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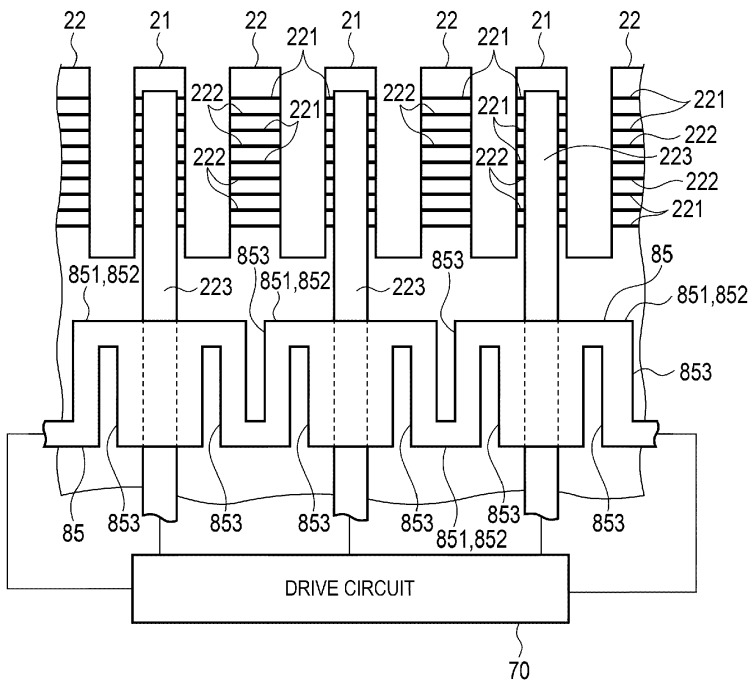
(54) **LIQUID EJECTION HEAD AND LIQUID EJECTION APPARATUS**

(57) Provided are a liquid ejection head and a liquid ejection apparatus capable of eliminating dot misalignment or density unevenness due to a drive pattern. A liquid ejection head according to an embodiment includes a plurality of pressure chambers, an actuator, a plurality of individual electrodes, a nozzle plate, a plurality of switching elements, and a plurality of electric resistances. The actuator includes a plurality of piezoelectric bodies that change volumes of the pressure chambers according to a drive signal. The plurality of individual electrodes are respectively provided on the plurality of piezoelectric bodies. The nozzle plate has a plurality of nozzles communicating with the plurality of pressure chambers, respectively. The switching element selectively connects the drive signal for the piezoelectric body. The switching elements are electrically connected to the plurality of individual electrodes. The electric resistances electrically connect the individual electrodes of the piezoelectric bodies adjacent to each other.

FIG. 4



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Description

FIELD

[0001] Embodiments described herein relate generally to a liquid ejection head and a liquid ejection apparatus.

BACKGROUND

[0002] A push mode type piezoelectric inkjet head that ejects ink as a liquid is known in related art. The ink jet head includes a plurality of nozzles, a plurality of pressure chambers, a vibration plate, and an actuator in which a plurality of piezoelectric drive piezoelectric poles and a plurality of support piezoelectric poles are alternately formed and the poles are electrically connected to a drive circuit. The actuator extends and contracts the drive piezoelectric poles to displace the vibration plate, thereby changing volumes of the pressure chambers to eject ink from the nozzles.

[0003] However, when adjacent nozzles are driven simultaneously, the support piezoelectric poles are deformed by a reaction force of a driving force of the actuator, a generated pressure is lower than when a single nozzle is driven, and an ejection speed or volume of the ink decreases. When the ejection speed or volume of the ink decreases, dot misalignment or density unevenness occurs due to a drive pattern.

DISCLOSURE OF INVENTION

[0004] To this end, there is provided a liquid ejection head according to claim 1. Preferred embodiments are set out in the dependent claims. There is also provided a liquid ejection apparatus according to claim 15.

DESCRIPTION OF THE DRAWINGS

[0005]

FIG. 1 is a cross-sectional view showing a configuration of a liquid ejection head according to an embodiment, with a part thereof omitted;
FIG. 2 is a cross-sectional view showing the configuration with a part thereof omitted;
FIG. 3 is a cross-sectional view showing the configuration with a part thereof omitted;
FIG. 4 is an explanatory view schematically showing a configuration of an electric resistor;
FIG. 5 is an explanatory diagram showing a configuration of a drive circuit with a part thereof omitted;
FIG. 6 is an explanatory diagram showing the configuration in an example of driving the liquid ejection head;
FIG. 7 is an explanatory diagram showing an example of voltages in the example;
FIG. 8 is an explanatory view schematically showing a configuration of a liquid ejection apparatus;
FIG. 9 is an explanatory diagram showing a configuration of a drive circuit in an example of driving a liquid ejection head according to another embodiment; and
FIG. 10 is an explanatory diagram showing an example of voltages in the example.

DETAILED DESCRIPTION

[0006] In general, according to an embodiment, a liquid ejection head and a liquid ejection apparatus capable of eliminating dot misalignment or density unevenness due to a drive pattern is provided.

[0007] A liquid ejection head according to an embodiment includes a plurality of pressure chambers, an actuator, a plurality of individual electrodes, a nozzle plate, a plurality of switching elements, and a plurality of electric resistances. The actuator includes a plurality of piezoelectric bodies that change volumes of the pressure chambers according to a drive signal. The plurality of individual electrodes are respectively provided on the plurality of piezoelectric bodies. The nozzle plate has a plurality of nozzles communicating with the plurality of pressure chambers, respectively. The switching element selectively connects the drive signal for the piezoelectric body. The switching elements are electrically connected to the plurality of individual electrodes. The electric resistances electrically connect the individual electrodes of the piezoelectric bodies adjacent to each other.

