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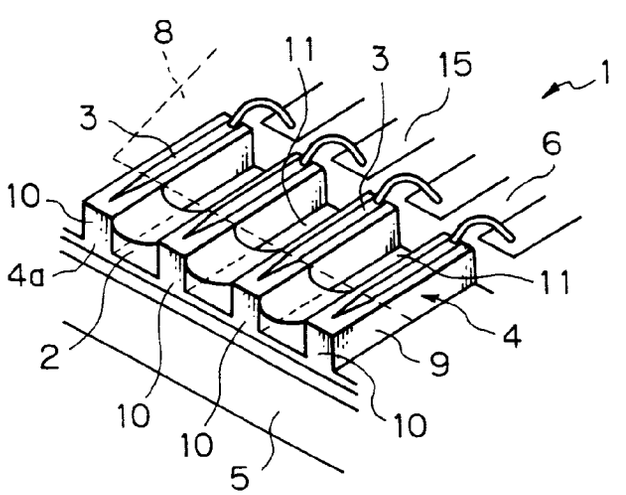
(54) Record head for an electrostatic ink jet recorder

(57) A record head for an electrostatic ink jet recorder of the present invention is formed with undulation having a high aspect ratio thereon. Channels formed between nearby ridges due to the undulation are used as ink passageways. This allows the ridges to form convex ink meniscuses stably at all times at their front ends or ejection points, and thereby insures stable ejection of ink drops. Moreover, ink fed to the front ends of the ridges is constantly circulated by way of an ink collecting member. The circulation of the ink maintains the toner content of the ink uniform throughout the ejection points, and prevents the toner particles from excessively concentrating on the ejection points where ink ejection does not occur.

Fig. 2B



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Description

BACKGROUND OF THE INVENTION

The present invention relates to a recorder of the type recording an image on a medium by depositing toner on the medium and, more particularly, to a record head for an electrostatic ink jet recorder.

Non-impact recording schemes are attracting increasing attention because they produce only a negligible degree of noise during operation. Among them, an ink jet recording scheme is capable of recording an image directly on a medium at a high speed despite its simple configuration, and practicable even with plain papers. Various kinds of ink jet recording systems heretofore proposed include one using ink consisting of a carrier liquid and toner particles dispersed in the liquid. In this system, a voltage is selectively applied between needle-like ejection electrodes and a counter electrode facing the ejection electrodes and located behind a sheet or recording medium. The resulting electric field causes a coloring material contained in the ink to electrostatically fly toward the sheet, forming an image on the sheet. A record head for such a system includes a substrate on which ejection electrodes are formed independently of each other. Meniscus forming members each overlies one of the ejection electrodes. A cover covers the meniscus forming members and has an ink inlet port and an ink outlet port. Fine ejection openings or slits are formed by the substrate, meniscus forming members, and cover. Ink introduced into the head via the ink inlet port forms meniscuses at the front ends or tips of the meniscus forming members.

The above conventional record head, however, has the following problems left unsolved. Because the meniscus forming members are implemented by a photoconductive resist, their thickness is limited to several tens of microns. Further, because the meniscus forming members are formed by photolithographic exposure and development, their front corner portions or ejection points are not sharp. These in combination prevent meniscus from having a stable shape. Moreover, the ink is not circulated around the ejection points of the meniscus forming members. This causes the toner density of the ink to differ from one ejection point to another ejection point and causes the toner particles to excessively concentrate around the points where ink is not ejected, resulting in defective ink ejection.

Technologies relating to the present invention are taught in, e.g., WO 93/11866 and Japanese Patent Laid-Open Publication Nos. 4-353460 and 4-241955.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a record head for an electrostatic ink jet recorder capable of ejecting ink drops containing toner particles stably in an electrostatic field.

