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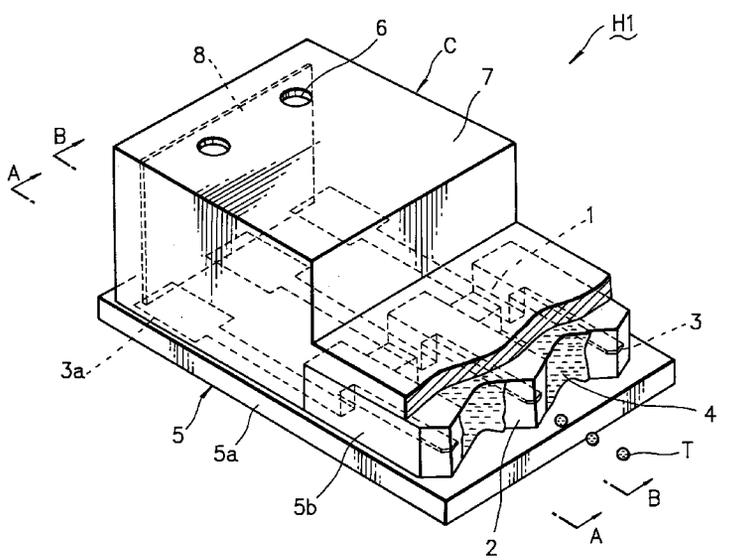
(54) Electrostatic ink jet recording head

(57) In a combination of an ink flow path (1) having at one end an ink chamber (10) for storing ink (I) containing charged toner particles and at the other end an ink outlet (4) communicating with the outside, a discharge part forming member (5b) constituting a contour of the ink flow path (1), and a discharge electrode (3) provided together with the discharge part forming member (5b) for generating an electric field to discharge an ink jet (T), the discharge part forming member (5b) has an ink discharge face (2) formed to be pointed in a V-shape so that the ink outlet (4) is substantially flush with a pointed end of the V-shape, and the discharge electrode (3) has its far end disposed substantially in a middle of the V-shape.

FIG. 1



EP 0 760 290 A2

Description

BACKGROUND OF THE INVENTION

The present invention generally relates to an electrostatic ink jet recording head, and particularly, to an ink jet recording head of an electrostatic type which employs liquid ink containing solid toner particles charged in a polarity and exerts thereon an electric field for discharging a quantity of toner particles as an ink jet to effect a recording or printing.

Description of the Related Art

There are known electrostatic ink jet recording devices of a conventional type in which an electric field is exerted on charged liquid ink, causing a volume of liquid ink to be discharged as an ink jet, which flies onto a sheet of recording paper, to effect a direct recording thereon.

In the direct recording, liquid ink is directly put on the paper so that a printed character tends to be blurred with ink stains, constituting an undesirable limit to efforts for an improved recording resolution.

Recent years have developed a new type of liquid ink containing solid toner particles charged in a polarity, accompanying yet continued efforts for developing electrostatic ink jet heads or devices of an advanced type in which an electric field is exerted on the new type of ink, forcing charged toner particles to fly out for a recording.

However, there are still left various unsolved problems, such as how to minituarize the device, how to efficiently discharge a quantity of charged toner particles out of liquid ink, how to increase the accuracy of a discharge direction, and how to achieve a rapid printing with a quality.

The present invention has been achieved with such points in mind.

SUMMARY OF THE INVENTION

It therefore is an object of the present invention to provide an electrostatic ink jet recording head of the advanced type, permitting a high-speed, high-quality printing at a substantially equivalent level to an electrophotographic system.

To achieve the object, a genus of the present invention provides an electrostatic ink jet recording head including an ink flow path having at one end thereof an ink chamber for storing therein a volume of ink containing electrically charged toner particles and at the other end thereof an ink outlet communicating with the outside, a discharge part forming member constituting a contour of the ink flow path, and a discharge electrode provided together with the discharge part forming member for generating an electric field to discharge an ink jet, wherein the discharge part forming member has an ink discharge face formed to be pointed in a V-shape so that the ink outlet is substantially flush with a pointed end of the V-shape of the ink discharge face, and the discharge electrode has a far end thereof disposed substantially in a middle of the V-shape of the ink discharge face.

