating apparatus 2 including electric heater 7, charging electrode 3, electric field shutter 4, back electrode 5, control unit 6, a preheating roller 8, and a resilient roller 9. Preheating roller 8 and resilient roller 9 are provided to face each other at the front with respect to the printing direction of the printing head. Preheating roller 8 is an aluminum tube coated with fluoroplastic and has a tungsten halogen lamp inserted in the tube. Resilient roller 9 is formed by a metal mandrel with silicon rubber rolled therearound.

Powder ink Ip is provided in printing head 1. At the lower portion of printing head 1, heating apparatus 2 for heating up ink Ip is disposed. In the upper half portion of printing head 1, charging electrode 3 formed of wire electrode of 50-80 μm is provided as a charging mechanism for charging ink Ipg thus heated and vaporized. An ejection hole for ejecting vaporized ink Ipg is disposed at the upper portion of the printing head 1, and electric field shutter 4 for controlling an ejection amount of vaporized ink Ipg is provided to surround the ejection hole. Shutter 4 is formed by two electrode plates to sandwich the wall of the upper portion of the printing head 1. Operation of shutter 4 is controlled by control unit 6. Over electric field shutter 4 recording medium RM is disposed, over which back electrode 5 is provided.

Now, the operation of the image recording apparatus thus structured will be described. Before printing, recording medium RM passes through the space between preheating roller 8 and resilient roller 9, brought into contact with these rollers by pressure of 300 gf/cm. Preheating roller 8 heats up recording medium RM to 120-180°C by turning on/off the internal tungsten halogen lamp.

Upon printing, heating apparatus 2 heats up ink Ip to 150-200°C to be vaporized. As coloring material of ink, anthraisothiazole family, quinophtalon family, pyrazolonazo family, pyridonazo family, styryl family or the like can be used for yellow; anthraquinone family, dicyanoimidazole family, thiadiazoleazo family, tricyanovinyl family or the like can be used for magenta; azo family, anthraquinone family, naphthoquinone family and indoaniline family can be used for cyan.

Ink Ip is vaporized to turn into gaseous ink Ipg, which is charged to + ions by applying a voltage of +2 - 5 kV to charging electrode 3 to cause corona discharge toward heating apparatus 2 connected to ground. A voltage of -0.5 to -2 kV is applied to back electrode 5 disposed at the rear surface with respect to the printing surface of recording medium RM, thereby attracting charged gaseous ink Ipg to recording medium RM. At electric field shutter 4, a voltage of 50 V - 1 kV is applied to the electrode on the side of recording medium RM and the electrode in printing head 1 in accordance with the output signal of control unit 6 corresponding to the electric signal of the image data to be recorded. As a result, gaseous ink Ipg is controlled to pass or to be blocked from passing through shutter 4. Gaseous ink Ipg passed through electric field shutter 4 is attracted by back electrode 5 and adhered and printed to the preheated recording medium RM.

Preheating roller 8 is desirably disposed near printing head 1 to achieve printing before the heat escapes. However, if preheating roller 8 is so disposed, consideration should be given to the effects imposed by the heat of roller 8 on printing head 1. While fluoroplastic is employed to coat the aluminum tube of preheating roller 8, other materials can be used for coating as long as the material is heat-resistant resin resisting the temperature of 300°C or higher, such as silicon.

Next, an image recording apparatus that can improve fixing properties of ink, one of the problems above, according to the fifth embodiment will be described with reference to the drawings. Fig. 7 is a block diagram showing a structure of the image recording apparatus according to the fifth embodiment of the present invention.

Referring to Fig. 7, the image recording apparatus includes printing head 1a, heating apparatus 2 including electric heater 7, charging electrode 3a, electric field shutter 4a, back electrode 5, control unit 6, a fixing roller 10, and a resilient roller 11.

Fixing roller 10 and resilient roller 11 are disposed to face each other at the back with respect to the printing direction of the printing head. Fixing roller 10 is an aluminum tube coated with fluoroplastic and has a tungsten halogen lamp inserted in the tube. Resilient roller 11 has a metal mandrel with silicon rubber rolled therearound.

