

(19)



Europäisches Patentamt

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(11)

EP 0 761 442 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
12.03.1997 Bulletin 1997/11

(51) Int. Cl.⁶: **B41J 2/06**, B41J 2/14

(21) Application number: **96113658.7**

(22) Date of filing: **26.08.1996**

(84) Designated Contracting States:
DE FR GB

(30) Priority: **28.08.1995 JP 218779/95**
14.09.1995 JP 236276/95

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(54) **Electrostatic ink-jet recording head having a plurality of partitions in the direction of ink ejection**

(57) Recording electrodes 2 are formed on a substrate 1. A cover member 6 having an ink chamber therein is fixed onto the recording electrodes 2. Charged color particulate materials are used in the ink. Partitions 10 are formed between the tips of the recording electrodes 2 and the tip portion of the cover member 6. The tip portions of the partitions 10 are disposed so as to be located on the side of ink ejection with respect

to the tip portions of the recording electrodes 2, and the tips of the partitions at a side of the substrate 1 are indented toward the tips of the recording electrodes 2. Therefore, charged toner particles quickly concentrate on ink menisci formed at the indenting portion under the partitions 10, to thereby enable stable ink supply and high-speed printing.

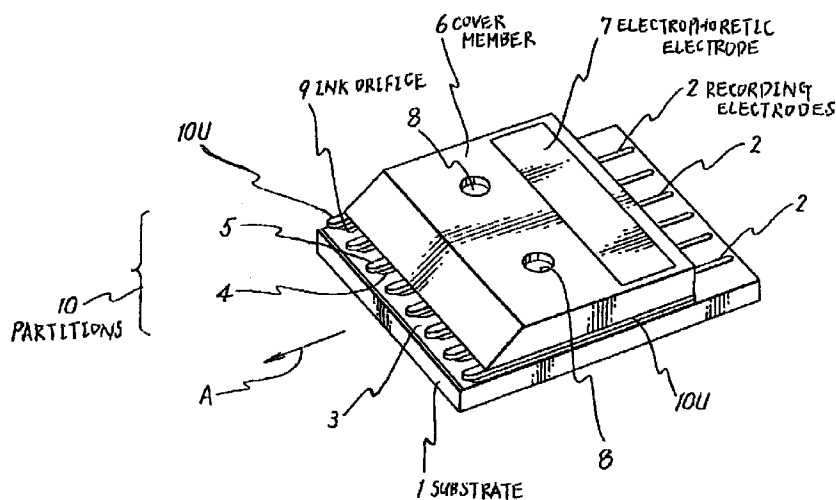


FIG. 3

EP 0 761 442 A2

Description

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an electrostatic ink-jet recording head with which ink particles are made to fly by electrostatic force onto recording paper for printing, and more particularly, to an electrostatic ink-jet recording head having a plurality of partitions in the direction of ink ejection.

Description of the Prior Art

Non-impact recording is advantageous in that noise made while recording is so low as can be neglected. In particular, ink-jet recording, which can record on plain paper at high speed with a simple mechanism, is quite reliable, and a variety of methods thereof have been proposed.

Ink-jet recording methods include a method in which pressure waves are generated within an ink chamber by a piezoelectric element to make ink fly from a nozzle for recording, a method in which bubbles are thermally generated to make ink fly from a nozzle for recording, and electrostatic recording method. Among these, the electrostatic recording method in which the size of ink droplets is easily controlled will attract attention in the future.

As described in PCT Publication Number WO 93/11866, an electrostatic ink-jet recording apparatus comprises a counter electrode provided at the back of recording paper and an ink-jet recording head. The ink-jet recording head comprises a supply tube for supplying ink liquid including ink particles, such as charged toner, to an ejecting location and a needle-like electrode facing the counter electrode. A tip of the needle-like electrode is formed at the ejecting location. Voltage is applied to the needle-like electrode to generate an electric field. Electrostatic force due to the electric field makes agglomerations including the ink particles in the ink liquid eject away from the ejecting location toward the counter electrode.

Fig. 1 is a schematic perspective view showing a conventional electrostatic ink-jet recording device. In Fig. 1, the surface of a substrate 52 of an ink-jet recording head 50 is covered with a cover 54, and a slit-like ink orifice 55 is provided at the side of a counter electrode 51. Ink liquid including ink particles is supplied to the ink orifice 55 from ink room (not shown).

A plurality of needle-like recording electrodes 53 are arranged in parallel on the surface of the substrate 52 along the direction of ink ejection. These recording electrodes 53 are connected with a voltage drive section (not shown) so that a high-voltage pulse is selectively applied to the recording electrodes 53. On the other hand, the counter electrode 51 is disposed via recording paper P on the extension of the recording

electrodes 53. In recording, an electric field is generated between the counter electrode 51 and the recording electrodes 53.

The ink particles in the ink liquid are color particulate materials (charged toner), and they are dispersed in a solution. The color particulate materials have apparent charge due to Zeta potential, and the charged color particulate materials are energized to migrate to a ejecting location of the ink orifice 55 by the electric field generated between the recording electrodes 53 and the counter electrode 51. Here, since the recording electrodes 53 are needle-like shape, in recording, the electric field is concentrated on the tips of the recording electrodes 53, and thus the charge conducts to the ink particles concentrated around the tip of the recording electrodes.

Therefore, the color particulate materials in the ink solution are strongly attracted to the side of the counter electrode 51, i.e. in the direction of the recording paper P due to Coulomb force acting on the charge stored by the recording electrodes 53. When the Coulomb force overcomes the surface tension of the liquid including the color particulate materials, agglomeration including the color particulate materials flies to attach to the surface of the recording paper P. Desired recording can be conducted by applying a high-voltage pulse to the recording electrodes 53 according to an image to be recorded.