According to the genus of the invention, an ink discharge face has an ink meniscus formed like a thin film along a pointed end thereof so that when a discharge electrode is applied with a discharge pulse, charged toner particles are concentrated substantially in a middle of the ink discharge face where a far end of the discharge electrode is disposed and wherefrom a quantity of toner particles is discharged to fly toward an opposing electrode.

According to a species of the genus of the invention, the electrostatic ink jet recording head further includes a substrate member, the ink flow path and the discharge part forming member are provided on a surface at one side of the substrate member, and a connection end of the discharge electrode is provided on a surface at the other side of the substrate member.

According to the species of the invention, a connection end of a discharge electrode is provided on either side of a substrate member, permitting a component part on the opposite side of the substrate member to be disposed in a superimposing location.

According to an individual of the species of the invention, the substrate member and the discharge part forming member are formed to be integral with each other by way of a green sheet hole forming method.

According to the individual of the invention, a necessary pattern is printed on a green sheet as a base, before a lamination of a subsequent green sheet followed by a binder elimination as an antecedent step of a main sintering employed to obtain a hardened ceramic green sheet, removing unnecessary pattern print portions, which process is repeated to integrally fabricate a substrate member and a discharge part forming member.

Moreover, to achieve the object, another genus of the present invention provides an electrostatic ink jet recording head comprising first and second recording heads each including an ink flow path having at one end thereof an ink chamber for storing therein a volume of ink containing electrically charged toner particles and at the other end thereof an ink outlet communicating with the outside, a discharge part forming member constituting a contour of the ink flow path, a discharge electrode provided together with the discharge part forming member for generating an electric field to discharge an ink jet, and a substrate member having a first surface at one side thereof and a second surface at the other side thereof, wherein the discharge part forming member has an ink discharge face formed to be pointed in a V-shape so that the ink outlet is substantially flush with a pointed end of the V-shape of the ink discharge face, the discharge electrode has a far end thereof disposed substantially in a middle of the V-shape of the ink discharge face, the ink flow path and the discharge part forming member are provided on the first surface of the sub-

strate member, a connection end of the discharge electrode is provided on the second surface of the substrate member, the respective second surfaces of the respective substrate members of the first and second recording heads face each other, and the respective ink discharge faces of the first and second recording heads are oriented in the same direction and located in a staggered manner.

According to this genus of the invention, the provision of an ink discharge face is doubled, permitting a selective discharge of toner particles.

BRIEF DESCRIPTION OF THE DRAWINGS

The objects, features and advantages of the present invention will become more apparent from consideration of the following detailed description, in conjunction with the accompanying drawings, in which:

Fig. 1 is a perspective view, partly in section, of an essential portion of an electrostatic ink jet recording head according to an embodiment of the invention;
Fig. 2 is a section along line A-A of Fig. 1;
Fig. 3 is a section along line B-B of Fig. 1; and
Fig. 4 is a front view of an essential portion of an electrostatic ink jet recording head according to another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

There will be detailed below the preferred embodiments of the present invention, with reference to the accompanying drawings. Like members are designated by like reference characters. As used herein, the term "member" sometimes refers to a concerned portion of an integral component.

Fig. 1 shows an essential portion of an electrostatic ink jet recording head H1 according to an embodiment of the invention, Figs, 2 and 3 are A-A and B-B sections of Fig. 1, respectively.

The ink jet recording head H1 comprises a horizontal array of multiple cell combinations each composed of a left ink jet cell C (Fig.1) and an unshown right ink jet cell, and has a partially shown ink supply system for supplying the respective cells with a circulating flow of liquid ink I containing toner particles charged in an apparently positive polarity due to a zeta potential or a negative polarity, and a partially shown electric field control system.

The left ink jet cell C comprises a left cell body composed of a left discharge cell member 5 and a left ink holding member 7 fitted on the left cell member 5, a left toner transfer or migration electrode 8, and a triple of parallel left discharge electrodes 3.

The left cell member 5 is cooperative with the left ink holding member 7 to define a left ink chamber 1 and a pair of parallel left ink flow paths 1 communicating at rear ends thereof with the left ink chamber 1. The left ink holding member 7 has a pair of left ink circulation slots 6. The left cell member comprises a left substrate (as a portion) 5a, a triple of parallel left discharge part forming members (as portions) 5b, and a pair of fluid resistance parts (as portions) 11 interposed between rear ends of neighboring two of the left discharge part forming members 5b.