Liquid ink Il is stored in printing head 1a. At a lower portion of printing head 1a, heating apparatus 2 is provided which is formed by a radiation plate and electric heater 7 for heating up ink Il as described above. At the side surfaces of the lower portion of the printing head 1a, charging electrodes 3a formed by two electrodes for introduction of electric charges are provided to sandwich the stored ink Il as a charging mechanism for charging ink Il. At the upper portion of printing head 1a, a slit is formed as an ejection hole for ejecting vaporized ink Ilg. Electric field shutter 4a is provided on either side of the longer side of the slit. The slit has a length corresponding to the printing width and has a width of 200 μm if the printing density is 150 dpi. Electric field shutter 4a has one side connected to ground and the other side provided with a plurality of electrodes 4b in a comb-like shape spaced apart by a distance of 169 μm corresponding to the recording density, similarly to the structure shown in Fig. 4. Operation of field electric shutter 4a is controlled by control unit 6. Over electric field shutter 4a recording medium RM is disposed, over which back electrode 5 is provided.

Next, operation of the image recording apparatus thus structured will be described. Upon printing, the difference in potential between charging electrodes 3a is set at 2-5 kV, thereby introducing electric charges to ink

Il and charging the ink to + ions. Ink Il thus charged is heated to 150-200°C and vaporized by heating apparatus 2 to turn into gaseous ink Ilg, maintaining the charged state. A voltage of -1 kV is applied to back electrode 5 disposed at the rear surface with respect to the printing surface of the recording medium RM, thereby attracting charged usually gaseous ink Ilg toward recording medium RM. A voltage of usually 50 V - 1kV is applied to electric field shutter 4a to prevent passage of gaseous ink Ilg and to permit passage of gaseous ink Ilg by controlling the potential of electrode 4b corresponding to each pixel in accordance with the output signal of control unit 6 corresponding to the electric signal of the image data to be recorded. Gaseous ink Ilg passed through electric field shutter 4a is attracted by back electrode 5, and adhered and printed to printing medium RM.

After printed, recording medium RM passes through the space between fixing roller 10 and resilient roller 11, brought into contact therewith by pressure of 1.5 - 2 kgf/cm. Fixing roller 10 turns on/off the tungsten halogen lamp, thereby heating up recording medium RM to 150-200°C to fix the ink on the recording medium RM.

Next, an image recording apparatus according to a sixth embodiment of the present invention will be described. The image recording apparatus according to the sixth embodiment of the present invention has a structure similar to that of the fourth embodiment shown in Fig. 6, and therefore the structure thereof will not be described in detail and only the characteristics of the sixth embodiment will be described below with reference to Fig. 6.

Referring to Fig. 6, preheating roller 8 and resilient roller 9 are disposed to face each other, at the front with respect to the printing direction of the printing head, similarly to the fourth embodiment. Preheating roller 8 is an aluminum tube coated with fluoroplastic and has a tungsten halogen lamp inserted into the tube. Resilient roller 9 has a metal mandrel with silicon rubber rolled therearound.

Before printing, recording medium RM is brought into contact with preheating roller 8 and resilient roller 9 at a pressure of 1.5 - 2 kgf/cm and passes through the rollers. Preheating roller 8 heats up recording medium RM to 120-180°C by turning on/off the tungsten halogen lamp. Upon printing, ink Ip is heated to 150-200°C and vaporized by heating apparatus 2. Ink Ip is vaporized to be gaseous ink Ipg, and gaseous ink Ipg is charged to + ions by applying a voltage of +2 - 5 kV to charging electrode 3 to cause corona discharge toward heating apparatus 2 connected to ground.

A voltage of -0.5 to -2 kV is applied to back electrode 5 disposed at the rear surface with respect to the printing surface of recording medium RM, whereby the charged gaseous ink Ipg is attracted toward recording medium RM. At electric field shutter 4, a voltage of 50 V-1 kV is applied to the electrode on the side of recording medium RM and the electrode in printing head 1 in accordance with the output signal of control unit 6 corresponding to the electric signal of the image data to be recorded. As a result, gaseous ink Ipg is controlled to pass or to be prevented from passing through electric field shutter 4. Gaseous ink Ipg passed through electric field shutter 4 is attracted by back electrode 5 and adhered and printed to the preheated recording medium RM.

