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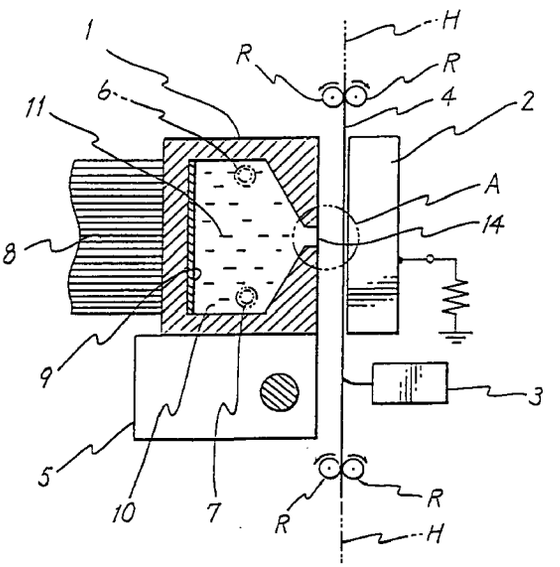
(54) Electrostatic ink jet recording device

(57) In an electrostatic ink jet recording device, an ink chamber stores liquid ink containing charged toner particles. An ejection opening or slit is formed in one end portion of the ink chamber. An electrophoresis electrode is positioned at the other end portion of the ink chamber facing the one end portion. A plurality of record electrodes are arranged in parallel in the ejection opening. A counter electrode faces the record electrodes with the intermediary of a path for transporting a recording medium. Discharging means is located upstream of the counter electrode with respect to the intended direction of medium transport. The discharging means dissipates any undesirable charge deposited on the recording medium before the medium reaches the counter electrode.

FIG. 3A



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Description

BACKGROUND OF THE INVENTION

The present invention relates to an electrostatic ink jet recording device and, more particularly, to an electrostatic ink jet recording device of the type electrostatically depositing toner particles contained in liquid ink on a recording medium and thereby recording a dot on the medium.

Nonimpact type recording devices are attracting increasing attention because they produce only negligible noise during printing. Among them, an ink jet recording device is capable of recording an image even on a plain paper at high speed with a simple configuration. One of conventional ink jet recording devices uses ink consisting of a carrier liquid and charged toner particles dispersed therein. In this kind of recording device, a voltage is applied to a designated record electrode and a counter electrode facing the record electrode with the intermediary of a paper transport path, forming an electric field between the two electrodes. The electric field causes the toner particles to fly in the form of a drop and record a dot on the paper.

However, the conventional recording device of the kind described has the following problem. While the paper or similar recording medium is conveyed, it is often charged due to friction acting between it and another paper, friction acting between the paper and conveyor rollers, etc. The charge deposited on the paper weakens the electric field formed between the record electrode and the counter electrode, and thereby prevents an electrostatic force intense enough to eject the toner particles from being attained. This obstructs the stable ejection of toner particles, i.e., stable printing operation.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide an electrostatic ink jet recording device insuring the stable ejection of toner particles toward a recording medium.

An electrostatic ink jet recording device of the present invention includes an ink chamber storing liquid ink containing charged toner particles. An ejection opening or slit is formed in one end portion of the ink chamber. An electrophoresis electrode is positioned at the other end portion of the ink chamber facing the one end portion. A plurality of record electrodes are arranged in parallel in the ejection opening. A counter electrode faces the record electrodes with the intermediary of a path for transporting a recording medium. Discharging means is located upstream of the counter electrode with respect to the intended direction of medium transport. The discharging means dissipates any undesirable charge deposited on the recording medium before the medium reaches the counter electrode.

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 a front view of a conventional electrostatic ink jet recording device, particularly its head assembly;
FIG. 1B is a section along line C-C of FIG. 1A;
FIG. 1C is a side elevation of the conventional recording device;
FIG. 2 is a perspective view showing an electrostatic ink jet recording device embodying the present invention, particularly its head assembly;
FIG. 3A is a view of the embodiment as seen in a direction B shown in FIG. 2; and
FIG. 3B is an enlarged view of a portion A shown in FIG. 3A.