However, since the conductivity and permittivity of the ink liquid to be used in recording are larger than the conductivity and permittivity of air, strictly speaking, the place on which the electric field concentrated depends not only on the arrangement of the recording electrodes but also on the shape of ink meniscus formed at the ink ejection opening. With respect to the ink-jet recording head 50 shown in Fig. 1, it is desirable that the ink menisci are uniform in the longitudinal direction of the ink ejection opening. However, in practice, due to the processing accuracy of the opening, vibration of a meniscus after ink ejection, natural fluctuation of the menisci, etc., there is fine irregularity on the surface of the ink menisci.

In such a case, according to the conductivity and permittivity of the ink liquid, the electric field concentrates on the fine irregular portion of the menisci generated around the recording electrode. Since the concentration of the electric field is further strengthened after the menisci begins to deform due to Coulomb force, the fine irregularity in the early stage causes displacement of fine agglomerations. Therefore, there is a case where, even if a high-voltage pulse is applied to a certain recording electrode, since the fine agglomerations fly from displaced position from the recording electrode, recording can not be conducted at the desired position. This causes the print quality to reduce.

On the other hand, Japanese Laid-open Patent Application No. Sho 60-228162 laid open on November 13, 1986 discloses an example to solve the above problem. An electrostatic ink-jet recording head described therein has, as shown in Fig. 2, convex portions 66 at

the tip portion of a substrate 62 in the direction of the tips of recording electrodes 63. The convex portions 66 permit to form the ink menisci formed around the tips of the recording electrodes 63. Also, the electric field at the tips of the recording electrodes 63 concentrates on the convex portions 66. As a result, if the ink liquid containing color particulate materials is used, ejection does not occur until charged color particulate materials in the ink liquid migrate to the tip of the menisci (the tips of the convex portions 66) according to the electric field in the ink liquid.

However, in the ink-jet recording head shown in Fig. 2, when the resolution of the printer is 300dpi, for example, the pitch of the arranged recording electrodes 63 must be set to be around 85 μm . In corresponding to the fine pitch of the recording electrodes, fine irregularity must be formed at the tip of the substrate 62. Therefore, there is a disadvantage that the material of the substrate and work process are limited and thus manufacturing cost is increased. Further, since, while the substrate 62 must be 100 μm in thickness or more so as to have sufficient mechanical strength, the pitch of the irregularity to be processed is several dozen percents of the thickness, there is a disadvantage that the processing is extremely difficult, which also leads to increase in manufacturing cost.

In Fig. 2, by disposing a reinforcing plate 67 at a place to partition the recording electrodes 63, the substrate 62 can be formed of a thin and flexible material. However, since this lowers the strength of the convex portions at the tip of the substrate, there is a disadvantage that the convex portions at the tip of the substrate are liable to be damaged when the tip portion of the head is cleaned or when recording paper is jammed.

Moreover, in the ink-jet head shown in Fig. 4 of the WO 93/11866, the recording electrodes have protruded ejecting points (20 in the Fig. 4) and ink (agglomeration including the color particulate materials) ejects from the protruded ejecting points. However, it is difficult to concentrate the electric field to the ink liquid disposed on the protruded ejecting points, because the electric field directs to a counter electrode side rather than to the ink on the protruded ejecting points, and thus the ejection of the ink liquid are delayed. As a result, the performance for the high speed ejection has to be improved.

SUMMARY OF THE INVENTION

In view of the above, an object of the present invention is to provide an electrostatic ink-jet recording head which improves the disadvantages of a conventional electrostatic ink-jet recording head, and particularly, which is easily processed and manufactured, which can be provided at a low cost, and with which color material particles in ink can be ejected with stability and high speed.

An electrostatic ink-jet recording head according to the present invention comprises a substrate, a plurality of band-like recording electrodes formed in parallel on

the surface of the substrate to generate an electric field for ejecting ink including charged particulate materials, a cover member disposed on the substrate, and a plurality of partitions disposed on the tip of the recording electrodes, respectively, and contacting to the tip of the cover member for forming a plurality of ink orifices. An ink chamber which communicates with the ink orifices is disposed between the cover member and the substrate. The tips of the partitions directs to an ink ejecting direction, and they are positioned or located forward from the tips of the recording electrodes. Moreover, the tips of the partitions at a side of said substrate are indented toward the tips of said recording electrodes.

According to the embodiment of the present invention, the tips of the partitions are provided with steps by first tips at the side of said substrate and second tips at a side of said cover member. The second tips protrude in the ink ejecting direction from the first tips.

According to the present invention, ink menisci are formed around the tip portions of the partitions. Here, the tips of the partitions are disposed forward from the tips of the recording electrodes and the tips are indented to the tips of the recording electrodes, thereby ink menisci are formed along the shape of the partitions and tips of the ink menisci are positioned forward from the tips of the respective recording electrodes. Further, the ink has conductivity due to charged particulate materials, for example, charged toner particles and permittivity larger than that of air. Therefore, the electric field emitted from the tips of the recording electrodes concentrates to the menisci between the tips of the partitions and the tips of the recording electrodes. As a result, the charged toner particles gather to the menisci quickly, thereby ink (agglomeration including the charged coners) are quickly ejected away from the tips of the partitions and this permits a high-speed printing.

According to the embodiments of the present invention, it is configured such that each of the partitions is formed by coupling a first partition layer provided on the side of the substrate and a second partition layer provided on the side of the cover member. The tips of the second partitions layers protrude in the direction of ink ejection from the tips of the first partition layers.