After first printing operation to recording medium RM is completed, recording medium RM is fed in a reverse direction to the printing direction, and recording medium RM is brought into contact with preheating roller 8 and resilient roller 9 by a pressure of 1.5-2 kgf/cm and passes therethrough. Preheating roller 8 heats recording medium RM to 150-200°C by turning on/off the tungsten halogen lamp, thereby fixing the ink on recording medium RM.

While the heating temperatures of preheating roller 8 are different for preheating and fixing, they are set at the same temperature if causing no problems in terms of heat resistant properties of recording medium RM and the ink and the like, and such setting contributes to easier temperature control. While the pressure imposed on the sheet by preheating roller 8 and resilient roller 9 is the same for preheating and fixing, the pressure upon preheating can be reduced by additionally providing a pressure adjusting mechanism. In that case, recording medium RM can be fed at an appropriate pressure upon preheating to reduce the burden on the transport system for recording medium RM, though the apparatus is undesirably increased in size and control thereof becomes complicated.

As a seventh embodiment, fixing roller 10 in the fifth embodiment can be used as a preheating roller for both fixing and preheating as in the sixth embodiment. Then, the recording medium is transported from the fixing roller side in a reverse direction with respect to the printing direction. The recording medium is brought into contact with the fixing roller and the resilient roller and passes through the rollers. By turning on/off the tungsten halogen lamp, the recording medium is heated to 120-180°C. After the sheet is fed, printing is conducted by the printing head while transporting the recording medium in the printing direction and the ink is fixed by the fixing roller as in the fifth embodiment. Since printing is not conducted immediately after preheating, the efficiency is rather low. Particularly, the difference in temperature of the recording medium upon printing may vary at the leading edge and the trailing edge of the medium.

Although the preheating roller 8 is used for both preheating and fixing in the sixth embodiment and fixing roller 10 is used for both preheating and fixing in the seventh embodiment, respective rollers dedicated to preheating and fixing can be provided as an eighth embodiment. If such rollers are provided, fixing roller 10 and resilient roller 11 are additionally provided at the side opposing to preheating roller 8 in the fourth embodiment shown in Fig. 6, and preheating roller 8 and resil-

ient roller 9 are additionally provided at the side opposing to fixing roller 10 in the fifth embodiment shown in Fig. 7. As a result, preheating and fixing can be conducted by using respective dedicated rollers, allowing preheating and fixing under the optimum conditions, so that resolution is improved and printing can be carried out with excellent density and fixing properties, and ink can be fixed more stably to improve preservation properties.

While the first through eighth embodiments are described above, the embodiments can be combined as desired and the effects thereof can be similarly obtained.

Although the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of the present invention being limited only by the terms of the appended claims.

Claims

1. An image recording method for recording a predetermined image on a recording medium with ink (Ipg), comprising:

   a first step of intermittently ejecting said ink (Ipg) vaporized, in accordance with image data corresponding to said image; and
   a second step of causing said vaporized ink (Ipg) to adhere or permeate on said recording medium (RM) and recording said image on said recording medium (RM);

   wherein
   said first step includes

   a third step of charging said ink (Ipg),
   a fourth step of vaporizing said ink by heating (7), and
   a fifth step of ejecting said vaporized ink by using a back electrode (5) provided at a rear surface of said recording medium (RM).

2. The image recording method according to claim 1, wherein said third step includes a sixth step of charging liquid ink (Ipg).

3. The image recording method according to claim 1, wherein said third step is carried out before said fourth step.

4. The image recording method according to claim 1, wherein said fourth step is carried out before said third step.

5. The image recording method according to claim 1, wherein said third step includes a sixth step of vaporizing liquid ink by heating (7).