[0008] Hereinafter, an inkjet head 1 as a liquid ejection head and an inkjet recording apparatus 100 as a liquid ejection apparatus according to an embodiment will be described with reference to FIGS. 1 to 8. FIGS. 1 to 3 are cross-sectional views schematically showing a configuration of the inkjet head 1. FIG. 1 is a cross-sectional view showing the configuration of the inkjet head 1 with a part thereof omitted, FIG. 2 is a cross-sectional view showing the configuration of the ink jet head 1 with a part thereof omitted in a direction different from that of FIG. 1, and FIG. 3 is a cross-sectional view showing the configuration of the ink jet head 1 in an example of driving different from that of FIG. 2. FIG. 4 is an explanatory view schematically showing a configuration of a second electric resistor 85, which is the configuration of the ink jet head 1. FIG. 5 is an explanatory diagram showing a configuration of a drive circuit 70 of the ink jet head 1 with a part thereof omitted, and FIG. 6 is an explanatory diagram showing the configuration of the drive circuit 70 in an example of driving the ink jet head 1. FIG. 7 is an explanatory diagram showing an example of voltages in the example of driving the inkjet head 1. FIG. 8 is an explanatory view schematically showing a configuration of the inkjet recording apparatus 100 using the ink jet head 1. In each of the drawings, the configuration is shown enlarged, reduced, or omitted as appropriate for a purpose of description.

[0009] As shown in FIGS. 1 to 4, the ink jet head 1 includes a base 10, a pair of actuators 20 each including a plurality of piezoelectric poles 21 and 22, a vibration plate 30, a flow path member 40, a nozzle plate 50 having a plurality of nozzles 51, a frame portion 60 as a structural portion, and the drive circuit 70. The ink jet head 1 forms a plurality of pressure chambers 31 by the vibration plate 30, the flow path member 40, and the nozzle plate 50, and ejects ink as a liquid within the pressure chambers 31 from the nozzles 51 by vibrating the vibration plate 30 using the piezoelectric poles 21 of the actuators 20.

[0010] The ink jet head 1 includes one or two actuators 20. For example, the two actuators 20 are arranged side by side in a direction orthogonal to an arrangement direction of the plurality of piezoelectric poles 21 and 22 as piezoelectric bodies.

[0011] The base 10 is a support member that supports the actuators 20. The base 10 is formed in a block shape or a plate shape, for example.

[0012] The actuators 20 are fixed to the base 10. The actuator 20 includes the plurality of piezoelectric poles 21 and 22 that are piezoelectric members (piezoelectric elements). The actuator 20 forms a piezoelectric pole row by the plurality of piezoelectric poles 21 and 22. The actuator 20 includes a plurality of drive piezoelectric poles (piezoelectric bodies) 21, a plurality of support piezoelectric poles (piezoelectric bodies) 22 alternately arranged with the plurality of drive piezoelectric poles 21 along a row direction of the piezoelectric pole row, and a coupling portion 26 integrally coupling the plurality of piezoelectric poles 21 and 22 on a base 10 side. The actuator 20 is formed of a laminated piezoelectric member. Here, the laminated piezoelectric member is formed by laminating a plurality of piezoelectric layers 211 and a plurality of internal electrodes 221 and 222. The actuator 20 includes external electrodes 223 and 224 formed on the plurality of drive piezoelectric poles 21.

[0013] For example, the laminated piezoelectric member constituting the actuator 20 is formed by laminating and sintering sheet-shaped piezoelectric materials on which electrode layers as the internal electrodes 221 and 222 are formed. The actuator 20 forms grooves 23 by dicing the laminated piezoelectric member joined to the base 10 in advance from an end surface opposite to the base 10 side, thereby forming, at predetermined intervals, the plurality of piezoelectric poles 21 and 22 each having a rectangular columnar shape. The external electrodes 223 and 224 are provided on the plurality of formed columnar piezoelectric members (piezoelectric elements). Through these steps, the plurality of drive piezoelectric poles 21 and the plurality of support piezoelectric poles 22 are formed, which are alternately arranged in the coupling portion 26 and have the external electrodes 223 and 224 formed on outer surfaces thereof.

[0014] The plurality of drive piezoelectric poles 21 and the plurality of support piezoelectric poles 22 are arranged in a longitudinal direction of the actuator 20 at predetermined intervals. A vibration direction of the drive piezoelectric poles 21 and the support piezoelectric poles 22 is a lamination direction of the plurality of piezoelectric layers 211. The drive piezoelectric pole 21 is an actuator that is driven by applying a voltage and vibrates the vibration plate 30. The support piezoelectric pole 22 is a non-driven piezoelectric pole that supports the vibration plate 30 and is restricted from vibrating the vibration plate 30 by the flow path member 40 even when a voltage is applied thereto.

[0015] As an example, each of the plurality of drive piezoelectric poles 21 and the plurality of support piezoelectric poles 22 is formed in a rectangular columnar shape having the same outer shape. The laminated piezoelectric member is divided into a plurality of parts by a plurality of grooves 23 having a predetermined depth formed in the actuator 20 (laminated piezoelectric member) except for the coupling portion 26, thereby forming the plurality of drive piezoelectric poles 21 and the plurality of support piezoelectric poles 22. For example, the plurality of grooves 23 formed in the actuator 20 have the same width and the same interval. Accordingly, the plurality of drive piezoelectric poles 21 and the plurality of support piezoelectric poles 22, which are alternately arranged, are arranged in one direction at the same pitch. For example, each of the plurality of drive piezoelectric poles 21 and the plurality of support piezoelectric poles 22 is formed in a rectangular columnar shape.

[0016] The plurality of drive piezoelectric poles 21 are arranged at positions respectively facing the plurality of pressure chambers 31 formed by the vibration plate 30, the flow path member 40, and the nozzle plate 50, with the vibration plate 30 interposed therebetween, in the lamination direction of the plurality of piezoelectric layers 211. As an example, for the drive piezoelectric poles 21 and the pressure chambers 31, a center position in the drive piezoelectric poles 21 in the row direction of the piezoelectric pole row and a center position in the pressure chambers 31 in the row direction of the piezoelectric pole row are arranged in the lamination direction of the plurality of piezoelectric layers 211 with the vibration plate 30 interposed therebetween.

[0017] The plurality of support piezoelectric poles 22 are arranged at positions respectively facing a plurality of partition wall portions 43 (described later) of the flow path member 40, with the vibration plate 30 interposed therebetween, in the lamination direction of the plurality of piezoelectric layers 211. As an example, a center position in the support piezoelectric poles 22 in the row direction of the piezoelectric pole row and a center position in the partition wall portions 43 in the same direction as the row direction of the piezoelectric pole row are arranged in the lamination direction of the plurality of piezoelectric layers 211.