The right ink jet cell is similar in constitution to the left ink jet cell C, but is different therefrom in numbers of ink flow paths and discharge electrodes. Therefore, it comprises a right cell body composed of a right discharge cell member and a right ink holding member fitted on the right cell member, a right migration electrode analogous to the left migration electrode 8, and a pair of parallel right discharge electrodes each analogous to the left discharge electrode 3.

The right cell member is cooperative with the right ink holding member to define a right ink chamber and a triple of parallel ink flow paths communicating at rear ends thereof with the right ink chamber. The right ink holding member has a pair of right ink circulation slots. The right cell member comprises a right substrate (as a portion), a pair of parallel right discharge part forming members (as portions), and a triple of fluid resistance parts (as portions). The right substrate may be integral with the left substrate 5.

The ink supply system includes an unhsown ink cartridge, an unshown ink circulation pump, the left and right ink circulation slots, the left and right ink chambers, and the left and right ink flow paths. The left and right ink chambers may directly communicate with each other, subject to a single left ink circulation slot and a single right ink circulation slot.

The electric field control system includes the left and right migration electrodes, the left and right discharge electrodes, an unshown voltage driver for commonly driving the left and right migration electrodes and independenly or selectively driving the left and right discharge electrodes, a contoller for controlling the driver, and a grounded opposing electrode 12 (Figs. 2 and 3) arranged in opposition to respective front ends of the left and right discharge electrodes, with a sheet transfer 13 route in between.

The left and right migration electrodes may be integral with each other. The opposing electrode 12 may be a cylindrical conductive member constituting an outside diameter portion of a platen in a sheet feed system of an electrostatic ink jet recorder, so that a sheet of recording paper put on the platen may have a grounded potential. The ink jet recorder may be a serial print type or a line print type.

More specifically, as shown in Figs. 1 to 3, the ink jet cell C includes: an ink chamber 10 for storing therein a volume of ink I containing electrically charged toner particles; a pair of ink flow paths 1 each communicating at a rear end thereof with the ink chmaber 10 and at a front end thereof with the outside, via an ink outlet 4; a triple of parallel discharge part forming members 5b of which a respective pair of neighboring two constitute a

contour of a corresponding one of the ink flow paths 1, i.e. defining the corresponding flow path 1 at both sides; and a triple of parallel discharge electrodes 3 each provided together with a corresponding one of the discharge part forming members 5b, i.e. provided therethrough in a stepwise extending manner, for generating an electric field having a controllable potential distribution along a corresponding flw path 1 to discharge a quantity of toner particles from the ink outlet 4, as an ink jet T.

Each discharge part forming member 5b has at a front end thereof an ink discharge face 2 formed to be pointed in a V-shape in plan so that the ink outlet 4 is substantially flush with a pointed end of the V-shape of the ink discharge face 2. Each discharge electrode 3 has a V-shaped far end (i. e. front end) thereof disposed substantially in a middle in both plan and elevation of the V-shape of the ink discharge face 2.

The ink jet cell C further includes a substrate 5a. The two ink flow paths 1 and the three discharge part forming members 5b are arranged on the upside of the substrate 5b, and a connection end (i.e. near end or rear end) 3a of each discharge electrode 3 is provided as a pad on the downside of the substrate 5b.

The substrate 5a and the discharge part forming members 5b are formed to be integral with each other to constitute a discharge cell member 5, by way of a green sheet hole forming method.

In the embodiment, there are provided on the upside of the substrate 5a a total of three discharge part forming members 5b arranged in parallel to each other to define a total of two ink flow paths 1 together with their ink outlets 4. The two ink flow paths 1 are connected to a single ink chamber 10.

Each discharge part forming member 5b has a body formed to be square or rectangular in section, and an ink discharge face 2 tapered to be pointed with a V-shape in a plan or in a section in a horizontal direction of Fig. 1, which face 2 is located at a slightly rearwardly offset position from a front end of the member 5b. The discharge part forming members 5b are provided at a pitch of approx. 85 μm corresponding to a resolution of 300 dpi (dots per inch).

Moreover, the upside of the substrate 5a is covered with an ink holding member 7 which defines corresponding portions of the ink chamber 10, the ink flow paths 1 and the ink outlets 4. The ink holding member 7 comprises a box-like rear part composed of top and side walls, and a stepped-down flat front part of which a front end is flush with the pointed end of the ink discharge face 2 of each discharge part forming member 5b.