According to the present invention, the recording electrodes and the partitions of the recording head is manufactured through photolithography technology from start to finish.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

Fig. 1 is a schematic perspective view showing a conventional electrostatic ink-jet recording device;

Fig. 2 is a schematic perspective view showing another conventional electrostatic ink-jet recording device;

Fig. 3 is a perspective view showing an embodiment of an electrostatic ink-jet recording head according to the present invention;

Fig. 4 is an enlarged plan view showing a portion around ink orifices of the electrostatic ink-jet recording head shown in Fig. 3;

Fig. 5 is a sectional view taken along the line B-B of Fig. 4;

Fig. 6 is a plan view of the electrostatic ink-jet recording head with a cover member removed;

Fig. 7 is a block diagram showing a drive circuit system;

Figs. 8A, 8B, 8C, and 8D are plan views showing manufacturing processes with parts omitted; and

Fig. 9 is a sectional view showing another embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

An electrostatic ink-jet recording head shown in Fig. 3 comprises a substrate 1, a plurality of recording electrodes 2 formed on the surface of the substrate 1 for generating an electric field for ink ejection, a cover member 6 disposed on the surface of the substrate 1 with the recording electrodes 2 and having an ink chamber formed therein, an electrophoretic electrode 7 fixed to the cover member 6, and partitions 10 of dual structure formed on the tips of the recording electrodes 2 along the direction A of ink ejection. (A plurality of) recording electrodes 2 are formed to be in the shape of strips, and their tips are directing to the side of ink ejection and are shaped to be smoothly sharpened. The respective recording electrodes 2 are arranged in parallel at constant intervals along the direction of ink ejection (arrow A).

As shown in Fig. 5, the tips of the respective recording electrodes 2 on the side of ink ejection are located to stand back somewhat from the tips of the substrate 1. The tip portions of the recording electrodes 2 are uniformly covered with an insulator layer 3. The insulator layer 3 is formed along an edge of the substrate 1 on the side of ink ejection so as to have a given width. Further, a plurality of partitions 10 for forming a plurality of ink orifices 9 (Fig. 3) are provided on the insulator layer 3. The partitions 10 are arranged right above the recording electrodes 2, respectively.

Each of the partitions 10 has a first and second partition layers 4 and 5 formed by being laminated from the bottom. The tips on the side of ink ejection of the first partition layers 4 in contact with the insulator layer 3 substantially align with the tips of the recording electrodes 2, while the back ends of the first partition layers

4 substantially align with the back end of the insulator layers 3. The width of each of the first partition layers 4 is set to be somewhat wider than that of the recording electrodes 2. On the other hand, the tips of the second partition layers 5 laminated to the first partition layers 4 protrude from the first partition layers 4 in the direction of ink ejection, while the back ends of the second partition layers 5 substantially align with the back ends of the first partition layers 4 and the width of the second partition layers 5 are the same as that of the first partition layers 4. Therefore, the tips of the partitions 10 at a side of the substrate 1 (that is, the tips of the first partition layers 4) are indented toward the tips of said recording electrodes 2.

The first and second partitions layers 4 and 5 as a whole are in the shape of square timber with the tip portions on the side of ink ejection rounded in the direction of the surface of the substrate.

Fig. 6 is a plan view of the electrostatic ink-jet recording head of Fig. 1 with a cover member 6 removed. A partition 10U is provided along the edge of the cover member 6 (not shown in Fig. 6) with the side of ink ejection released. The partition 10U forms the side walls of an ink chamber 11 (Fig. 5). The partitions 10 and 10U are formed at the same time and have the same material.

The cover member 6 is fixed to the above of the partitions 10 and 10U. As shown in Fig. 5, the cover member 6 is bored deeper upward on the side of the ink chamber 11 compared to the side of the ink orifices 9. As a result, the ink orifices 9 are formed to be like slits and the ceiling of the ink chamber 11 is somewhat higher than the ceilings of the ink orifices 9. Further, the tip of the cover member 6 on the side of ink ejection is positioned so as to stand back from the tips of the second partitions layer 5 by around one third.

Two ink circulation openings 8 for supplying and circulating ink from an ink reservoir are provided on the top of the cover member 6. The ink circulation openings 8 are connected with the ink reservoir via a tube (omitted in the figures). This makes ink within the ink chamber 11 to circulate compulsorily with negative pressure around 1cmH₀ applied thereto. Ink used here is preferably petroleum organic solvent (isoparaffine hydrogen carbide) with charge control material and colored particulate material of thermoplastic resin dispersed therein. In this embodiment, the color particulate materials are charged toner which are apparently charged to positive polarity due to Zeta potential.

The electrophoretic electrode 7 is located on the opposite side to ink ejection with respect to the ink circulation openings 8. The electrophoretic electrode 7 generates an electric field within the ink chamber 11 (Fig. 5) to make the charged toner in the ink migrate to the ink orifices 9 due to electrophoresis.

Each of the recording electrodes 2 and the electrophoretic electrode 7 are driven by a recording electrode drive circuit 200, an electrophoretic electrode drive circuit 201, and a control circuit 203 as shown in Fig. 7.

The recording electrode drive circuit 200 applies a predetermined recording voltage individually to each of the recording electrodes 2. The polarity of the recording voltage is the same as the charged polarity (plus) of the color particulate materials such as charged toner used in the ink. Specifically, in a stand-by state of recording, bias voltage around 1 kV is always applied to the recording electrodes 2, except during long-term non-recording. In recording, a drive pulse around 70 V superimposed on the bias is applied.

The electrophoretic electrode drive circuit 201 applies a predetermined electrophoretic voltage to the electrophoretic electrode 7. Since the charged toner in the ink are made to migrate to the orifices 9 by the electrophoretic voltage, the electrophoretic voltage is set to be 2 kV, which is higher than the bias voltage applied to the recording electrodes 2.

The control circuit 203 controls the recording electrode drive circuit 200 and the electrophoretic electrode drive circuit 201 based on print data.

It is the same as with a conventional electrostatic ink-jet recording head that a counter electrode is disposed on the side of ink ejection.