[0018] The plurality of drive piezoelectric poles 21 and the plurality of support piezoelectric poles 22 include the plurality of piezoelectric layers 211 laminated in a Z direction, and the internal electrodes 221 and 222 formed on main surfaces of the piezoelectric layers 211. As an example, the drive piezoelectric pole 21 and the support piezoelectric pole 22 have the same laminated structure. The drive piezoelectric pole 21 each includes the external electrodes 223 and 224 as surface wirings formed on the surfaces.

[0019] The piezoelectric layer 211 is formed in a thin plate shape from a piezoelectric ceramic material such as a PZT (lead zirconate titanate) based material or a lead-free KNN (sodium potassium niobate) based material. A thickness direction of the piezoelectric layer 211 is along the lamination direction in which the plurality of piezoelectric layers 211 are laminated. The plurality of laminated piezoelectric layers 211 are bonded to each other. In the present embodiment, the thickness direction and the lamination direction of the piezoelectric layers 211 are along a vibration direction of the piezoelectric poles 21 when driven.

[0020] The laminated piezoelectric member forming the drive piezoelectric poles 21 and the support piezoelectric poles 22 may further include a dummy layer 212 on either or both of end portions on the base 10 side and a nozzle plate 50 side. The dummy layer 212 is formed of, for example, the same material as the piezoelectric layer 211, has an electrode only on one side, and is not deformed because no electric field is applied thereto. For example, the dummy layer 212 does not function as a piezoelectric body, but serves as a base for fixing the actuator 20 to the base 10, or serves as a polishing allowance for polishing to improve accuracy during and after assembly.

[0021] The internal electrodes 221 and 222 are conductive films formed of a sinterable conductive material such as silver palladium, and each having a predetermined shape. The internal electrodes 221 and 222 are formed in predetermined regions on the main surfaces of the piezoelectric layers 211. The internal electrodes 221 and 222 have different poles.

[0022] For example, one internal electrode 221 is formed in a region that reaches one end of the piezoelectric layer 211 but does not reach the other end of the piezoelectric layer 211 in a width direction orthogonal to both the row direction and the vibration direction, which are the arrangement direction of the plurality of drive piezoelectric poles 21 and the plurality of support piezoelectric poles 22. Hereinafter, the internal electrode 221 may be referred to as a first internal electrode 221.

[0023] The other internal electrode 222 is formed in a region that does not reach one end of the piezoelectric layer 211 but reaches the other end of the piezoelectric layer 211 in the width direction orthogonal to both the row direction and the vibration direction. Hereinafter, the internal electrode 222 may be referred to as a second internal electrode 222.

[0024] The external electrodes 223 and 224 are formed on the surfaces of each of the plurality of drive piezoelectric poles 21, and are formed by collecting end portions of the internal electrodes 221 and 222. For example, the external electrode 223 is formed on one end surface of the piezoelectric layer 211 in the width direction. Hereinafter, the external electrode 223 may be referred to as a first external electrode 223. The external electrode 224 is formed on the other end surface of the piezoelectric layer 211 in the width direction. The external electrode 224 may extend to an end surface of the piezoelectric layer 211 on the base 10 side. Hereinafter, the external electrode 224 may be referred to as a second external electrode 224.

[0025] The external electrodes 223 and 224 are formed of Ni, Cr, Au, or the like by a known method such as plating or sputtering. The external electrode 223 and the external electrode 224 have different poles. The first external electrode 223 and the second external electrode 224 are respectively formed on different side surfaces of each of the plurality of drive piezoelectric poles 21.

[0026] In the present embodiment, as an example, the first external electrode 223 is an individual electrode, and the second external electrode 224 is a common electrode. As shown in FIG. 4, the first external electrode 223 is formed on each of the plurality of drive piezoelectric poles 21. One second external electrode 224 is provided and connects all of the plurality of drive piezoelectric poles 21. The plurality of first external electrodes 223 and the single second external electrode 224 are disposed independently of each other.

[0027] The first external electrode 223 is connected to a plurality of first internal electrodes 221 formed in one drive piezoelectric pole 21. For example, the single second external electrode 224 is a ground electrode. The single second external electrode 224 is connected to the plurality of second internal electrodes 222 formed in the plurality of provided drive piezoelectric poles 21.

[0028] The plurality of first external electrodes 223 and the single second external electrode 224 are connected to an FPC 71 serving as a flexible substrate (described later) of the drive circuit 70. For example, the single second external electrode 224 is provided on facing outer surfaces of the pair of actuators 20.

[0029] For example, the individual external electrodes 223 and 224 are connected to a control unit 116 serving as a drive unit via the drive circuit 70, and a signal capable of driving and controlling each piezoelectric pole 21 is input under the control of a control circuit 1161.

[0030] When the drive signal is input to the internal electrodes 221 and 222 via the external electrodes 223 and 224 and an electric field is applied, the piezoelectric pole 21 is displaced in a d33 direction, and the vibration direction of the piezoelectric pole 21 is along the lamination direction of the piezoelectric layers 211.

[0031] Specifically, when a voltage is applied to the internal electrodes 221 and 222 via the external electrodes 223 and 224, the drive piezoelectric pole 21 vibrates longitudinally along the lamination direction of the piezoelectric layers 211. Longitudinal vibration referred to here is, for example, "vibration in the thickness direction defined by the piezoelectric constant d33". The drive piezoelectric pole 21 displaces the vibration plate 30 in the lamination direction of the piezoelectric layers 211 by the longitudinal vibration to deform the pressure chamber 31.

[0032] As an example, each piezoelectric pole 21 includes 3 or more and 50 or less piezoelectric layers 211, a thickness of each piezoelectric layer 211 is 10 μm or more and 40 μm or less, and a product of the thickness and the total number of laminated layers is less than 1000 μm.

[0033] The vibration plate 30 is fixed to end portions of the plurality of drive piezoelectric poles 21 and the plurality of support piezoelectric poles 22 of the pair of actuators 20 on a side opposite to the coupling portion 26 in the Z direction. In other words, the vibration plate 30 is joined to surfaces of the plurality of piezoelectric poles 21 and 22 opposite to the base 10 in the vibration direction of the plurality of piezoelectric poles 21, that is, surfaces of the plurality of piezoelectric poles 21 and 22 on the nozzle plate 50 side.