In the ink chamber 10 is installed an exposed plate-like migration or toner transfer electrode 8. The ink holding member 7 has a pair of ink supply slots 6 formed through the top wall facing the chamber 10. On the upside of the substrate 5a is further provided a total of three fluid resistance parts 11 each convexed with an overhead gap left not to fully block a corresponding ink flow path 1. Each resistance part 11 is located between rear ends of neighboring two of the three discharge part forming members 5b.

The three discharge electrodes 3, one-to-one correspondent to the discharge part forming members 5b, are each stripe-shaped up to a front end thereof, where it is pointed along the shape of the ink discharge face 2 of corresponding member 5b.

Each discharge electrode 3 is provided through, i.e. burried in, the corresponding discharge part forming member 5b, along a logitudinal direction thereof, while the electrode 3 is bent on the way, stepwise or like a crankshaft, to downwardly extend through a via-hole in the member 5b and the substrate 5a until it reaches the downside or bottom of the substrate 5a, where it is rearwardly bent to constitute a lower part thereof that is formed on the downside of the substrate 5a, to rearwardly extend, ending at a connection part 3a, which is formed underside of a rear periphery of the substrate 5a, as one of pads arrayed therealong for an electrical connection to an external voltage driver.

The front end of the discharge electrode 3 is exposed at a corresponding location in the discharge face 2 of corresponding discharge part forming member 5a, and the connection part 3a at the rear end of the discharge electrode 3 has a slightly smaller width than a width of the corresponding discharge part forming member 5a.

The ink supply slots 6 formed through the ink holding member 7 are connected via tubes to an ink pump, which is adapted to exert a bias on a volume of ink I in the chamber 10 with a negative pressure near 1 cmH_2O, forcing the ink I to circulate.

For an intended recording, employed ink I contains a system of toner particles as thermoplastic fine particles colored and dispersed together with a charge controlling agent in a petroleum organic solvent (an isoparaffin) so that the particles are charged in an apparently positive polarity due to a zeta potential.

The three ink discharge faces 2 are disposed in opposition to a grounded opposing electrode 12, with a sheet transfer route 13 in between. The respective connection parts 3a of the three discharge electrodes 3 and the toner transfer electrode 8 are connected to the voltage driver, which is adapted to be operable for continuously or normally supplying the toner transfer electrode 8 with a relatively high voltage identical in polarity to the charged toner particles, and to be controllable in the recording for independently or selectively supplying the discharge electrodes 3 with a voltage pulse of an identical polarity to the toner particles.

The substrate 5a and the discharge part forming members 5b are formed to be integral by way of a green sheet hole forming method, as described.

The green sheet is employed to constitute a multilayered ceramic substrate, as it has a high sterength, a low dielectric constant and an excellent stability in contraction, exemplarily permitting an array of via-holes to be formed with a diameter of 100 μm at a pitch of 250 μm, in addition to a mating adaptivity good to a semi-

conductive material so that 50- μm fine patterns are laminatable with a high precision.

In a fabrication, a necessary pattern is printed on a green sheet as a base, before a lamination of a subsequent green sheet, which is followed by a binder elimination that is an antecedent step of a main sintering employed to obtain a hardened ceramic green sheet, removing unnecessary pattern print portions. Such the fabrication process is repeated to integrally fabricate an intended component with a voluntary pattern, i.e. a discharge cell member 5 including the substrate 5a and the discharge part forming members 5b.

There will be described below actions of the recording head H1.

As the ink chamber 10 is supplied with a volume of ink I, columns of ink I invade the ink flow paths 1, respectively, having a thin film-like ink meniscus formed along the ink discharge face 2 with ink I induced from the ink outlet 4 of each flow path 1.

As the entire device is put to an operation, the toner transfer electrode 8 is applied with a migration voltage of an identical polarity to charged toner particles, cooperating with each discharge electrode 3 to have an electric potential field developed in accordance with a potential difference therebetween, which potential field is exerted on charged toner particles, causing them to migrate, i.e. to be electrically transferred, through the ink outlet 4 to a region close to the ink meniscus end.