DESCRIPTION OF THE PREFERRED EMBODIMENT

To better understand the present invention, a brief reference will be made to a conventional electrostatic ink jet recording device, particularly its head assembly, shown in FIGS. 1A-1C. As shown, the head assembly, generally 101, has an ink chamber 113 delimited by a lower plate 110, a side wall 111, and an upper plate 112. A pump, not shown, constantly circulates ink in the ink chamber 113 via ports 114 and 115. A slit or ejection opening 109 is formed in the side wall 111 and plays the role of a gap for forming an ink meniscus. A record electrode 102 is disposed in the slit 109 and so positioned as to slightly protrude outward from the slit 109. The outermost end of the record electrode 102 is sharpened. The record head 102 is coated with an insulating material and insulated from the ink thereby.

An electrophoresis electrode 105 surrounds the ink chamber 113 at three sides where the record electrode 102 is absent. The electrophoresis electrode 105 is partly disposed in the chamber 113 and held in electrical contact with the ink. A driver, not shown, applies a high-voltage pulse to the record electrode 102 in the event of recording. A counter electrode, not shown, is positioned on the imaginary extension of the record electrode 102 and connected to ground via a paper transport path, not shown. The ink consists of a petroleum-based organic solvent (isoparaffin) and toner particles dispersed in the solvent. The toner particles are apparently charged to the positive polarity by zeta potential beforehand.

In operation, a bias voltage of the same polarity as the charge deposited on the toner particles is applied to the electrophoresis electrode 105, causing the toner particles in the ink to collect densely at the slit 109 due to electrophoresis. Subsequently, a high-voltage pulse of the same polarity as the charge of the toner particles is applied to the record electrode 102. As a result, an

electric field is formed between the record electrode 102 and the counter electrode. The electric field concentrates around the sharp tip of the record electrode 102 and extends toward the counter electrode with high intensity. The toner particles charged by zeta potential beforehand and forming an ink meniscus is pulled by the counter electrode due to a Coulomb's force derived from the above electric field. When the Coulomb's force overcomes the surface tension of the ink, the toner particles fly toward the counter electrode in the form of a mass or drop. The toner particles forming the drop deposit on a paper or similar recording medium positioned between the head 101 and the counter electrode, forming a dot on the paper. The high-voltage pulse to be applied to the record electrode 102 is controlled in accordance with print data so as to form a desired image.

Only the toner particles are mainly consumed at the time of recording. Therefore, just after the ejection of the toner particles toward the recording medium, the toner content of the ink is lowered around the record electrode 102. However, the high voltage constantly applied to the electrophoresis electrode 105 causes the toner particles to migrate from the electrode 105 toward the electrode 102 due to electrophoresis. This allows only the toner particles to be replenished to around the electrode 102. Particularly, the electrode 102 is insulated from the ink. Therefore, when the potential distribution in the ink chamber 113 reaches equilibrium due to the migration of the charged toner particles, no more particles are replenished to the above position.

The conventional recording device with the above head assembly has the previously stated problem left unsolved.

Referring to FIGS. 2, 3A and 3B, an electrostatic ink jet recording device embodying the present invention, particularly its head assembly, will be described. As shown, the head assembly, generally 1, has an ink chamber 10 storing ink 11 containing charged toner particles. A slit or ejection opening 14 is formed in one end of the ink chamber 10. An electrophoresis electrode 9 is positioned at the other end of the ink chamber 10 facing the slit 14. A record electrode 12 is disposed in the slit 14. A counter electrode 2 faces the record electrode 12 with the intermediary of a paper transport path H. Discharging means 3 for discharging a paper or similar recording medium 4 is positioned upstream of the counter electrode 2 with respect to an intended direction of paper transport D (FIG. 2).

The head assembly 1 is mounted on a carriage 5 movable back and forth in a direction E (FIG. 2) perpendicular to the direction of paper transport D. The head assembly 1 is implemented as a serial print head and has its outside walls mainly formed of a dielectric material. The carriage 5 is movably mounted on a guide shaft 5A. The ink 11 consists of a petroleum-based organic solvent (isoparaffin) and a charge control agent and toner particles dispersed in the solvent. The toner refers to fine colored particles of thermoplastic resin. Again, the toner is apparently charged to the positive polarity by zeta potential. A pump or similar pressure source, not shown, constantly circulates the ink in the ink chamber 10 via an inlet port 6 and an outlet port 7.