A record head for an electrostatic ink jet recorder of the present invention includes a head base formed of an insulating material and so undulated as to form ridges at intervals. Independent ejection electrodes are formed of a conductive material and formed on the tops of the ridges or on at least one of the walls of the ridges facing each other and the bottoms of channels defined between the ridges. An ink collecting member covers the front end of the head base with respect to the direction of ink ejection and the bottoms of the channels, and collects ink overflown the head base. A cover covers the top of the head base except for a front portion thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become apparent from the following detailed description taken with the accompanying drawings in which:

FIG. 1A is an external perspective view showing a conventional record head for an electrostatic ink jet recorder;
FIG. 1B is a plan view showing the front end portion of the conventional record head;
FIG. 1C is a section along line I-I of FIG. 1B;
FIG. 2A is an external perspective view showing a record head embodying the present invention;
FIG. 2B is a fragmentary perspective view showing a portion labeled A in FIG. 2A;
FIG. 3 is a section along line II-II of FIG. 2A;
FIG. 4 is a fragmentary section of the embodiment shown in FIG. 2A; and
FIG. 5 is an external perspective view showing an alternative embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

To better understand the present invention, brief reference will be made to a conventional record head of an electrostatic ink jet recorder, shown in FIGS. 1A-1C. Briefly, the recorder to be described uses ink consisting of a carrier liquid and toner particles dispersed in the liquid. A voltage is selectively applied between needle-like ejection electrodes and a counter electrode facing the ejection electrodes and located behind a sheet or recording medium. The resulting electric field causes a coloring material contained in the ink to electrostatically fly toward the sheet, forming an image on the sheet.

As shown in FIGS. 1A-1C, the record head includes a flat substrate 101 formed of an insulating material. A plurality of ejection electrodes 102 are formed on the surface of the substrate 101 at intervals corresponding to a desired resolution. To form the ejection electrodes 102, the entire surface of the substrate 101 is covered with Cu, Ni or similar conductive substance by sputtering, and then the conductive material is exposed and

developed via a mask formed with a pattern representative of the electrodes 102. The electrodes 102 are independent of each other and connected to a driver, not shown, at one end thereof. During recording, a high pulse voltage is selectively applied to the electrodes 102. The surface of the substrate formed with the electrodes 102 is coated with an insulative coating material by spin coating, so that the electrodes 102 and ink are insulated from each other.

Meniscus forming members 103 each overlies the respective ejection electrode 102 on the substrate 101. To form the meniscus forming members 103, an insulative photoconductive resist is laminated or spin-coated on the substrate 101 over the electrodes 102, and then the resist is exposed and developed via a mask formed with a pattern representative of the members 103. A cover 104 is formed of an insulating material and mounted on the meniscus forming members 103 at a position recessed from the front ends of the members 103. An ink inlet port 105 and an ink outlet port 106 are formed in the cover 104, as illustrated. The substrate 101, cover 104 and nearby meniscus forming members 103 form a fine opening or slit 107. Ink fed via the inlet port 105 is routed through the slit 107 to the front ends of the meniscus forming members 103. In this condition, the members 103 each forms an ink meniscus 108 at the front end or tip thereof. In FIG. 1B, the reference numeral 109 designates a drop ejected from the head.

The conventional record head described above has some problems left unsolved, as follows. Because the meniscus forming members 103 are implemented by a photoconductive resist, their thickness is limited to several tens of microns. Further, because the members 103 are formed by photolithographic exposure and development, their front corner portions or ejection points are not sharp. These in combination prevent the meniscus from having a stable shape. Moreover, the ink is not circulated around the tips or ejection points of the members 103. This causes the toner density of the ink to differ from one ejection point to another ejection point and causes the toner particles to excessively concentrate around the points where the ink is not ejected, resulting in defective ink ejection.

Referring to FIGS. 2A, 2B, 3 and 4, a record head embodying the present invention is shown and generally designated by the reference numeral 1. As shown, the record head 1 includes a head base 4 formed with ejection electrodes 3 to which drive pulses are selectively applied. An ink collecting member 5 receives ink 2 overflown the head base 4. A base plate 6 is formed of an insulating material and allows the head base 4 to be mounted thereon at a desired position. A cover 8 is positioned above the base plate 6 and cooperates with the base plate 6 to form an ink chamber 7. The ink chamber 7 is filled with the ink 2.