As respective or selective one or neighboring two of the discharge electrodes 3 is/are supplied with a voltage pulse of an identical polarity to charged toner particles, the discharge electrode(s) 3 cooperate(s) at the front end(s) with the opposing electrode 12 to have an electric potential field developed therebetween, which is exerted on charged toner particles in a vicinity of the ink meniscus, forcing them to be concentrated near the front end of each or corresponding discharge electrode 3 and discharged as ink jet(s) T therefrom toward the opposing electrode 12, thus flying onto a sheet of recording paper in front thereof, where they are deposited, before a thermal fixing thereof to be effected in an unshown fixing system to complete a printing.

Along with the discharge of toner particles as ink jet T, the ink meniscus is caused to vibrate. This vibration is transmitted into the ink I in flow path 1. The vibration of ink meniscus tends to give errors to the direction of concentration of an associated electric field, causing errors in the flying direction of toner particles. To this point, in the present embodiment H1, each ink flow path 1 is provided with a fluid resistance part 11 for controlling to suppress vibrations of ink meniscus.

The quantity of charged toner particles in and near the ink meniscus is reduced to get short, as they are discharged. However, in the embodiment H1, the toner transfer electrode 8 is always applied with a bias voltage for promptly supplementing a necessary quantity of toner particles to provide a meniscus region with a sufficient quantity to permit an immediate and substantially continuous recording.

As charged toner particles are discharged, the ink discharge face 2 has counter ions left therearound (with a reverse polarity to the toner particles), which ions tend to influence a development direction of electric field, constituting an objection to the electric migration by which charged toner particles are transferred. To eliminate the issue, the embodiment H1 has the toner transfer electrode 8 exposed to be in direct contact with ink I, so that those conter ions excessively left in ink I are electrically discharged through the electrode 8.

The foregoing actions are repeated to achieve an intended recording or printing. The electrostatic ink jet recording head H1 thus achieves an ink jet recording by way of discharging toner particles as a jet of ink I.

According to the present embodiment, an ink outlet 4 is defined with a pair of V-shape-pointed ink discharge faces 2 of which central portions each have a pointed distal or far end of an associated discharge electrode 3 arranged therein with a matching configuration, permitting the discharge faces 2 to have a thin-film-like ink meniscus developed therebetween, allowing a quantity of charged toner particles to be discharged from a middle region thereof, without giving undue vibrations to the ink meniscus that otherwise might be cuased by the discharge of toner particles.

Accordingly, even in a contnuous discharge of toner particles, the flight direction of ink jet is kept with a high accuracy, securing a high-quality printing.

Moreover, according to the embodiment, a near end as a connection end 3a of each discharge electrode 3 is provided on a downside of a substrate 5a, permitting various component parts such as members 7 and 8 to be installed on the opposite side of the substrate 5a in a superimposing manner.

Further, as a substrate 5a and a necessary number of discharge part forming members 5b are integrated with each other by way of a green sheet hole forming method, an associated fabrication process is facilitated with a corresponding reduction in cost.

Furthermore, each flow path 1 is provided with a resistance part 11, effectively preventing ink vibrations due to a discharge of toner particles from being transmitted to other ink flow paths.

The far end of each discharge electrode 3 may be upwardly or downwardly offset from the central portion of an associated ink discharge face 2.

The number of ink discharge faces 2 of any discharge cell C may be increased or decreased, as necessary. The fabrication may employ a photolithography. Discharge electrodes may may have their connection ends arranged on an upside of a substrate.

The toner transfer electrode 8 may be arranged along a left or right side wall of the ink chamber 10.

Fig. 4 shows an essential portion of an electrostatic ink jet recording head H according to another embodiment of the invention.

The recording head H comprises a pair of upper and lower ink jet recording heads H1 and H2 both in accordance with the previous embodiment, as their sub-

strates 5a directly face each other at bottom sides thereof, and respective ink discharge faces of their discharge part forming members 5b are oriented in an identical direction (upside of the drawing sheet) and located in a staggered manner therebetween.

In other words, an electrostatic ink jet recording head H comprises first and second recording heads H1 and H2 each composed of an array of combinations each consisting of a left ink discharge cell C and a right ink discharge cell.

The ink discharge cells each include: at least one ink flow path (1, Fig. 1) having at a rear end thereof an ink chamber (10, Fig. 3) for storing therein a volume of ink (I, Fig. 2) containing electrically charged toner particles and at a front end thereof an ink outlet 4 communicating with the outside; at least one discharge part forming member 5b constituting a contour of the ink flow path (1); at leat one discharge electrode 3 provided together with the discharge part forming member 5b for generating an electric field to discharge an ink jet (T, Fig. 1); and a substrate 5a having a first surface at one side thereof (i.e. upside in Fig. 1) and a second surface at the other side thereof (i.e. downside in Fig. 1).