[0034] The vibration plate 30 is formed in a flat plate shape. The vibration plate 30 is, for example, a metal plate. The vibration plate 30 is deformable by deformation of the drive piezoelectric poles 21. The vibration plate 30 forms the pressure chambers 31 together with the flow path member 40 and the nozzle plate 50. The vibration plate 30 extends in the arrangement direction (row direction) of the plurality of piezoelectric poles 21 and 22. That is, the vibration plate 30 extends along a plane orthogonal to the vibration direction of the piezoelectric poles 21. One main surface of the vibration plate 30 is joined to the drive piezoelectric poles 21 and the support piezoelectric poles 22 of the actuator 20, and the frame portion 60. The other main surface of the vibration plate 30 is joined to the flow path member 40.

[0035] As an example, the vibration plate 30 is formed of a nickel or SUS plate, and a thickness dimension thereof along the vibration direction is approximately 5 μm to 15 μm. The vibration plate 30 may have a fold or step formed at a portion adjacent to a vibration portion that vibrates due to driving of the drive piezoelectric poles 21 or between vibration portions adjacent to each other so as to be easily displaced by the driving of the drive piezoelectric poles 21.

[0036] The vibration plate 30 has, in a region joined to the frame portion 60, a through hole 33 communicating with a common chamber 61 (described later) formed in the frame portion 60. For example, the through hole 33 may be provided with a filter having a large number of pores through which a liquid can pass. One or more through holes 33 may be formed.

[0037] The flow path member 40 is provided between the vibration plate 30 and the nozzle plate 50. The flow path member 40 includes a peripheral wall portion 41 and the plurality of partition wall portions 43. When two actuators 20 are provided, a division wall portion is provided to divide the pressure chambers 31 driven by the actuators 20. The peripheral wall portion 41 and the partition wall portions 43 are provided between the vibration plate 30 and the nozzle plate 50 to form, together with the vibration plate 30 and the nozzle plate 50, a predetermined ink flow path including the plurality of pressure chambers 31 separated from each other and a plurality of individual flow paths 32 separated from each other and allowing the pressure chambers 31 to communicate with the common chamber 61.

[0038] The peripheral wall portion 41 surrounds a region forming the plurality of pressure chambers 31 and the plurality of individual flow paths 32 between the vibration plate 30 and the nozzle plate 50. The plurality of partition wall portions 43 partition a region in the peripheral wall portion 41 into the plurality of pressure chambers 31 and the plurality of individual flow paths 32. That is, both side walls of the plurality of pressure chambers 31 (the plurality of individual flow paths 32) in a parallel direction are formed by the partition wall portions 43. The plurality of partition wall portions 43 are provided at positions facing the support piezoelectric poles 22 with the vibration plate 30 interposed therebetween in the Z direction. Accordingly, the partition wall portions 43 restrict displacement of the support piezoelectric poles 22 at portions of the support piezoelectric poles 22 and the vibration plate 30 where the support piezoelectric poles 22 are fixed.

[0039] The plurality of pressure chambers 31 are spaces formed on one side of a vibration region of the vibration plate 30, and communicate with the common chamber 61 via the individual flow paths 32 and the through hole 33. The plurality of pressure chambers 31 communicate with the nozzles 51 formed in the nozzle plate 50. The pressure chambers 31 are closed by the vibration plate 30 on a side opposite to the nozzle plate 50.

[0040] The plurality of nozzles 51 are formed in the nozzle plate 50 at positions facing the plurality of pressure chambers 31. The nozzle plate 50 is formed of a metal such as SUS or Ni, or a resin material such as polyimide, and has a rectangular plate shape with a thickness of approximately 10 μm to 100 μm. The nozzle plate 50 is joined to surfaces of the peripheral wall portion 41 and the partition wall portions 43 opposite to the vibration plate 30 so as to cover openings of the pressure chambers 31 on one side.

[0041] The plurality of nozzles 51 are arranged in the same direction as the parallel direction of the plurality of pressure chambers 31 to form a nozzle row. For example, in a configuration in which one actuator 20 is provided, one row of the nozzles 51 is provided, and in a configuration in which the pair of actuators 20 are provided, two rows of the nozzles 51 are provided.

[0042] The frame portion 60 is a structure joined to the vibration plate 30 together with the piezoelectric poles 21 and 22. A pair of frame portions 60 are provided on main surfaces of the piezoelectric poles 21 and 22 and the vibration plate 30 on a side opposite to the peripheral wall portion 41. For example, the pair of frame portions 60 are adjacent to the actuator 20. The frame portions 60 constitute an outer shell of the ink jet head 1. For example, the common chamber 61 serving as a flow path of a liquid is formed inside the frame portion 60. The common chamber 61 is formed inside the frame portion 60. The common chamber 61 communicates with the through hole 33 formed in the vibration plate 30, and communicates with the pressure chambers 31 through the individual flow paths 32. For example, the pair of frame portions 60 in each of which the common chamber 61 is formed are provided, a pair of individual flow paths 32 are provided, and the pair of individual flow paths 32 are connected to the pair of common chambers 61, respectively. For example, one common chamber 61 and one individual flow path 32 are used to supply ink to the pressure chamber 31, and the other common chamber 61 and the other individual flow path 32 are used to discharge ink from the pressure chamber 31. The pair of common chambers 61 and the pair of individual flow paths 32 may be used for supplying ink, or may be commonly used for supplying and discharging ink.

[0043] The drive circuit 70 includes the flexible printed circuit (FPC) 71 having one end connected to the external electrodes 223 and 224, a drive IC 72 mounted on the FPC 71, and a printed wiring board 73 mounted on the other end of the FPC 71.

[0044] The drive circuit 70 drives the drive piezoelectric pole 21 by applying a drive voltage to the external electrodes 223 and 224 by the drive IC 72, increases or decreases a volume of the pressure chamber 31, and causes droplets to be ejected from the nozzle 51.