The head base 4 is made up of a substrate 9 formed of glass, ceramic or similar insulating material, and ejection electrodes 3 formed of Ni, Cu or similar conductive material. The surface of the substrate 9 is so undulated as to form a plurality of projections or ridges 10 at intervals corresponding to a desired resolution. The ejection electrodes 3 are independent of each other, and each is formed on the top of the respective ridge 10. The ridges 10 are formed by dicing, laser machining, isotropic etching or similar technology and provided with a high aspect ratio. A channel formed by nearby ridges 10 has a bottom 11 whose width is small enough to generate capillarity. Each ridge 10 has a height greater than the width of the bottom 11.

The ink collecting member 5 is implemented as a molding of plastics or similar insulating material. The member 5 is so positioned as to cover the end faces, or front end faces, 4a of the head base 4 and the bottoms 11 of the channels. Specifically, the member 5 includes a wall 5A facing the front end faces 4a and rising to a higher level than the bottoms 11. A gutter 12 is formed in the inner periphery of the member 5 in order to collect the ink 2 overflown the head base 4 in cooperation with the base 4. An ink outlet 13 is formed in the bottom of the member 5, so that the ink 2 collected by the gutter 12 can flow out. The ink outlet 13 is communicated to an ink tank by a tubing, although not shown specifically.

Electrode pads 14 and a pattern of conductors 15 are formed on the surface of the base plate 6. The electrode pads 14 are connected to a driver not shown. The conductors 15 each receives a drive voltage from associated one of the electrode pads 14 and applies it to associated one of the ejection electrodes 3. The head base 4 is mounted on the base plate 6 such that its front end faces 4a protrude outward from the base plate 6. The ejection electrodes 3 and conductors 15 are electrically connected together by wire bonding or similar technology. The portions connecting the ejection electrodes 3 and conductors 15 and the individual conductor 15 are covered and sealed by use of an insulating resin. If desired, the base plate 6 may be implemented as a printed circuit board or a flexible printed circuit board adhered to an insulating plate.

The cover 8 is implemented as a molding of plastics or similar insulating material and forms the previously mentioned ink chamber 7. An ink inlet 16 is formed in the top of the cover 8 in order to feed the ink 2 into the ink chamber 7. The ink inlet 16 is connected to an ink circulation pump and the ink tank by a tubing, although not shown specifically. A part of the cover 8 is disposed above the head base 4 and covers the tops of the ridges 10 at a position recessed from the front end faces 4a.

The ink 2 introduced into the ink chamber 7 via the inlet 16 is fed to the front ends or tips of the ejection electrodes 3 via the channels between the ridges 10. The ink 2 overflown the head base 4 via the front end faces 4a is collected in the gutter 12 and returned to the ink tank via the outlet 13. The ink 2 returned to the ink tank is again fed under pressure to the inlet 16 by the pump.

As shown in FIG. 4, a counter electrode 18 is locat-

ed in front of the front end of the head base 4 and plays the role of a platen at the same time. The head 1 is positioned such that at the front end of the head base 4, the corner portions 10a of the ridges 10 are closest to the counter electrode 18. A fine gap for ejection is defined between the corners 10a of the ridges 10 and the counter electrode 18. A sheet 17 is conveyed along the counter electrode 18 in the gap between the head 1 and the electrode 18. The counter electrode 18 is constantly connected to ground or to a preselected negative bias source.

In operation, a drive pulse voltage is selectively applied to the ejection electrodes 3 in order to generate electric fields between them and the counter electrode 18. A Coulomb force based on the concentration of the electric field is generated in the toner particles of the ink 2 forming a convex meniscus at the corner portion 10a of each ridge 10 where the driven electrode 3 is present. As a result, an ink drop 19 containing the toner particles is ejected from the corner portion or ejection point 10a toward the counter electrode 18. The ink drop 19 forms a dot on the sheet 17 on arriving at the sheet 17.