The discharge part forming member 5b has an ink discharge face (2, Fig. 1) formed to be pointed in a V-shape so that the ink outlet 4 is substantially flush with a pointed end of the V-shape of the ink discharge face (2).

The discharge electrode 3 has a far end thereof disposed substantially in a middle of the V-shape of the ink discharge face (2).

The ink flow path (1) and the discharge part forming member 5b are provided on the first surface of the substrate 5a, and a connection end (3a, Fig. 1) of the discharge electrode 3 is provided on the second surface of the substrate 5a.

The respective second surfaces of the respective substrates 5a, 5a of the first and second recording heads H1, H2 face each other, and the respective ink discharge faces (2) of the first and second recording heads H1, H2 are oriented in the same direction and located in a staggered manner.

According to the present embodiment, besides the effects and advantages of the previous embodiment, the provision of ink discharge faces (2) vertically doubled in number gives a recording resolution multiplied by two or more, permitting a printing speed to be increased to a double or more.

Moreover, as the conneciton end (3a) of each discharge electrode 3 has a slightly smaller width than a corresponding discharge part forming member 5b, respective connection ends (3a) are arrayed in a staggered manner, when the two heads H1 and H2 are assembled, so that they can be handled as a single connection block, permitting a connector design to be facilitated.

As will be underdtood from the foregoing embodiments, according a genus of to the invention, as one end of an ink discharge electrode is disposed at a middle of a V-shape-pointed ink discharge face defining an ink outlet, the ink discharge face has an ink meniscus formed like a thin film along the pointed end so that toner particles are discharged from a central region of the ink meniscus, without giving undue vibrations thereto, permitting the flight direction of ink jet to be kept with a high accuracy, securing a high-quality printing, even in a contnuous ink jet discharge.

Moreover, according to a species of the invention, a connection end of a discharge electrode is provided on either side of a substrate member, permitting component parts to be installed on the opposite side of the substrate member in a superimposing manner, and a substrate member to be reduced in size, as well as an entirety of a recording head.

Further, according to an individual of the invention, a substrate member and a discharge part forming member are formed to be integral with each other by way of a green sheet hole forming method, so that an associated fabrication process is facilitated with a corresponding reduction in cost.

Still more, according to another genus of the invention, as a pair of recording heads are assembled together so as to have their ink discharge faces arrayed in a staggered manner, the provision of ink discharge faces doubled in number gives a recording resolution multiplied by two or more, permitting a printing speed to be increased to a double or more.

While the present invention has been described with reference to the particular illustrative embodiments, it is not to be restricted by those embodiments but only by the appended claims. It is to be appreciated that those skilled in the art can change or modify the embodiments without departing from the scope and spirit of the present invention.

Claims

1. An electrostatic ink jet recording head (H1), including:

   an ink flow path (1) having at one end thereof an ink chamber (10) for storing therein a volume of ink (I) containing electrically charged toner particles and at the other end thereof an ink outlet (4) communicating with the outside;
   a discharge part forming member (5b) constituting a contour of the ink flow path; and
   a discharge electrode (3) provided together with the discharge part forming member for generating an electric field to discharge an ink jet (T), wherein:
   the discharge part forming member (5b) has an ink discharge face (2) formed to be pointed in a V-shape so that the ink outlet (4) is substantially flush with a pointed end of the V-shape of the ink discharge face; and
   the discharge electrode (3) has a far end thereof disposed substantially in a middle of

the V-shape of the ink discharge face.

2. An electrostatic ink jet recording head (H1) according to claim 1, further including a substrate member (5a), wherein:

the ink flow path (1) and the discharge part forming member (5b) are provided on a surface at one side of the substrate member; and

a connection end (3a) of the discharge electrode (3) is provided on a surface at the other side of the substrate member.

3. An electrostatic ink jet recording head (H1) according to claim 2, wherein the substrate member (5a) and the discharge part forming member (5b) are formed to be integral with each other by way of a green sheet hole forming method.