Specifically, as shown in FIG. 3B, a plurality of elongate record electrodes 12 are arranged in parallel at intervals corresponding to a desired number of dots. Each record electrode 12 is implemented as an about 50 μm wide strip formed of Cu, Ni or similar conductive material and produced by electroforming. The portions of the electrode 12 contacting the ink 11 are coated with insulating resin. Preferably, the insulating resin should be hydrophilic in order to enhance affinity between the surface of the electrode 12 and the ink 11. The outer end of the electrode 12 protrudes from the slit 14 by about 80 μm to 100 μm. Walls 13 are each positioned on the respective electrode 12. The walls 13 form slit-like passageways fine enough to cause capillarity to occur as soon as the ink 11 is fed thereto. An ink meniscus is formed between each of the walls 13 and the associated electrode 12.

The electrophoresis electrode 9 facing the slit 14 is formed of metal or similar conductive material and held in direct contact with the ink 11. The electrophoresis electrode 9 and record electrodes 12 are connected to a voltage drive section, not shown, by a cable 8 implemented by a flexible print cable (FPC). The voltage drive section applies a high-voltage pulse of the same polarity as the charge of the toner particles to the electrode 9, and applies a high-voltage pulse of the same polarity as the charge of the toner particles to designated one of the electrodes 12 at a record timing.

The counter electrode 2 is connected to ground via a preselected resistance, so that great current does not flow between it and the record electrode 12. The electrode 2 has a width corresponding to the width of the paper 4 and serves as a platen at the same time. The paper 4 is conveyed in the direction D by roller pairs R.

The discharging means 3 is held in contact with the paper 4 over the entire width of the paper 4 while the paper 4 is in transport. In the illustrative embodiment, the discharging means 3 is implemented as a discharge brush extending in the widthwise direction of the paper 4. The discharge brush may be replaced with a discharge brush roller or a conductive rubber blade, if desired.

The guide shaft 5A on which the carriage 5 is mounted, the counter electrode 2 and the discharging means are each affixed to a particular part of the body of the recording device.

In operation, a voltage of the same polarity as the charge of the toner particles existing in the ink 11 is applied to the electrophoresis electrode 9. As a result, a difference in potential occurs between the electrode 9 and the record electrodes 12 set at a lower potential than the electrode 9. In this condition, the toner particles of the ink 11 apparently play the role of a charge. Therefore, the toner particles are fed to the surfaces of the insulating resin covering the record electrodes 12, in an

amount great enough for the potential in the ink 11 to become equal to the potential of the electrode 9. Consequently, the ink 11 on the electrodes 12 become equal in potential to the electrode 9.

As shown in FIG. 3A, the paper 4 is conveyed upward along the path H by the roller pairs R. At this instant, the discharging means or brush 3 is held in contact with the rear of the paper 4. As a result, any charge undesirably deposited on the paper 4 during transport is dissipated before the paper 4 reaches the gap between the counter electrode 2 and the record electrodes 12.

Subsequently, a high-voltage pulse of the same polarity as the charge of the toner particles is applied to designated one of the record electrodes 12, forming an electric field between the designated electrode 12 and the counter electrode 2. When a Coulomb's force acting on the toner particles included in the ink meniscus overcomes the surface tension of the meniscus, the toner particles of the meniscus are ejected in the from of a drop 15 from the slit 14 toward the counter electrode 15. The drop 15 deposits on the paper 4 and records a dot thereon.

Just after the ejection of the drop 15, the toner particles become short around the record electrode 12. This again produces a difference in potential between the electrophoresis electrode 9 and the record electrode 12. As a result, the toner particles are replenished to the surface of the resin covering the electrode 12. Such a procedure is repeated to form a desired image on the paper 4.

As stated above, even when the paper 4 is undesirably charged during transport, the paper 4 is successfully discharged before it reaches the counter electrode 2. This insures a stable electric field between the record electrodes 1 2 and the counter electrode 2, i.e., the stable ejection of the drop 15 at the time of recording.

While the illustrative embodiment has concentrated on a serial print head, it may, of course, be implemented as a line print head, if desired.

In summary, in accordance with the present invention, discharging means is positioned upstream of a counter electrode with respect to an intended direction of paper transport. Therefore, even when a paper is undesirably charged during transport, the paper is successfully discharged before it reaches the counter electrode 2. This insures a stable electric field between record electrodes and the counter electrode, i.e., the stable ejection of a drop at the time of recording.