[0045] The FPC 71 is connected to one side surface of the laminated piezoelectric member and is connected to the plurality of external electrodes 223 and 224. A chip on film (COF) on which the drive IC 72 is mounted as an electronic component is used as the FPC 71.

[0046] The drive IC 72 is connected to the external electrodes 223 and 224 via the FPC 71. The drive IC 72 is an electronic component used for ejection control.

[0047] The drive IC 72 generates a control signal and a drive signal for operating each drive piezoelectric pole 21. The drive IC 72 generates the control signal for controlling a timing of ejecting the ink and selection of the drive piezoelectric pole 21 to eject the ink according to an image signal received from the control unit 116 of the ink jet recording apparatus 100 on which the ink jet head 1 is mounted. The drive IC 72 generates a voltage to be applied to the drive piezoelectric pole 21, that is, the drive signal, according to the control signal from the control unit 116. When the drive IC 72 applies the drive signal to the drive piezoelectric pole 21, the drive piezoelectric pole 21 is driven so as to displace the vibration plate 30 and change a volume of the pressure chamber 31. Accordingly, the ink filled in the pressure chamber 31 generates pressure vibration. Due to the pressure vibration, the ink is ejected from the nozzle 51 communicating with the pressure chamber 31. The ink jet head 1 may implement gradation expression by changing an amount of ink droplets that land on one pixel. The inkjet head 1 may change the amount of ink droplets that land on one pixel by changing the number of times of ink ejection. In this way, the drive IC 72 is an example of an application unit that applies the drive signal to the drive piezoelectric pole 21.

[0048] For example, the drive IC 72 includes a data buffer, a decoder, and a driver. The data buffer stores printing data in time series for each drive piezoelectric pole 21. The decoder controls the driver based on the printing data stored in the data buffer for each drive piezoelectric pole 21. The driver outputs a drive signal for operating each drive piezoelectric pole 21 based on the control of the decoder. The drive signal is, for example, a voltage applied to each drive piezoelectric pole 21.

[0049] The printed wiring board 73 is a printing wiring assembly (PWA) on which various electronic components and connectors are mounted, and includes a head control circuit 731. The printed wiring board 73 is connected to the control unit 116 of the ink jet recording apparatus 100.

[0050] The drive circuit 70 selects and supplies a drive signal or a standby voltage to the plurality of drive piezoelectric poles 21 based on a command from the control unit 116 of the ink jet recording apparatus 100 and the printing data. The drive circuit 70 drives the drive piezoelectric pole 21 using single nozzle driving and multinozzle simultaneous driving as a drive pattern. The single nozzle driving is a drive pattern in which the adjacent drive piezoelectric poles 21 are not driven, a drive signal is applied to the first external electrode 223 in one channel, and one drive piezoelectric pole 21 is driven. The multi-nozzle simultaneous driving is a drive pattern in which a drive signal is applied to the first external electrodes 223 in a plurality of channels, and all of the plurality of drive piezoelectric poles 21 or a part of the adjacent drive piezoelectric poles 21 are driven simultaneously.

[0051] As shown in FIG. 5, the drive circuit 70 includes a drive signal source 81 that outputs a drive signal to be applied to the first external electrode 223 which is an individual electrode, a standby voltage source 82 that outputs a standby voltage to be applied to the second external electrode 224 which is a common electrode, switching elements 83 that selectively connect the drive piezoelectric poles 21 to one of the drive signal source 81 and the standby voltage source 82, a plurality of first electric resistors 84 that are internal resistances of the switching elements 83 between the drive piezoelectric poles 21 and the drive signal source 81 or the standby voltage source 82, and a single or a plurality of second electric resistors 85 that connect adjacent drive piezoelectric poles 21 that are at least a part of the plurality of drive piezoelectric poles 21 among the plurality of drive piezoelectric poles 21.

[0052] The switching element 83 is switched based on the printing data. The switching element 83 connects the drive piezoelectric pole 21, which is driven to eject ink, to the drive signal source 81, and connects the non-driven drive piezoelectric pole 21, which does not cause ink to be ejected, to the standby voltage source 82. The plurality of switching elements 83 are included in, for example, the drive IC 72.

[0053] The first electric resistor 84 is an internal resistance of the switching element 83. Here, a resistance value of the first electric resistor 84 is RA. A resistor may be added to the first electric resistor 84 in series with the switching element 83 outside the switching element 83. At this time, the resistance value RA of the first electric resistor 84 is a sum of the internal resistance of the switching element 83 and a resistance added outside the switching element 83.

[0054] Between the drive piezoelectric pole 21 and the switching element 83, the second electric resistor 85 electrically connects the first external electrodes 223, which are individual electrodes of a part of adjacent drive piezoelectric poles 21, with a predetermined resistance value. That is, the second electric resistor 85 includes a plurality of electric resistances 851 provided between the first external electrodes 223 of the adjacent drive piezoelectric poles 21. Here, the number of electric resistances 851 is n-1, where n is the number of first external electrodes 223 to be connected. Here, a resistance value of the electric resistance 851 is RB. As the resistance value RB of the electric resistance 851 decreases, an ejection speed or an ejection volume during the single nozzle driving decreases. Therefore, the resistance value RB of the electric resistance 851 is set to match the ejection speed and the ejection volume for the multi-nozzle simultaneous driving. Here, a reduction rate D of a voltage amplitude with respect to the multi-nozzle simultaneous driving during the single nozzle driving is $D = 2/(3 + RB/RA)$.

[0055] The second electric resistor 85 is formed of, for example, a thin film formed over the first external electrodes 223 of the plurality of drive piezoelectric poles 21 that are formed in the actuator 20 and subjected to multi-nozzle simultaneous driving. As a specific example, the second electric resistor 85 electrically connects the first external electrodes 223 of all the drive piezoelectric poles 21. A plurality of second electric resistors 85 may be provided, and the second electric resistors 85 may connect the first external electrodes 223 of a part of the drive piezoelectric poles 21 that are subjected to multi-nozzle simultaneous driving.

[0056] The second electric resistor 85 is formed of, for example, a metal with high resistivity such as a nickel-chromium alloy or titanium, or a carbon film (carbon). A thickness of the second electric resistor 85 is several nanometers to several micrometers, and is formed by forming a film by vacuum deposition, sputtering, or the like, or printing by a printing method such as screen printing.