4. An electrostatic ink jet recording head (H), comprising:

first and second recording heads (H1, H2) each including:

an ink flow path (1) having at one end thereof an ink chamber (10) for storing therein a volume of ink (I) containing electrically charged toner particles and at the other end thereof an ink outlet (4) communicating with the outside;

a discharge part forming member (5b) constituting a contour of the ink flow path;

a discharge electrode (3) provided together with the discharge part forming member for generating an electric field to discharge an ink jet (T); and

a substrate member (5a) having a first surface at one side thereof and a second surface at the other side thereof, wherein:

the discharge part forming member (5b) has an ink discharge face (2) formed to be pointed in a V-shape so that the ink outlet (4) is substantially flush with a pointed end of the V-shape of the ink discharge face;

the discharge electrode (3) has a far end thereof disposed substantially in a middle of the V-shape of the ink discharge face;

the ink flow path (1) and the discharge part forming member (5b) are provided on the first surface of the substrate member;

a connection end (3a) of the discharge electrode (3) is provided on the second surface of the substrate member;

the respective second surfaces of the respective substrate members (5b, 5b) of the first and second recording heads (H1, H2) face each other; and

the respective ink discharge faces (2, 2) of the first and second recording heads (H1, H2) are oriented in the same direction and located in a staggered manner.