Claims

1. An electrostatic ink jet recording device comprising:

   an ink chamber storing liquid ink containing charged toner particles;
   an ejection opening formed in one end portion of said ink chamber;
   an electrophoresis electrode positioned at the other end portion of said ink chamber facing said one end portion;
   a plurality of record electrodes arranged in parallel in said ejection opening;
   a counter electrode facing said plurality of record electrodes with the intermediary of a path for transporting a recording medium; and
   discharging means located upstream of said counter electrode with respect to an intended direction of medium transport, for dissipating any charge undesirably deposited on the recording medium during transport.

2. A device as claimed in claim 1, wherein said discharging means comprises a discharge brush.

3. A device as claimed in claim 1, wherein said discharging means comprises a discharge brush roller.

4. A device as claimed in claim 1, wherein said discharging means comprises a conductive rubber plate.

Fig. 1A PRIOR ART

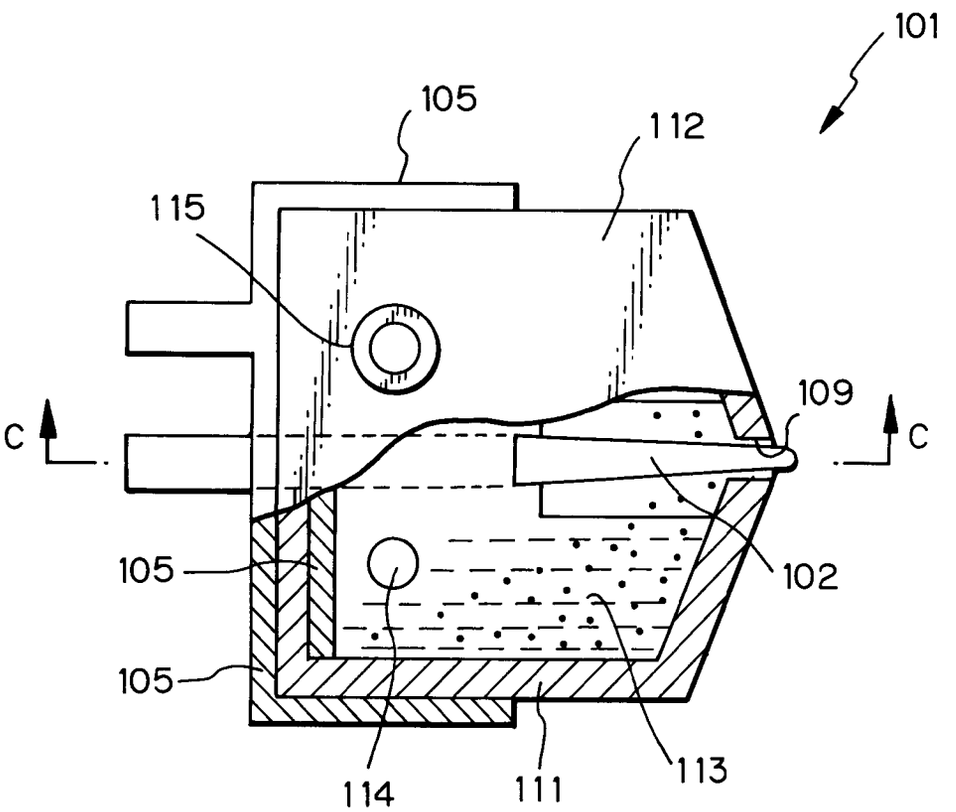

Fig. 1B PRIOR ART

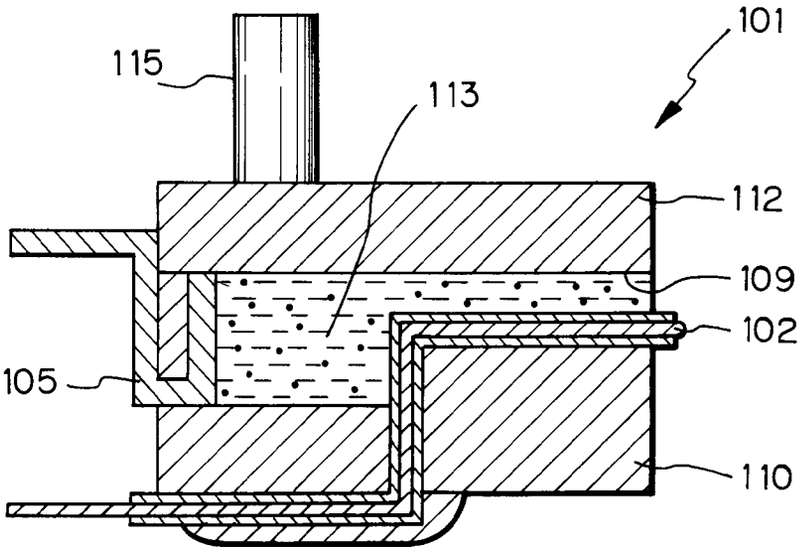

Fig. 1C PRIOR ART

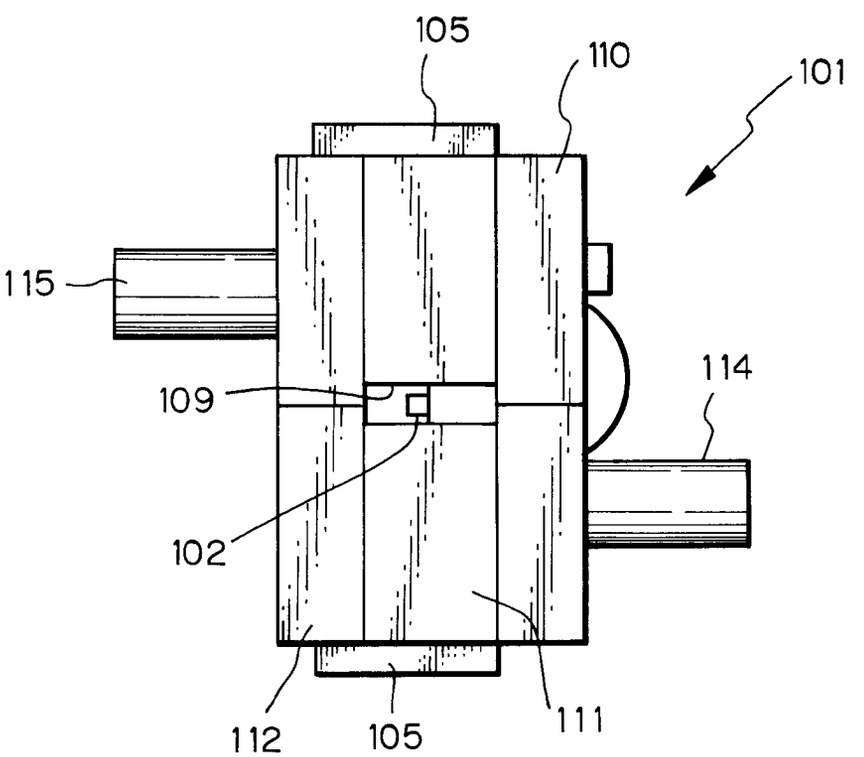

Fig. 2

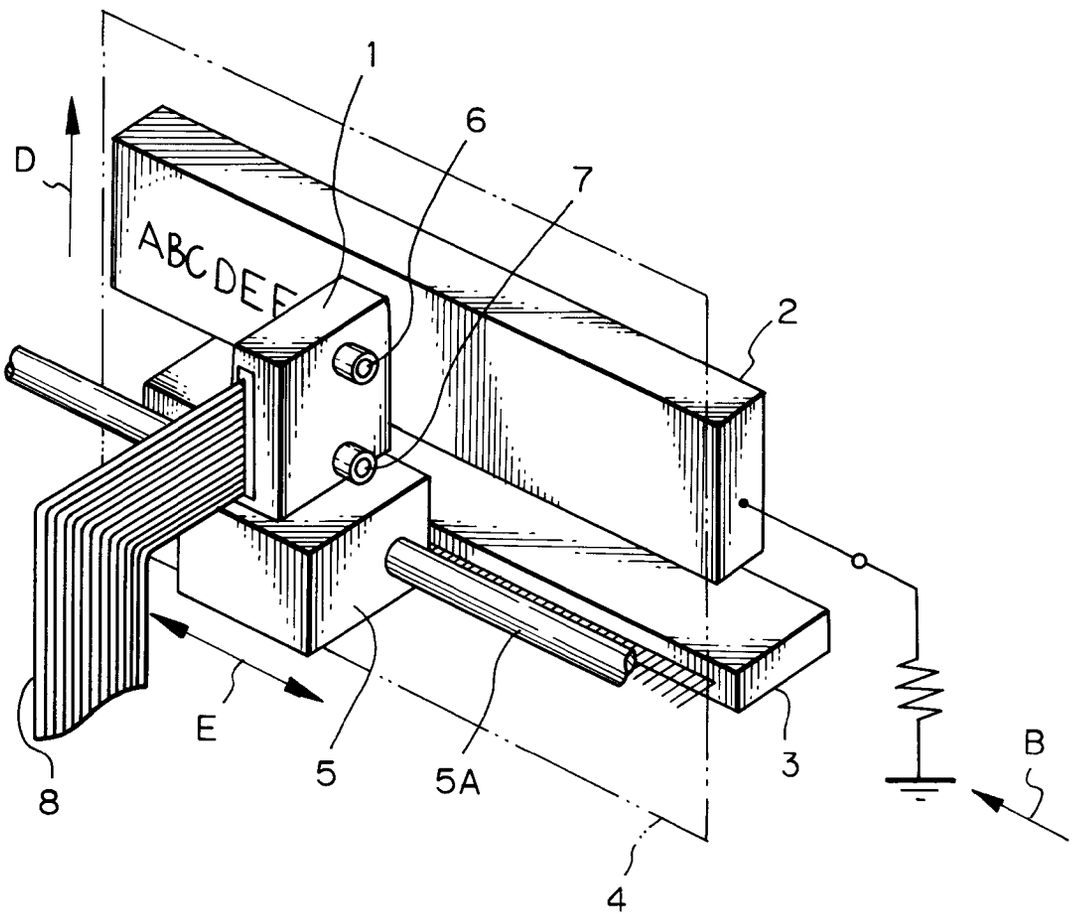

Fig. 3A

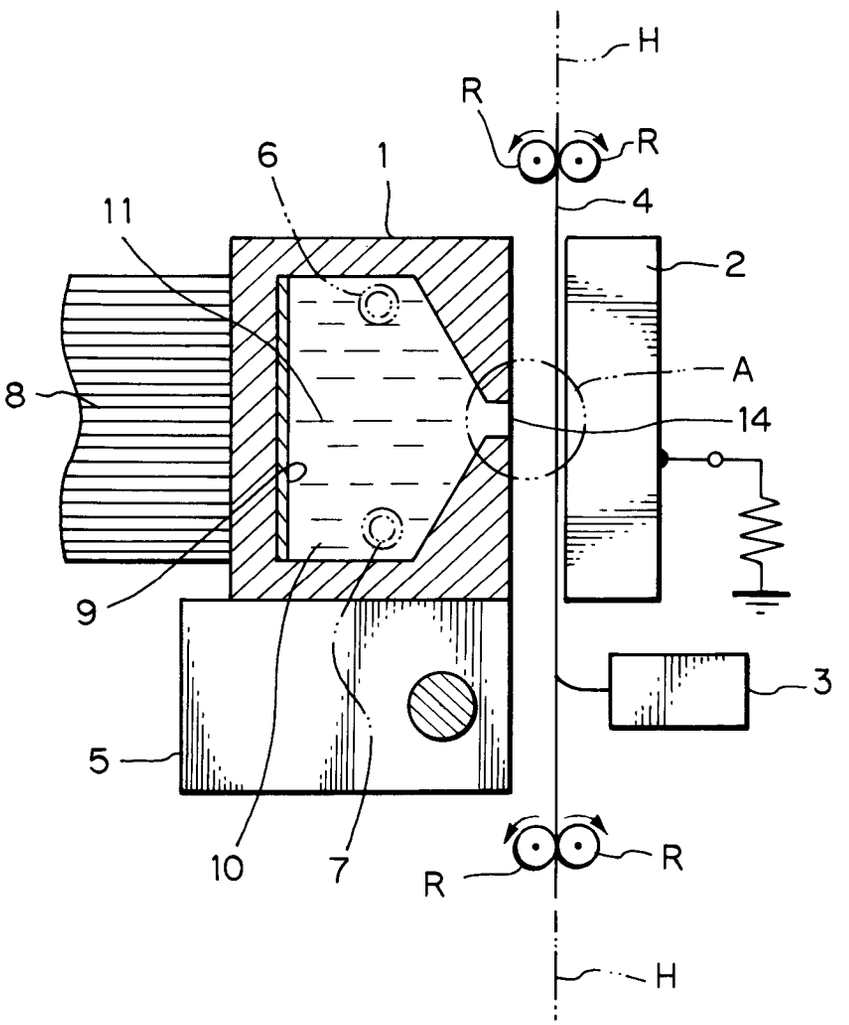

Fig. 3B