[0057] As a specific example, the second electric resistor 85 extends in an arrangement direction of the first external electrodes 223, and is formed of a thin film having a uniform width in a direction (width direction) orthogonal to a longitudinal direction and a thickness direction. The plurality of electric resistances 851 formed in the second electric resistor 85 are formed by, for example, trimming portions 852 formed by a plurality of slits 853 formed between the plurality of first external electrodes 223 by laser processing or the like. In other words, in the second electric resistor 85, the plurality of electric resistances 851 are formed by partially narrowing a width and increasing a length, due to the plurality of slits 853 formed between adjacent first external electrodes 223 to be connected.

[0058] The resistance value RB of the electric resistance 851 can be set by adjusting a shape of the trimming portion 852, specifically, the number, length, and width of the slits 853. In an example in FIG. 4, the trimming portions 852 are formed by alternately forming three rectangular slits 853 arranged in the longitudinal direction of the second electric resistor 85 so as to be shifted in the width direction orthogonal to the longitudinal direction and the thickness direction of the second electric resistor 85. The number, width, length, and shape of the slits 853 are appropriately set according to the resistance value RB of the electric resistance 851. Therefore, the slit 853 may not be rectangular, but may have a shape that is elongated in the width direction of the second electric resistor 85 and is curved in end portions, a semicircular shape, a polygonal shape other than a rectangular shape, or the like.

[0059] In the present embodiment, the second electric resistor 85 is an integral thin film on the actuator 20 so as to connect the plurality of first external electrodes 223, and the plurality of trimming portions 852 are provided to form the plurality of electric resistances 851. However, the second electric resistor 85 is not limited to this configuration, and for example, the second electric resistor 85 may be configured such that the electric resistances 851 are provided between the switching elements 83 and the first external electrodes 223 that perform the multi-nozzle simultaneous driving, and between a plurality of adjacent first external electrodes 223. For example, the second electric resistor 85 may be provided in the FPC 71 or the drive IC 72. The second electric resistor 85 may be formed of a semiconductor such as a transistor. However, it is desirable that the resistance value RB of the electric resistance 851 can be adjusted for the second electric resistor 85 by trimming or the like.

[0060] According to the ink jet head 1 configured as described above, when the switching element 83 is switched and a voltage is applied to the drive piezoelectric pole 21 according to a drive signal, the drive piezoelectric pole 21 extends. The extended drive piezoelectric pole 21 deforms the vibration plate 30, and a volume of the pressure chamber 31 decreases. That is, the vibration plate 30 applies a pressure to ink in the pressure chamber 31, and ink droplets are ejected from the nozzle 51. When a certain drive piezoelectric pole 21 extends, the support piezoelectric pole 22 also extends due to a mechanical reaction force.

[0061] In general, in a case of single nozzle driving, as shown in FIG. 2, since the drive piezoelectric pole 21 adjacent to the drive piezoelectric pole 21 that is driven is not driven, extension of the support piezoelectric pole 22 is small. In general, in a case of multi-nozzle simultaneous driving, as shown in FIG. 3, adjacent drive piezoelectric poles 21 are driven simultaneously and thus extension of the support piezoelectric pole 22 between the drive piezoelectric poles 21 that are driven becomes large.

[0062] Therefore, in a related-art inkjet head that does not include the second electric resistor 85, a deformation amount of the vibration plate 30 with respect to a deformation amount of the drive piezoelectric pole 21 is smaller in the multi-nozzle simultaneous driving than in the single nozzle driving. Since the deformation amount of the vibration plate 30 in the multi-nozzle simultaneous driving is smaller than that in the single nozzle driving, a pressure generated in the pressure chamber 31 is smaller in the multi-nozzle simultaneous driving than in the single nozzle driving according to the related-art technique. Therefore, a speed or volume of ink droplets to be ejected may vary depending on a printing pattern, resulting in a so-called crosstalk problem that deteriorates printing quality.

[0063] In contrast, as shown in FIGS. 4 to 6, the ink jet head 1 according to the embodiment electrically connects the adjacent first external electrodes 223 that perform the multi-nozzle simultaneous driving by the second electric resistor 85, and includes the electric resistances 851 between the first external electrodes 223. Accordingly, in the case of the single nozzle driving, a part of a current of a drive signal applied to the first external electrode 223 provided on the drive piezoelectric pole 21 that is driven flows through the electric resistance 851 to the first external electrode 223 of the adjacent drive piezoelectric pole 21. Therefore, a voltage amplitude for driving the drive piezoelectric pole 21 is reduced. In the case of the multi-nozzle simultaneous driving, since voltages of the plurality of first external electrodes 223 that are driven simultaneously are the same, no current flows through the electric resistance 851, and a voltage amplitude is not reduced.

[0064] In this way, due to the second electric resistor 85, a pressure generated in the pressure chamber 31 when a single nozzle is driven is lowered, and thus it is possible to make the generated pressure generated in the pressure chamber 31 the same or approximate in the single nozzle driving and the multi-nozzle simultaneous driving. Therefore, the inkjet head 1 can eliminate dot misalignment or density unevenness due to the drive pattern.

[0065] For example, in an example in FIG. 6, the single nozzle driving and the multi-nozzle simultaneous driving are performed in six channels ChA to ChF. In FIG. 6, the drive piezoelectric poles 21 in the channels ChA to ChF are denoted by CA to CF, respectively, and the first electric resistors 84 provided between the drive piezoelectric poles CAto CF and the switching elements 83 in the channels ChA to ChF are denoted by 841 to 846, respectively. The electric resistances 851 of the second electric resistor 85 provided between the first external electrodes 223 of the drive piezoelectric poles CA to CF are denoted by 8511 to 8515. For example, in the example in FIG. 6, the drive piezoelectric pole CB in the channel ChB is subjected to single nozzle driving, and the drive piezoelectric poles CD to CF in the channels ChD to ChF are subjected to multi-nozzle simultaneous driving. Accordingly, the ink is not ejected from the nozzles 51 in the channels ChA and ChC, and the ink is ejected from the nozzles 51 in the channels ChB and ChD to ChF. FIG. 7 shows an example of a simulation of voltages applied to the drive piezoelectric poles CA to CF (first external electrodes 223) in the example shown in FIG. 6. Here, voltage values applied to the drive piezoelectric poles CA to CF are denoted by VAto VF, respectively. In FIG. 7, a vertical axis represents voltage and a horizontal axis represents time.