FIG. 1

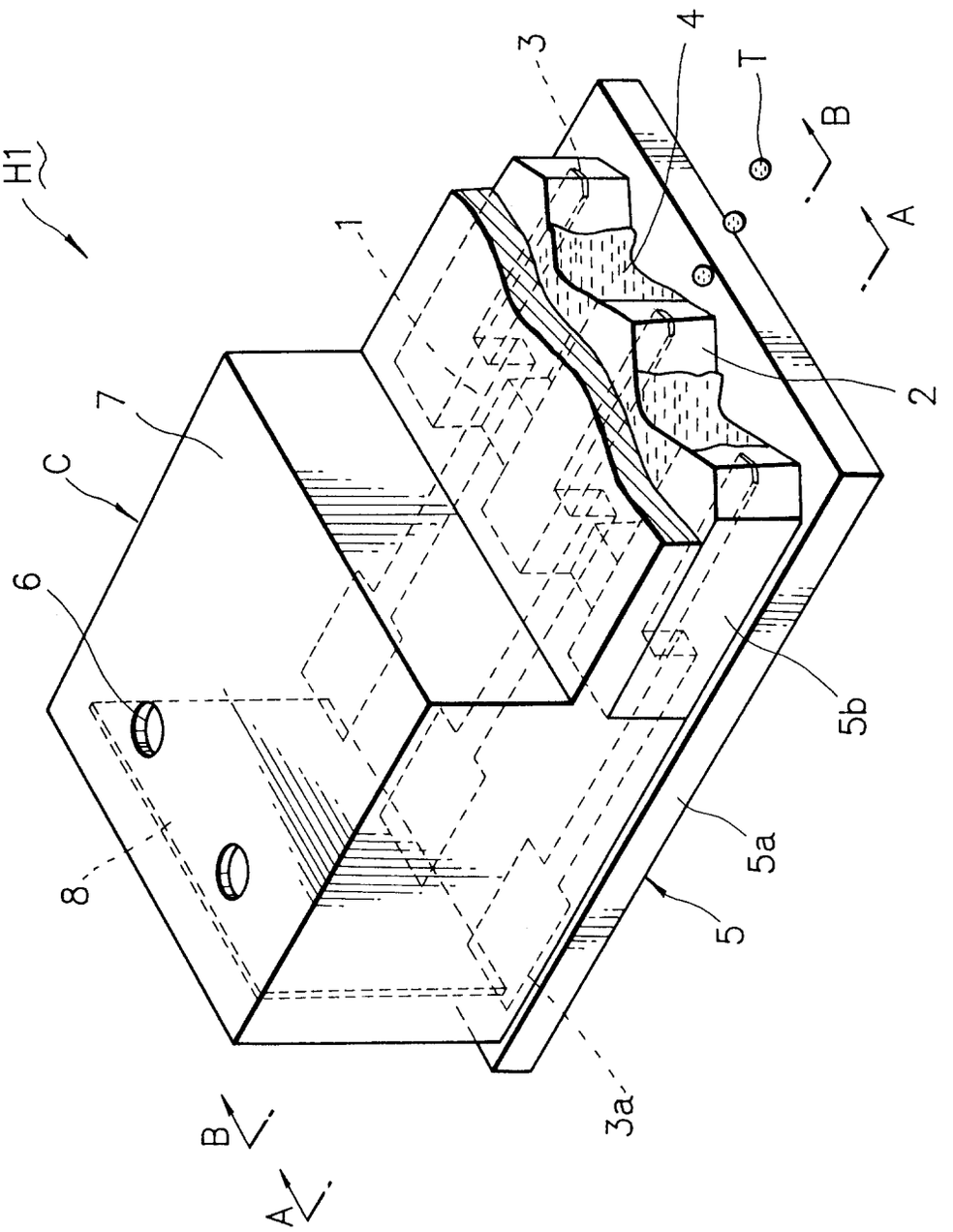


FIG. 2

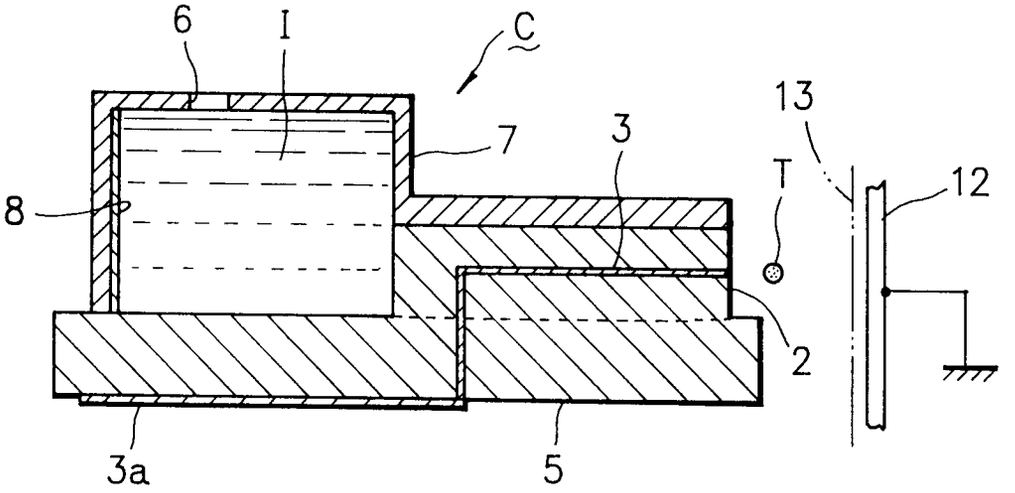


FIG. 3

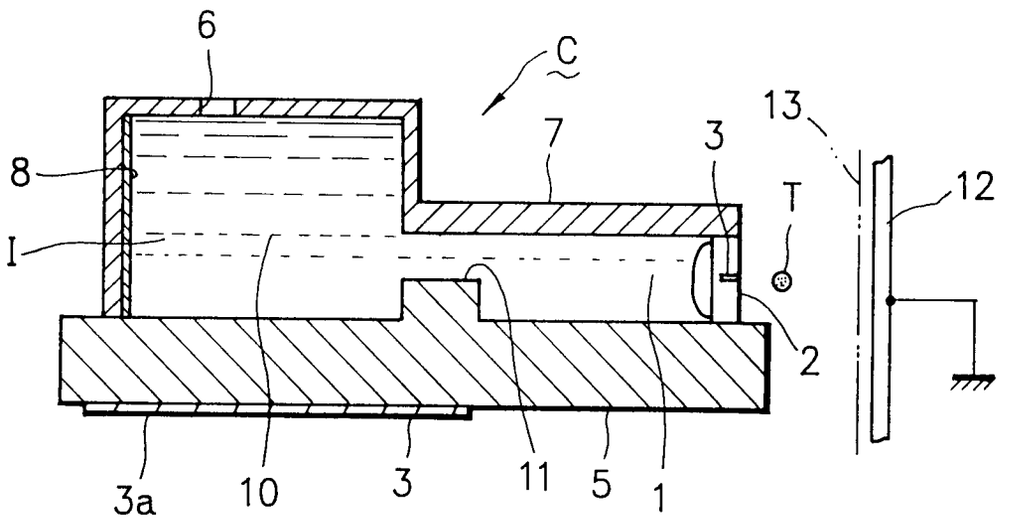


FIG. 4