6. An image recording apparatus for recording a predetermined image on a recording medium with ink (Ipg), comprising:

   heating means (7) for vaporizing said ink by heating;
   ejection means (3, 5) for ejecting said vaporized ink (Ipg) to said recording medium (RM); and
   control means (6) for controlling said vaporized ink so that said heated ink (Ipg) is ejected intermittently in accordance with image data corresponding to said image.

7. The image recording apparatus according to claim 6, wherein
   said ejection means (3, 5) includes

   a charging electrode (3) for charging said ink, and
   a back electrode (5) provided at a rear surface of said recording medium for attracting the ink charged by said charging electrode to said recording medium (RM);

   said control means (6) includes

   a shutter (4) for controlling said ink to be intermittently ejected, and
   a controller for controlling operation of said shutter (4) in accordance with said image data; and

   said heating means (7), said charging electrode (3) and said shutter (4) are integrally formed.

8. The image recording apparatus according to claim 7, wherein
   said shutter (4) includes

   an ejection hole in the form of a slit for ejecting said ink (Ipg), and
   a plurality of electrodes having a width corresponding to a record pixel of said image and provided on both sides of a longer side of said ejection hole.

9. The image recording apparatus according to claim 6, wherein
   said heating means (7) includes

   first heating means (7a) for preheating said ink, and second heating means (7b) for further heating the ink heated by said first heating means and vaporizing said ink.

10. The image recording apparatus according to claim 6, further comprising preheating means (8) for preheating said recording medium (RM) before said

ejection means (3, 5) ejects said vaporized ink (Ipg) to said recording medium (RM).

11. The image recording apparatus according to claim 6 or 10, further comprising fixing means (10) for fixing the ink on said recording medium (RM) after said ejection means (3, 5) ejects said vaporized ink (Ipg) to said recording medium (RM).

12. The image recording apparatus according to claim 6, further comprising:

preheating means (8) for preheating said recording medium (RM) before said ejection means (3, 5) ejects said vaporized ink (Ipg) to said recording medium (RM); and
fixing means (10) for fixing the ink on said recording medium (RM) after said ejection means (3, 5) ejects said vaporized ink (Ipg) to said recording medium;

wherein

said preheating means (8) and said fixing means (10) are formed by one apparatus used both as said preheating means (8) and said fixing means (10).