As stated above, the surface of the head base 4 is undulated with a high aspect radio, forming the channels between the ridges 10. By using the channels as ink passageways, it is possible to form convex ink meniscuses stably at the corner portions 10a of the ridges 10. This insures the stable ejection of the ink drops 19. Further, the ink 2 fed to the corner portions or ejection points 10a is constantly circulated by way of the ink collecting member 5. Such circulation of the ink 2 maintains the toner content of the ink 2 uniform throughout the ejection points, and prevents the toner particles from excessively concentrating on the ejection points where ink ejection does not occur.

FIG. 5 shows an alternative embodiment of the present invention. As shown, the head base shown in FIG. 5 differs in configuration from the head bases 4 shown in FIG. 2B. The head base 4 is made up of the substrate 9 and election electrodes 3, as in the configuration of FIG. 2B. The ridges 10 are also formed on the substrate 9 at intervals corresponding to a desired resolution. The ejection electrodes 3 are formed of metal and formed on at least one of the walls 10b and 10c of the ridges 10 facing each other and the bottoms 11 of the channels.

In summary, in accordance with the present invention, a record head for an electrostatic ink jet recorder is formed with undulation having a high aspect ratio thereon. Channels between nearby ridges are used as ink passageways. This allows the ridges to form convex ink meniscuses stably at all times at their front ends or ejection points, and thereby insures stable ejection of ink drops. Moreover, ink fed to the front ends of the ridges is constantly circulated by way of an ink collecting member. The circulation of the ink maintains the toner content of the ink uniform throughout the ejection points, and prevents the toner particles from excessively concentrating on the ejection points where ink ejection does not occur.

Various modifications will become possible for those skilled in the art after receiving the teachings of the present disclosure without departing from the scope thereof.

Claims

1. A record head for an electrostatic ink jet recorder, comprising:

   a head base formed of an insulating material and so undulated as to form ridges at intervals, independent ejection electrodes formed of a conductive material being formed on tops of said ridges or on at least one of walls of said ridges facing each other and bottoms of channels defined between said ridges;
   an ink collecting member covering a front end of said head base with respect to a direction of ink ejection and said bottoms of said channels, for collecting ink overflown said head base; and
   a cover covering a top of said head base except for a front portion of said head base.

2. A record head as claimed in claim 1, wherein each of said channels between said ridges has a width small enough to generate capillarity, and wherein said ridges have a height greater than the width of said channels.

3. A record head as claimed in claim 1, wherein said ejection electrodes are coated with an insulating coating material.

4. A record head as claimed in claim 3, wherein each of said channels between said ridges has a width small enough to generate capillarity, and wherein said ridges have a height greater than the width of said channels.

5. A record head as claimed in claim 1, wherein said ejection electrodes are formed on the tops of said ridges, and wherein said ridges are regularly positioned at intervals corresponding to a desired resolution.

6. A record head as claimed in claim 5, wherein said ejection electrodes are coated with an insulating coating material.

7. A record head as claimed in claim 5, wherein each of said channels between said ridges has a width small enough to generate capillarity, and wherein said ridges have a height greater than the width of said channels.