Next, a description is made of a method for manufacturing the electrostatic ink-jet recording head of Fig. 3 with reference to Fig. 8.

First, as shown in Fig. 8A, a plurality of the recording electrodes 2 are formed on the substrate 1 made of an insulator such as glass fiber. Then, the insulator layer 3 is formed so as to cover the tip portions of the recording electrodes 2. Here, in Fig. 8A, a part of the insulator layer 3 is cut away in order to clarify the shape of the tips of the recording electrodes 2. The recording electrodes 2 are formed by pattern formation with photolithography of a conductive material such as nickel or chromium sputtered on the whole surface of the substrate, and are disposed at the pitch of 300 dpi, i.e. at intervals of around 85 μm . The tips of the recording electrodes 2 are shaped to be smoothly sharpened such that an electric field easily concentrates thereon.

On the other hand, the insulator layer 3 is formed by photolithography processing of a spin coated insulative member such as photosensitive polyimide, and covers like a band only the tip portions of the recording electrodes 2.

Next, as shown in Fig. 8B, the first partition layers 4 are formed on the insulator layer 3 at the tips of the recording electrodes 2. The first partition layer 4 are formed by laminating an acrylic photosensitive dry film having a thickness around 30 μm , and by pattern formation through photolithography. Subsequently, as shown in Fig. 8c, the second partition layers 5 are formed on the first partition layers 4. The second partition layers 5 are, in the same way as the first partition layers 4 mentioned in the above, formed by applying photolithography to an acrylic photosensitive dry film having a thickness around 30 μm . In this way, all the partitions 10 and 10U (Fig. 6) are formed at the same time. Here, the tips of the second partitions layer 5 protrude from the

tips of the first partitions layer 4 by around 30 μm to the side of ink ejection (and the counter electrode).

Finally, as shown in Fig. 8D, the cover member 6 is adhered on the partitions 10 and 10U. Synthetic resin is used as the cover member 6. This makes ink within the ink chamber 11 not to leak out except from the ink orifices 9. Here, the cover member 6 is in advance provided with ink circulation openings 8 and with the electrophoretic electrode 7 made of metal.

The operation as a whole of the electrostatic ink-jet recording head of Fig. 3 is described in the following.

When the ink chamber 11 is filled with ink I as shown in Fig. 5, due to surface tension of the ink I, the ink I forms ink menisci M around the ink orifices 9 and partitions 10. Though negative pressure is energized to the ink I within the ink chamber 11, due to the wettability of the ink menisci M, the formed menisci M protrude gently along the shape of the tips of the partitions 10. Between the tips of the partitions layer 5 and the tips of the recording electrodes 2, as shown in Fig. 5, meniscus portions m are formed. The meniscus portions m are positioned forward from the tips of the recording electrodes 2.

Next, when electrophoretic voltage is applied to the electrophoretic electrode 7 from the electrophoretic electrode drive circuit 201 of Fig. 7, in a stand-by state of recording, due to electric potential difference (around 1kV) between the electrophoretic electrode 7 and the recording electrodes 2 or between the electrophoretic electrode 7 and the counter electrode (omitted in the figures), charged toner in the ink moves and gather to the ink orifices 9 under electrophoresis phenomenon. Next, a drive pulse is applied to an arbitral one of the recording electrodes 2 from the recording electrode drive circuit 200 of Fig. 7, and thus an electric field from the tips of the recording electrodes 2 toward the counter electrode is emitted.

Since the ink I has conductivity due to the charged toner and permittivity larger than that of air, the direction of the electric field emitted from each of the tips of the recording electrode 2 affects to the shape of the surface of the ink meniscus M. The electric field emitted from the tip of the recording electrode 2 goes toward the vertex of the ink meniscus M, and particularly concentrates on the meniscus portion m positioned forward from the tip of the recording electrode 2. This makes the charged toner in the meniscus M gather to the meniscus portion m quickly.

Subsequently, when a predetermined amount of charged toner gather at the meniscus portion m, the toner particles are drawn from the meniscus portion m to the side of the counter electrode (not shown), and as shown in Fig. 4, and then agglomeration T including the toner particles flies from the meniscus portion m toward the counter electrode. The agglomeration T attaches to a recording paper fed on the counter electrode, and is heated by a heater (not shown) to fix. Recording on recording paper is thus conducted.

Toner particles which run snort around the ink ori-

fice 9 due to discharge of the agglomeration T are replenished by migrating toner particles within the ink chamber 11 to the side of the ink orifice 9 energized by the voltage difference between the electrophoretic electrode 7 and the recording electrode 2 or the counter electrode. Thereafter, the processes described in the above are repeated, and recording is conducted continuously.

As described in the above, according to the electrostatic ink-jet recording head of Fig. 3, the partitions 10 are formed by coupling the first and second partition layers 4 and 5, and the second tips of the second partition layers 5 provided on the side of the cover member 6 protrudes in the ink ejecting direction from the first tips of the first partition layers 4 provided on the side of the substrate 1. Further, at least the tips of the second partition layers 5 protrude to the side of ink ejection from the tips of the recording electrodes 2. As a result, ink meniscus portions m as shown in Fig. 5 are formed forward (to the side of the ink ejection) from the recording electrode 2, and the electric field emitted from the tip of the recording electrode 2 is allowed to concentrate on the meniscus portion m. Therefore, the charged toner particles in the ink I are supplied quickly to the meniscus portion m, to thereby cope with the high-speed printing.

Furthermore, since each of the second partition layers 5 is sharpened with their tip rounded, the charged toner particles in the ink meniscus M concentrate on the tips and the electric field emitted from the recording electrode 2 is easily allowed to concentrate on the tip of the second partition layer 5, and therefore, the accuracy in the direction of ink ejection can be further improved.