FIG. 1

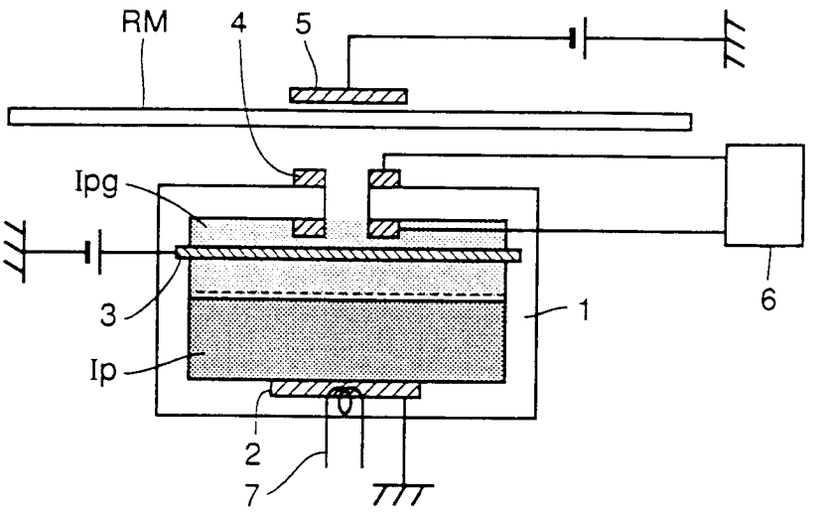


FIG. 2

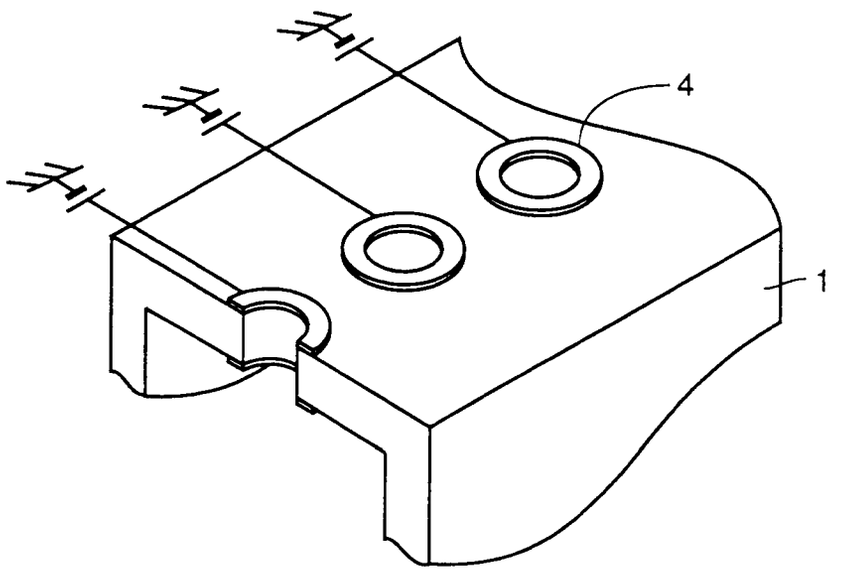


FIG. 3

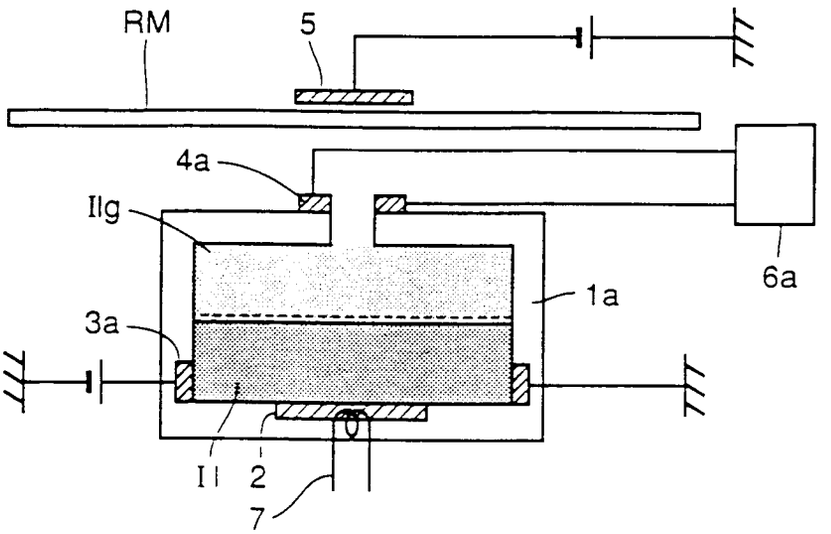


FIG. 4

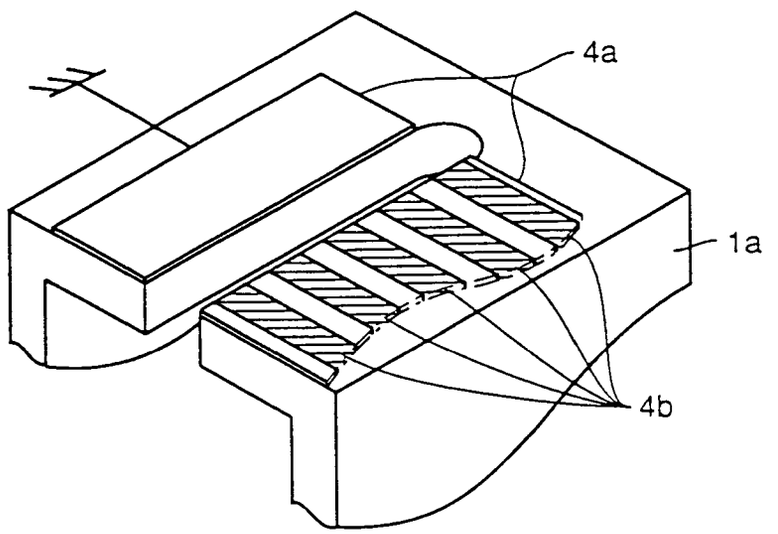