Fig. 1A

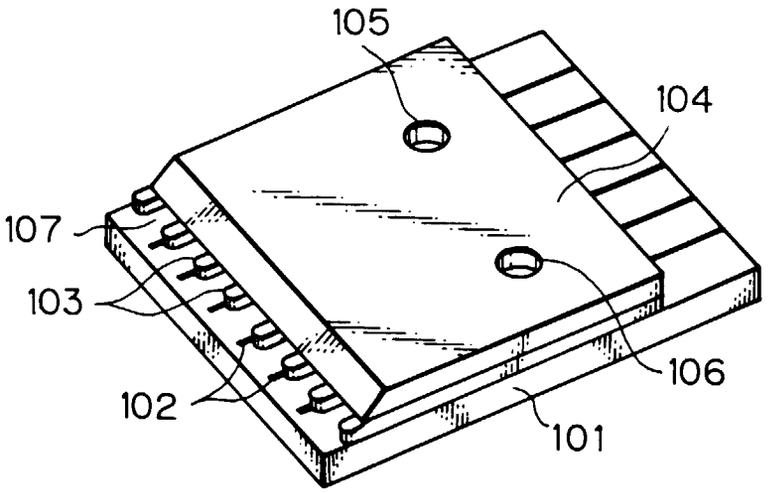

Fig. 1B

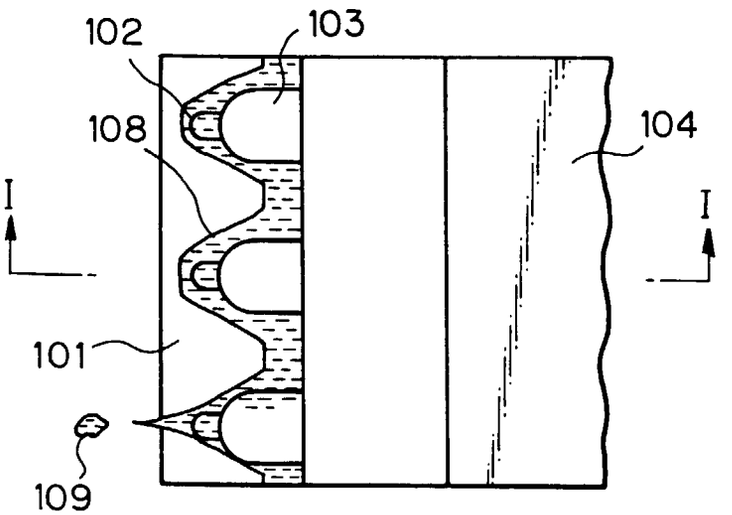

Fig. 1C

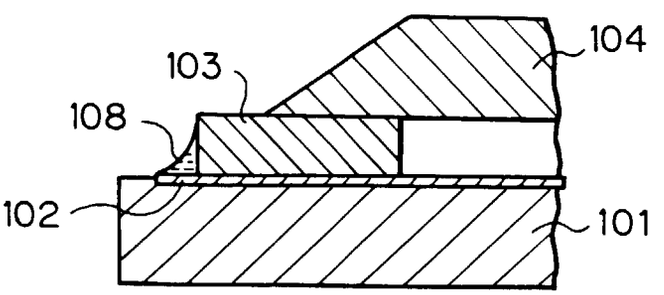

Fig. 2A