In addition to the above, since a plurality of the ink circulation openings 8 are provided on the cover member 6 for applying negative pressure to the ink I within the ink chamber 11 and for compulsorily circulating the ink, only toner particles in the ink I can be easily ejected, toner particles can be appropriately supplied into the ink chamber 11; and a disadvantage that ink is hardened within the ink chamber 11 can be prevented.

Further, since the electrophoretic electrode 7 is provided on the cover member 6 on the opposite side to the ink orifice 9, toner particles within the ink chamber 11 are allowed to migrate easily toward the ink orifice 9.

Still further, since the tips of the recording electrodes 2 are covered with the insulator layer 3, even in the case of short circuit between the recording electrodes 2 and the counter electrode due to jamming of recording paper, excess current is restrained, and thus, voltage drive portion connected to the recording electrodes 2 can be protected.

In addition to the above, since the recording head of the present invention can be manufactured by pattern formation with photolithography from start to finish, manufacture allowance does not accumulate, and thus, even with respect to a long head such as a line head having a large number of recording electrodes, similarly to a short head, a high-resolution head can be manufactured at a low cost.

In the present embodiment, the partitions 10 are formed by forming the two kinds of partition layers 4 and 5 in different processes. However, if the tips of the partitions 10 at a side of said substrate are indented toward the tips of the recording electrodes 2, only one kind of partition layers are provided in advance have the same effect as the recording head of Fig. 3. Further, the number of steps or the number of the partitions layer of the partitions 10 may be more than two.

As shown in Fig. 5, the ink meniscus portions m under the tips of the second partitions layers 5 are formed over the tip of the substrate 1. As a result, part of the charged toner particles remains on the tip of the substrate 1, which prevents efficient ejection. In order to solve this problem, as shown in Fig. 9, a film 20 having a property of repelling ink may be formed on the tip portion of the substrate 1 on the side of ink ejection. The film 20 prevents ink from getting onto the tip portion of the substrate 1, thereby allowing the charged toner particles to migrate concentratively toward the ink menisci under the partitions 10 and eject.

Claims

1. An electrostatic ink-jet recording head comprising:
 - a substrate (1);
 - a plurality of band-like recording electrodes (2) formed in parallel on the surface of said substrate for generating an electric field for ejecting ink including charged particulate materials;
 - a cover member (6) disposed on the substrate for forming an ink chamber (11); and
 - a plurality of partitions (10) for forming a plurality of ink orifices (9), said electrostatic ink-jet recording head characterized in that,
 - said partitions (10) are disposed on tips of said recording electrodes (2) and contacts to a tip of said cover member (6), and tips of said partitions are positioned in ink ejecting direction (A) with protruding from the tips of said recording electrodes, and the tips of said partitions at a side of said substrate are indented toward the tips of said recording electrodes.
2. The electrostatic ink-jet recording head according to claim 1, wherein the tips of said partitions (10) are provided with steps by first tips at the side of said substrate and second tips at a side of said cover member, said second tips protrude in the ink ejecting direction from said first tips.
3. The electrostatic ink-jet recording head according to claim 1, wherein said partitions (10) comprise a first partition layer (4) provided on the side of said

substrate, and a second partition layer (5) provided on the side of said cover member, and the tips of said second partition layer (5) protrude to the side of ink ejection from the tips of said first partition layer (4).

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4. The electrostatic ink-jet recording head according to claim 3, wherein the tips of said second partitions layer (5) are tapered.

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5. The electrostatic ink-jet recording head according to claim 3, wherein said first and second partition layers (4,5) are formed by laminating an acrylic photosensitive dry film on said recording electrodes (2) and then by pattern formation through photolithography.

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6. The electrostatic ink-jet recording head according to claim 1, wherein said cover member (6) is provided with a plurality of ink circulation openings (8).

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7. The electrostatic ink-jet recording head according to claim 1, wherein an electrophoretic electrode (7) is provided on said cover member (6) on the opposite side to said ink orifices (9).

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8. The electrostatic ink-jet recording head according to claim 1, wherein a film (20), having a property of repelling ink for preventing ink from getting onto the tip portion of said substrate, is formed on the tip portion of said substrate on the side of ink ejection.