FIG. 5

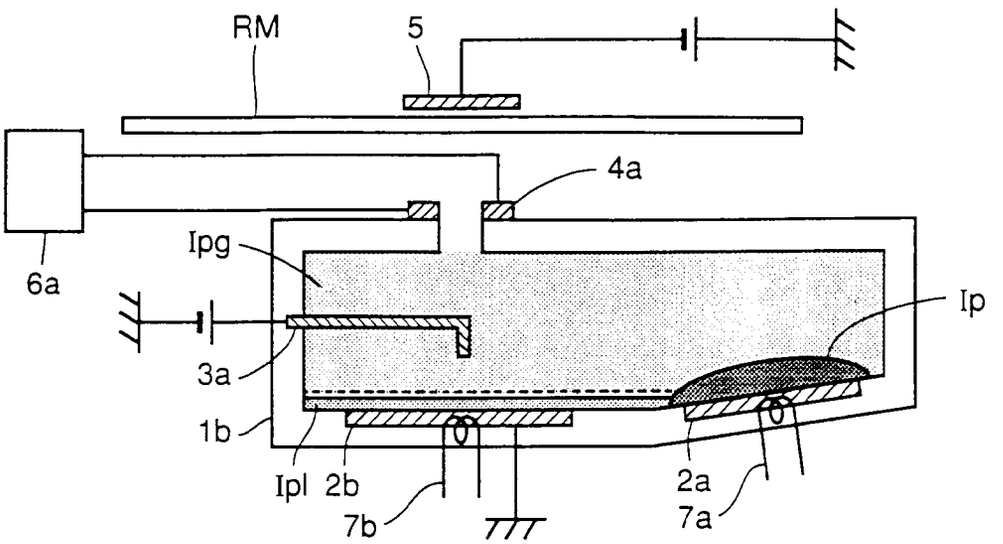

RM
5
4a
Ipg
6a
Ip
3a
1b
Ipl
2b
7b
2a
7a

FIG. 6

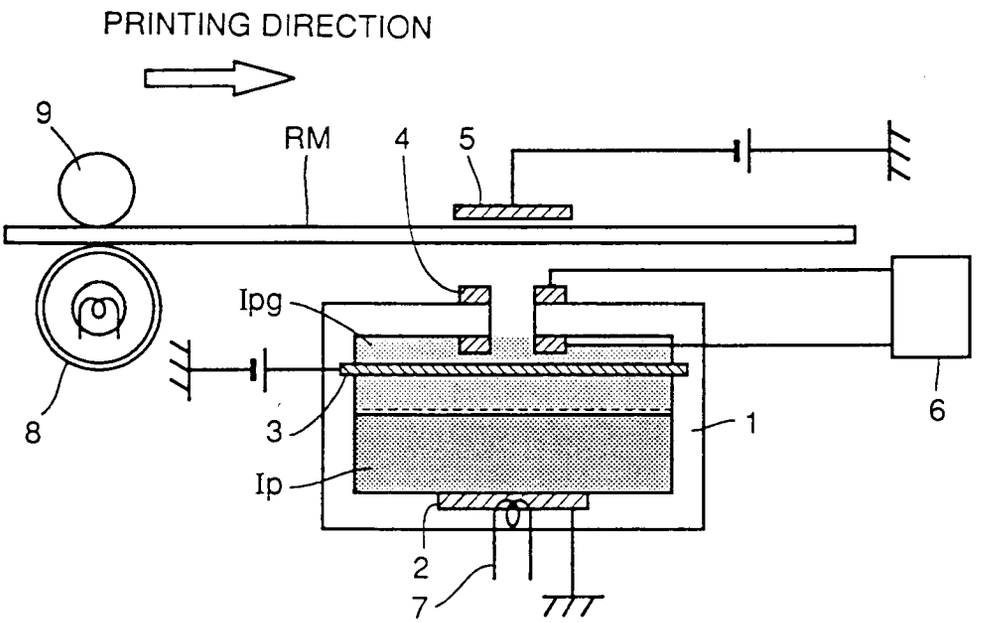

PRINTING DIRECTION
9
RM
4
5
Ipg
8
3
1
6
Ip
2
7

FIG. 7