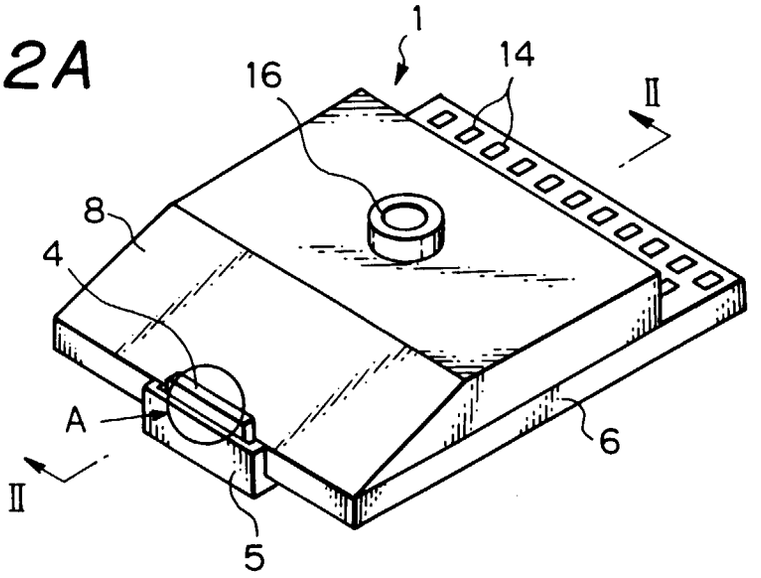

Fig. 2B

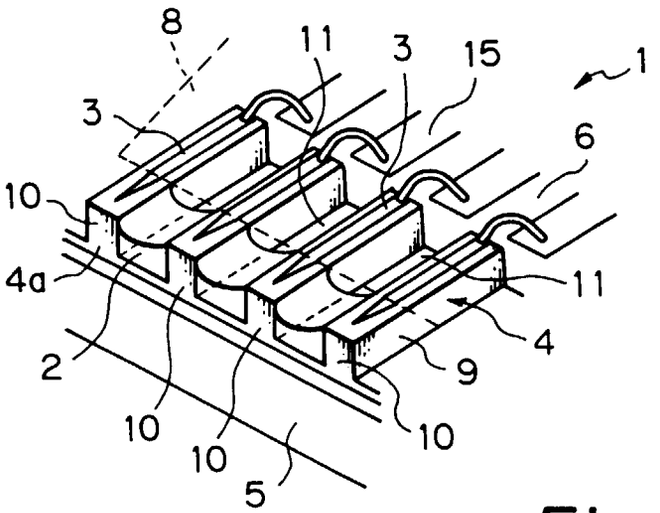

Fig. 3

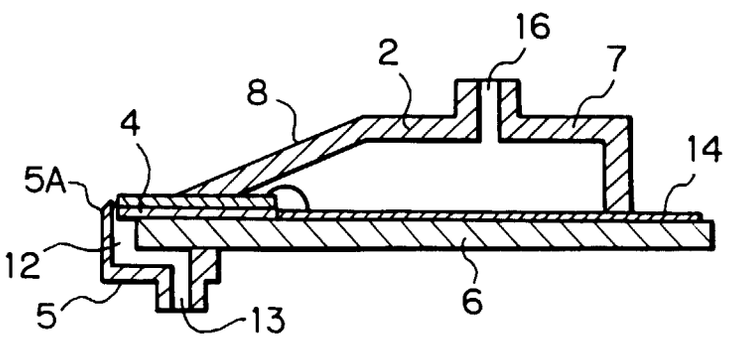

Fig. 4

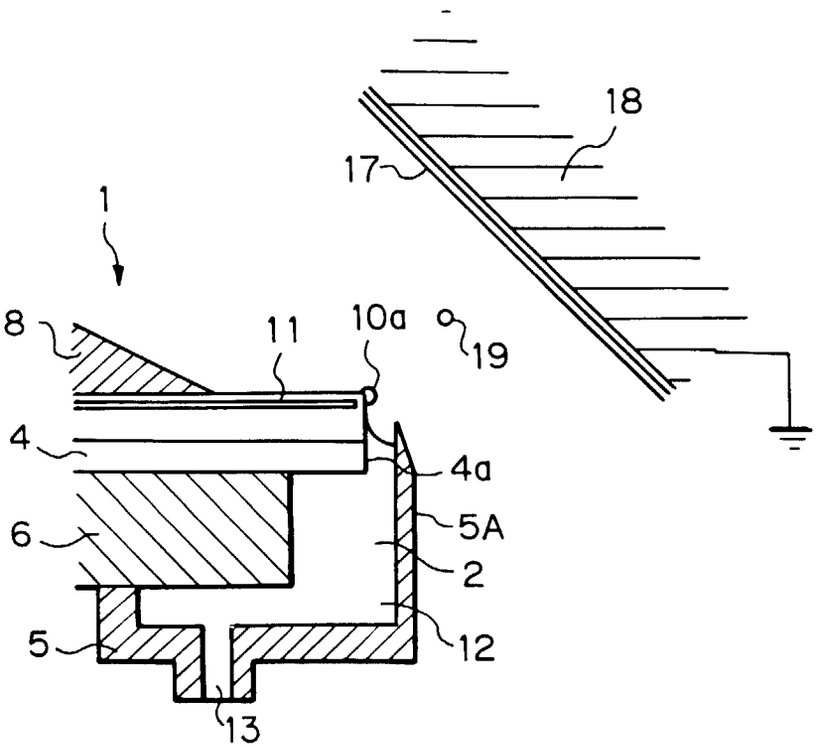

Fig. 5