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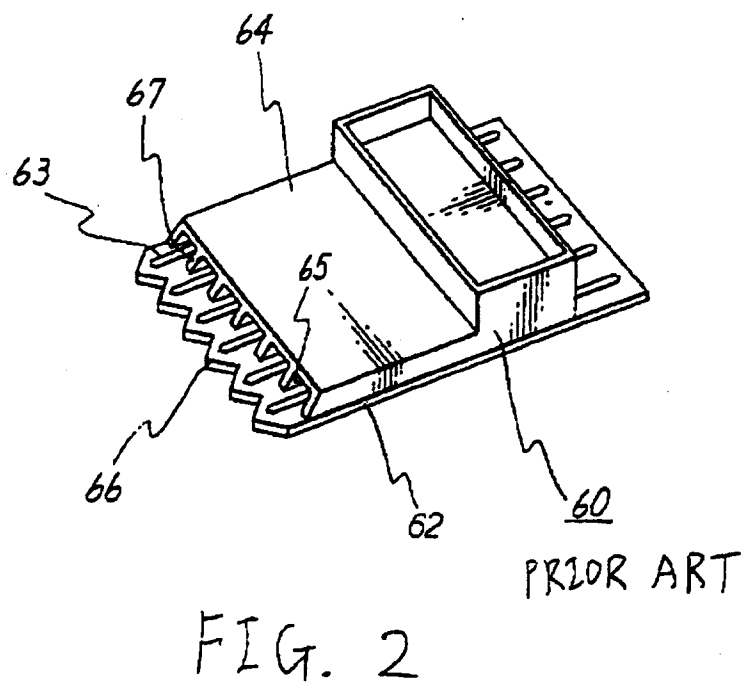
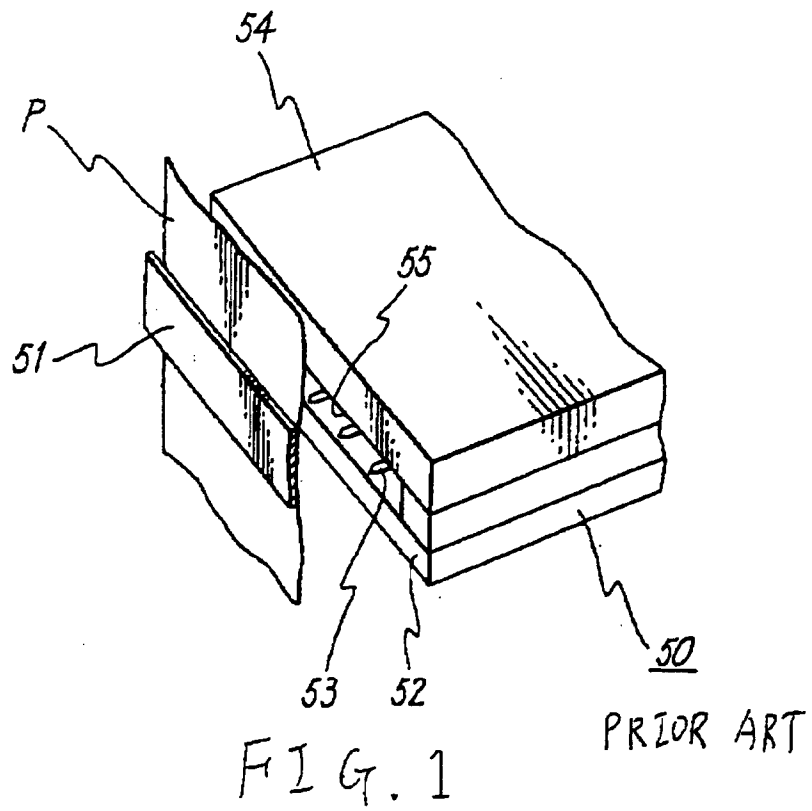
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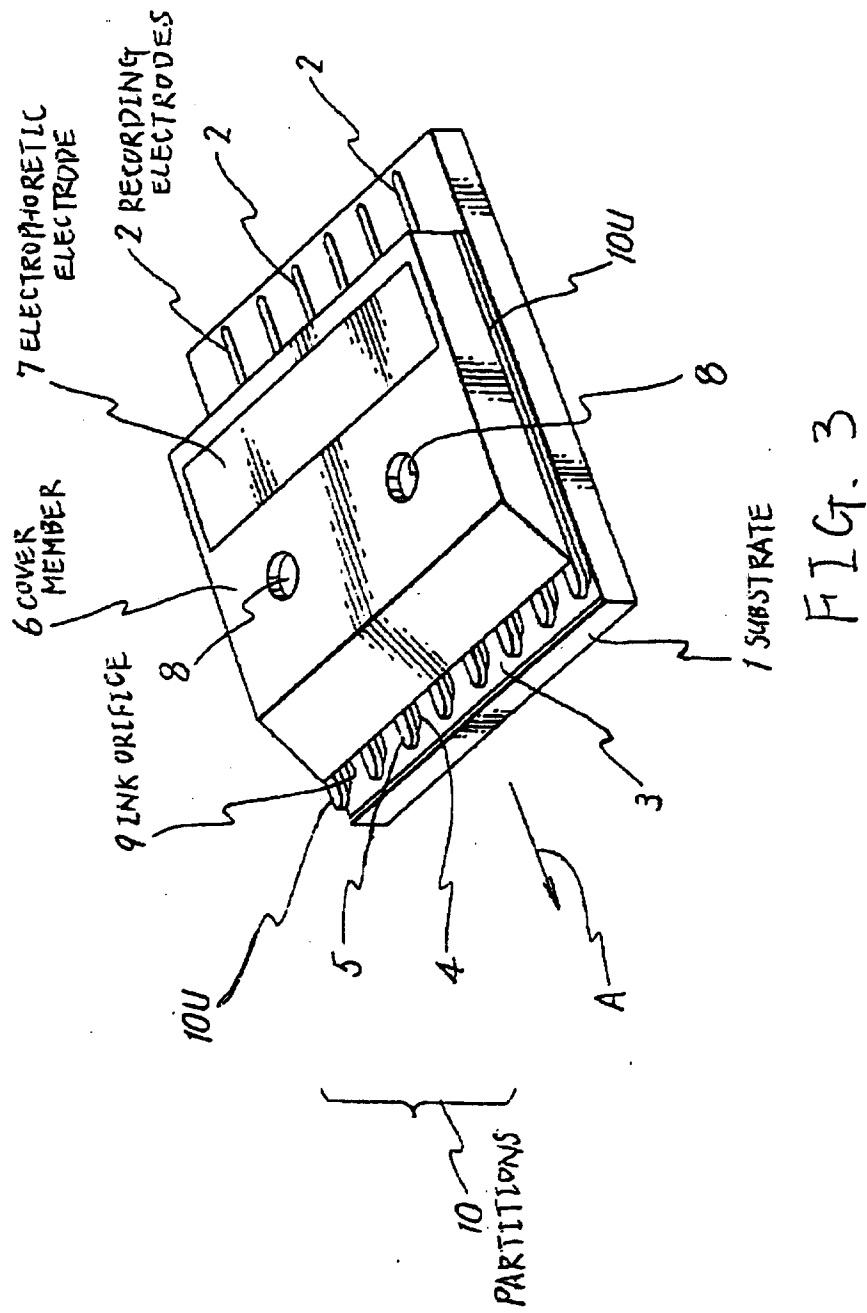