[0066] As shown in FIG. 7, a voltage amplitude of the voltage value VB of the drive piezoelectric pole CB that is subjected to single nozzle driving is smaller than voltage amplitudes of the voltage values VD to VF of the drive piezoelectric poles CD to CF that are subjected to multi-nozzle simultaneous driving. Therefore, a phenomenon of crosstalk in which a pressure generated in the pressure chamber 31 is smaller in the multi-nozzle simultaneous driving than in the single nozzle driving is corrected, and the pressure generated in the pressure chamber 31 becomes substantially the same value in the single nozzle driving and the multi-nozzle simultaneous driving, and a crosstalk problem that deteriorates printing quality due to variations in speed or volume of ink droplets ejected depending on a printing pattern is solved. The voltage values VA and VC of the non-driven drive piezoelectric poles CA and CC adjacent to the drive piezoelectric pole CB subjected to the single nozzle driving are standby voltages. A slight voltage amplitude occurs between the voltage value VA and the voltage value VC, and a minute pressure is generated in the pressure chamber 31, but a problem of ink being ejected from a non-driven nozzle does not occur since a pressure sufficient to cause ink to be ejected is not generated.

[0067] Hereinafter, an example of the inkjet recording apparatus 100 including the ink jet head 1 will be described with reference to FIG. 9. The inkjet recording apparatus 100 includes a housing 111, a medium supply unit 112, an image forming unit 113, a medium discharge unit 114, a conveyance device 115, and the control unit 116.

[0068] The inkjet recording apparatus 100 is a liquid ejection apparatus that performs image forming processing on a sheet P by ejecting a liquid such as ink while conveying the sheet P as a print medium that is an ej ection target along a predetermined conveyance path R from the medium supply unit 112 to the medium discharge unit 114 through the image forming unit 113.

[0069] The housing 111 constitutes an outer shell of the ink jet recording apparatus 100. A discharge port through which the sheet P is to be discharged to the outside is provided at a predetermined position of the housing 111.

[0070] The medium supply unit 112 includes a plurality of sheet feed cassettes, and can stack and hold a plurality of sheets P of various sizes.

[0071] The medium discharge unit 114 includes a sheet discharge tray that can hold the sheet P discharged from the discharge port.

[0072] The image forming unit 113 includes a support portion 117 that supports the sheet P, and a plurality of head units 130 that face the support portion 117 above the support portion 117.

[0073] The support portion 117 includes a conveyance belt 118 provided in a loop shape in a predetermined region where image formation is performed, a support plate 119 that supports the conveyance belt 118 from a back side, and a plurality of belt rollers 120 provided on the back side of the conveyance belt 118.

[0074] During image formation, the support portion 117 supports the sheet P on a holding surface that is an upper surface of the conveyance belt 118, and conveys the sheet P downstream by sending the conveyance belt 118 at a predetermined timing by rotation of the belt rollers 120.

[0075] The head unit 130 includes a plurality of (for example, four colors) inkjet heads 1, ink tanks 132 as liquid tanks respectively mounted on the inkjet heads 1, connection flow paths 133 that connect the inkjet heads 1 and the ink tanks 132, and supply pumps 134.

[0076] In the present embodiment, for example, the inkjet heads 1 of four colors: cyan, magenta, yellow, and black, and the ink tanks 132 that respectively store ink of these colors are provided. The ink tank 132 is connected to the ink jet head 1 by the connection flow path 133.

[0077] A negative pressure control device such as a pump (not shown) is connected to the ink tank 132. A negative pressure in the ink tank 132 is controlled by the negative pressure control device according to water head values of the ink jet head 1 and the ink tank 132, thereby forming the ink supplied to each nozzle 51 of the inkjet head 1 into a meniscus having a predetermined shape.

[0078] The supply pump 134 is, for example, a liquid sending pump formed of a piezoelectric pump. The supply pump 134 is provided in the supply flow path. The supply pump 134 is connected to the control circuit 1161 of the control unit 116 through a wiring and can be controlled by the control unit 116. The supply pump 134 supplies a liquid to the ink jet head 1.

[0079] The conveyance device 115 conveys the sheet P along the conveyance path R from the medium supply unit 112 to the medium discharge unit 114 through the image forming unit 113. The conveyance device 115 includes a plurality of guide plate pairs 121 disposed along the conveyance path R and a plurality of conveyance rollers 122.

[0080] Each of the plurality of guide plate pairs 121 includes a pair of plate members facing each other across the sheet P to be conveyed, and guides the sheet P along the conveyance path R.

[0081] The conveyance roller 122 is driven and rotated under the control of the control unit 116, thereby conveying the sheet P downstream along the conveyance path R. Sensors that detect a state of sheet conveyance are disposed at various locations in the conveyance path R.

[0082] The control unit 116 includes a control circuit 1161 such as a central processing unit (CPU) serving as a controller, a read only memory (ROM) that stores various programs, a random access memory (RAM) that temporarily stores various variable data, image data, and the like, and an interface unit that receives data from the outside and outputs data to the outside.

[0083] In the ink jet recording apparatus 100 configured as described above, for example, when the control unit 116 detects a print instruction by a user operating an operation input unit at an interface, the control unit 116 drives the ink jet head 1 by driving the conveyance device 115 to convey the sheet P and outputting a printing signal to the head unit 130 at a predetermined timing. As an ejection operation, the inkjet head 1 transmits a drive signal to the drive IC 72 according to an image signal corresponding to image data, and applies a drive voltage to the internal electrodes 221 and 222 to selectively drive the drive piezoelectric pole 21 for an ejection target, for example, to vibrate the drive piezoelectric pole 21 vertically in a lamination direction, thereby changing a volume of the pressure chamber 31 to eject ink from the nozzle 51 and form an image on the sheet P held on the conveyance belt 118. As the liquid ejection operation, the control unit 116 drives the supply pump 134 to supply the ink from the ink tank 132 to the common chamber 61 of the inkjet head 1.