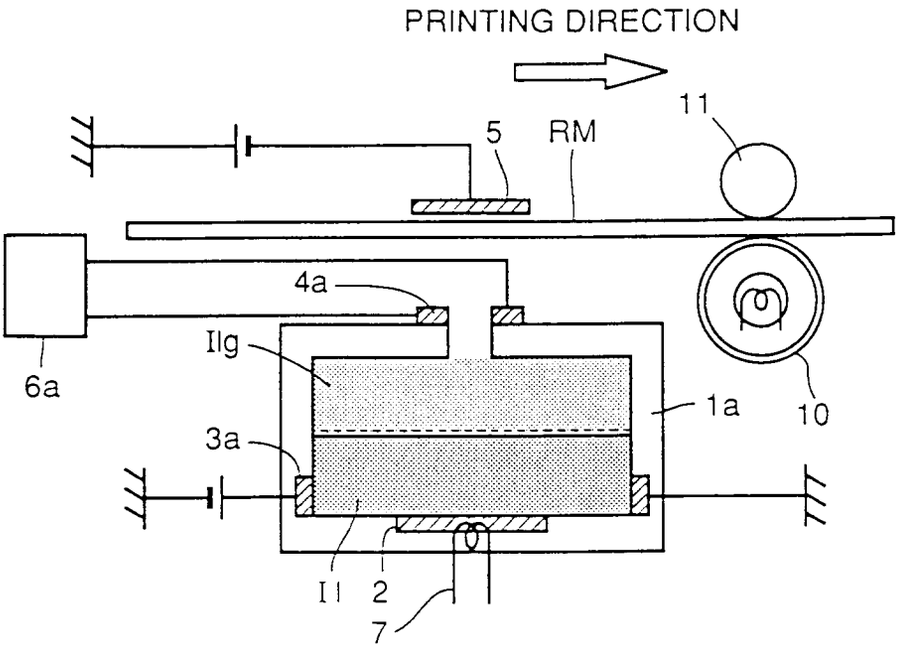
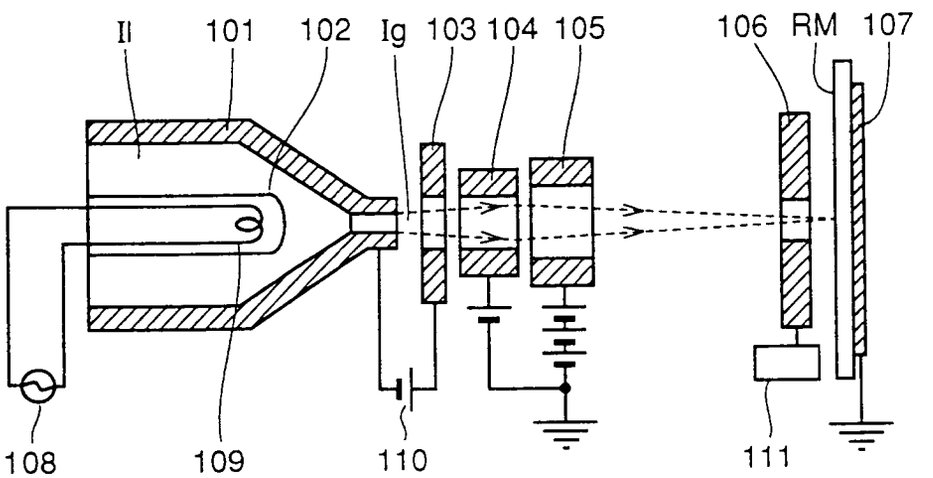

PRINTING DIRECTION
11
5
RM
4a
Ilg
6a
1a
10
3a
I I
2
7

FIG. 8


Il
101
102
Ig
103
104
105
106
RM
107
108
109
110
111