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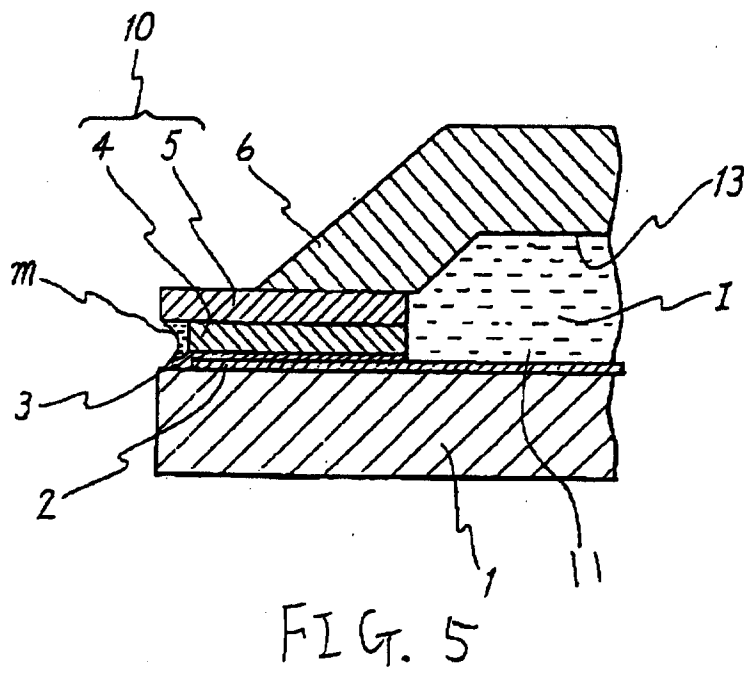
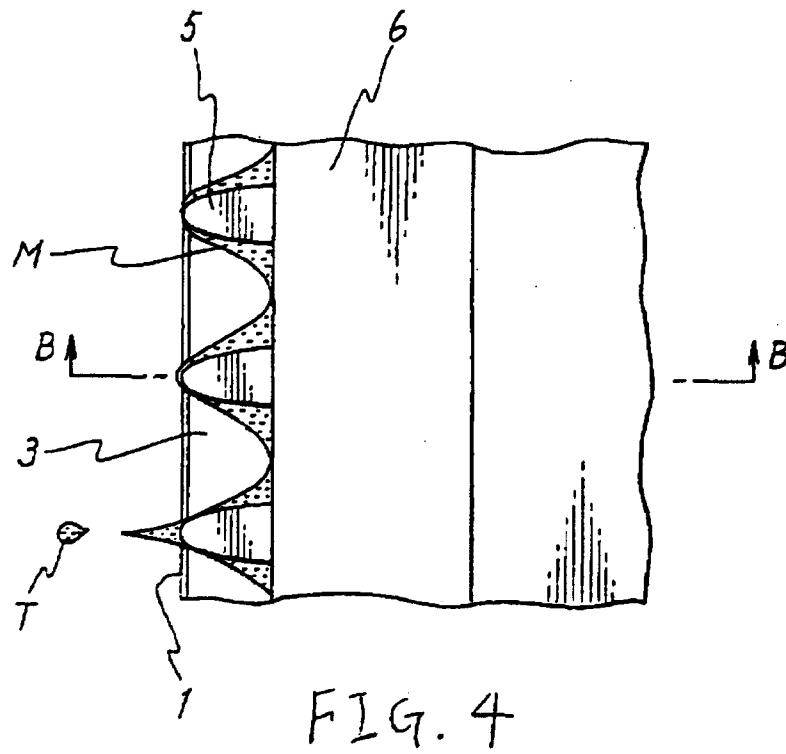
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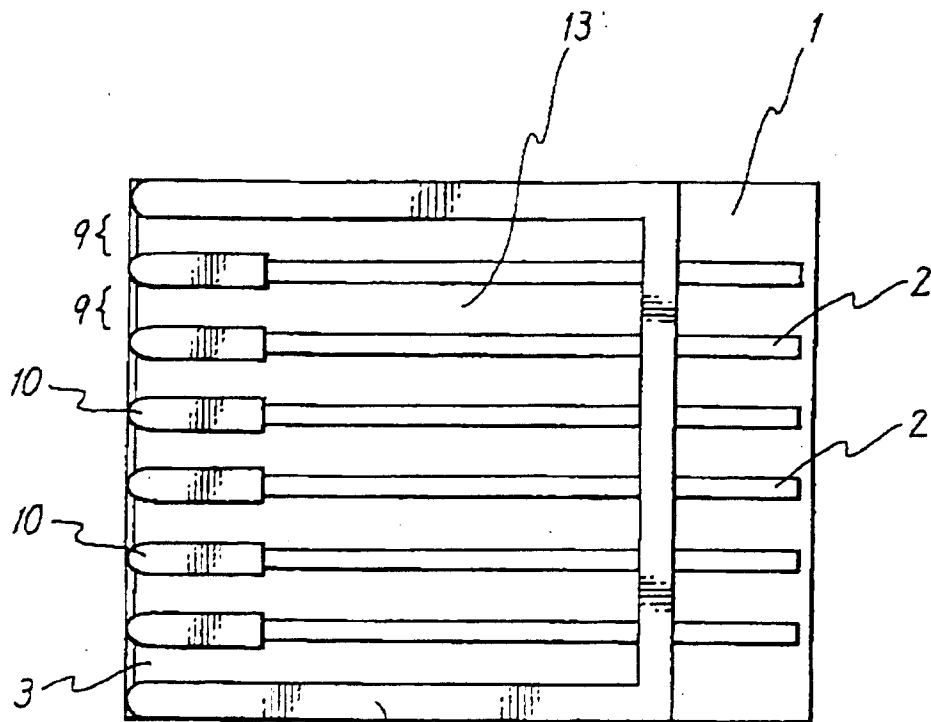
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100 FIG. 6

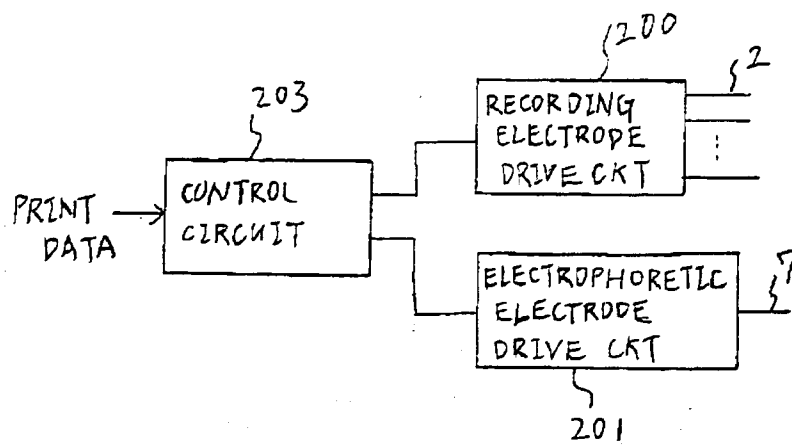


FIG. 7

FIG. 8A

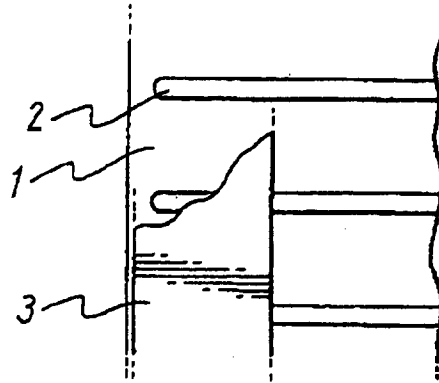


FIG. 8B

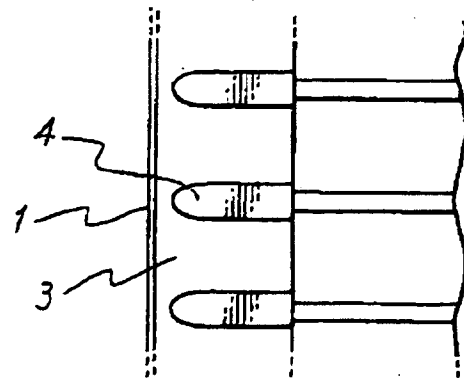


FIG. 8C

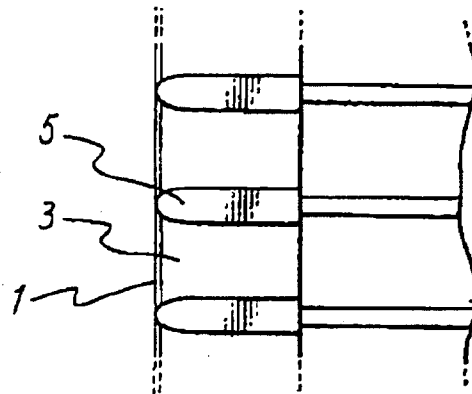
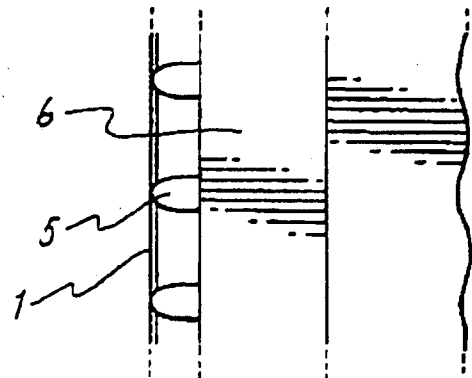


FIG. 8D



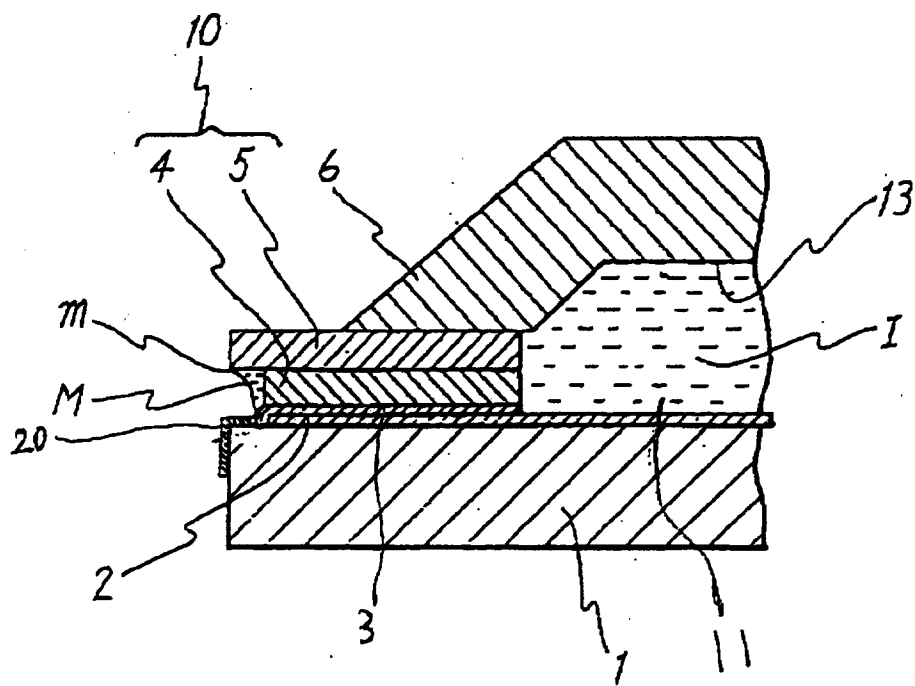


FIG. 9