[0084] In the ink jet head 1 and the ink jet recording apparatus 100 according to the embodiment described above, since the electric resistances 851 are provided between the plurality of first external electrodes 223 that individually apply voltages to the plurality of drive piezoelectric poles 21, dot misalignment or density unevenness due to the drive pattern can be eliminated.

[0085] The embodiment is not limited to the example described above. For example, in the example described above, the drive circuit 70 switches the switching element 83 to apply a standby voltage to the support piezoelectric pole 22 that does not cause ink to be ejected, but the embodiment is not limited thereto. For example, the switching element 83 may disconnect the support piezoelectric pole 22, which does not cause ink to be ejected, from the drive signal source 81. For example, FIG. 10 shows an example of a simulation of voltages applied to the drive piezoelectric poles CA to CF (first external electrodes 223) in the example shown in FIG. 9. As shown in FIG. 10, even when the inkjet head 1 opens the first external electrode 223 in a non-ejection channel, it is found that a voltage amplitude during single nozzle driving is reduced, and deterioration in printing quality due to crosstalk can be prevented. However, since the drive piezoelectric pole 21 that does not cause ink to be ejected is also charged and discharged, energy consumption may increase, or meniscus variation may occur in the non-ejection nozzle 51, which may cause a problem when there is a subsequent ink ejection operation.

[0086] In a configuration in which the first external electrode 223 is opened during non-ejection, among the plurality of drive piezoelectric poles 21 (first external electrodes 223) electrically connected by the second electric resistor 85, a so-called edge may occur in which a voltage difference occurs between the drive piezoelectric pole 21 (first external electrode 223) located at an end portion and the adjacent drive piezoelectric pole 21. Therefore, in order to prevent occurrence of an edge in a printing range, among the plurality of drive piezoelectric poles 21 connected by the second electric resistor 85, the drive piezoelectric pole 21 located at the end portion may be used as a dummy that is not to be driven, or the same voltage as the second drive piezoelectric pole 21 from the end portion may be applied without providing the corresponding nozzle 51.

[0087] In the example described above, the second electric resistor 85 extends in an arrangement direction of the first external electrodes 223, and is formed of a thin film having a uniform width in a direction (width direction) orthogonal to a longitudinal direction and a thickness direction, but the embodiment is not limited thereto. For example, a width of the second electric resistor 85 may be partially changed in order to increase a resistance difference between a region connected to the first external electrode 223 and the trimming portion 852 constituting the electric resistance 851. For example, the second electric resistor 85 may be configured such that a width of the region connected to the first external electrode 223 in the direction orthogonal to the longitudinal direction and the thickness direction is larger than a width of a region forming the electric resistance 851.

[0088] In the example described above, the liquid ejection apparatus 100 ejects ink as a liquid from the liquid ejection head 1, but the liquid is not limited to ink. That is, the liquid ejection head 1 and the liquid ejection apparatus 100 can be used for 3D printers, industrial manufacturing machines, and medical applications, for example, and can eject various liquids.

[0089] According to at least one embodiment described above, it is possible to provide a liquid ejection head and a liquid ejection apparatus capable of eliminating dot misalignment or density unevenness due to a drive pattern by providing electric resistances between a plurality of individual electrodes that individually apply voltages to a plurality of drive piezoelectric poles.

[0090] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the disclosure. These novel embodiments can be implemented in various other forms, and various omissions, substitutions, and modifications can be made without departing from the scope of the disclosure. The embodiments and the modifications thereof are included in the scope of the disclosure, and are included in a scope of the disclosure disclosed in the claims.

Claims

1. A liquid ejection head (1) comprising:

a plurality of pressure chambers (31);
an actuator (20) comprising a plurality of piezoelectric bodies that change volumes of the pressure chambers according to a drive signal;
a plurality of individual electrodes (223) provided on the plurality of piezoelectric bodies, respectively;
a nozzle plate (50) comprising a plurality of nozzles communicating with the plurality of pressure chambers, respectively;
a plurality of switching elements (83) configured to selectively connect the drive signal for the piezoelectric bodies and to be electrically connected to the plurality of individual electrodes; and
a plurality of electric resistances (851) configured to electrically connect the individual electrodes of the piezoelectric bodies adjacent to each other.

2. The liquid ejection head according to claim 1, further comprising a first electric resistor (84) that is an internal resistance of the switching elements.

3. The liquid ejection head according to claim 1 or 2, further comprising:
a second electric resistor (85) configured to electrically connect at least one of the plurality of individual electrodes.

4. The liquid ejection head according to claim 3, wherein
the plurality of electric resistances are formed by partially narrowing a width and increasing a length.

5. The liquid ejection head according to claim 3 or 4, wherein
the plurality of electric resistances are formed by slits provided between the individual electrodes of the second electric resistor.

6. The liquid ejection head according to any one of claim 3 to 5, wherein
the second electric resistor electrically connects all of the plurality of individual electrodes.

7. The liquid ejection head according to any one of claim 3 to 6, wherein
the second electric resistor extends in an arrangement direction of the individual electrodes, and is formed of a thin film having a uniform width in a

direction orthogonal to a longitudinal direction and a thickness direction.

8. The liquid ejection head according to any one of claim 3 to 7, wherein the second electric resistor is formed of a metal with high resistivity.

9. The liquid ejection head according to claim 8, wherein the metal includes a nickel-chromium alloy or titanium, or a carbon film (carbon).

10. The liquid ejection head according to any one of claims 1 to 9, wherein
the switching element selectively connects a drive signal for ejecting a liquid and a standby voltage for not ejecting the liquid.

11. The liquid ejection head according to any one of claims 1 to 10, comprising two or more actuators.

12. The liquid ejection head according to claim 11, wherein the actuators are arranged side by side in a direction orthogonal to an arrangement direction of the plurality of piezoelectric bodies.

13. The liquid ejection head according to any one of claims 1 to 12, wherein the actuator further comprises a dummy layer.

14. The liquid ejection head according to claim 13, wherein the dummy layer has an electrode only on one side.

15. A liquid ejection apparatus comprising:
the liquid ejection head according to any one of claims 1 to 14.

FIG. 1

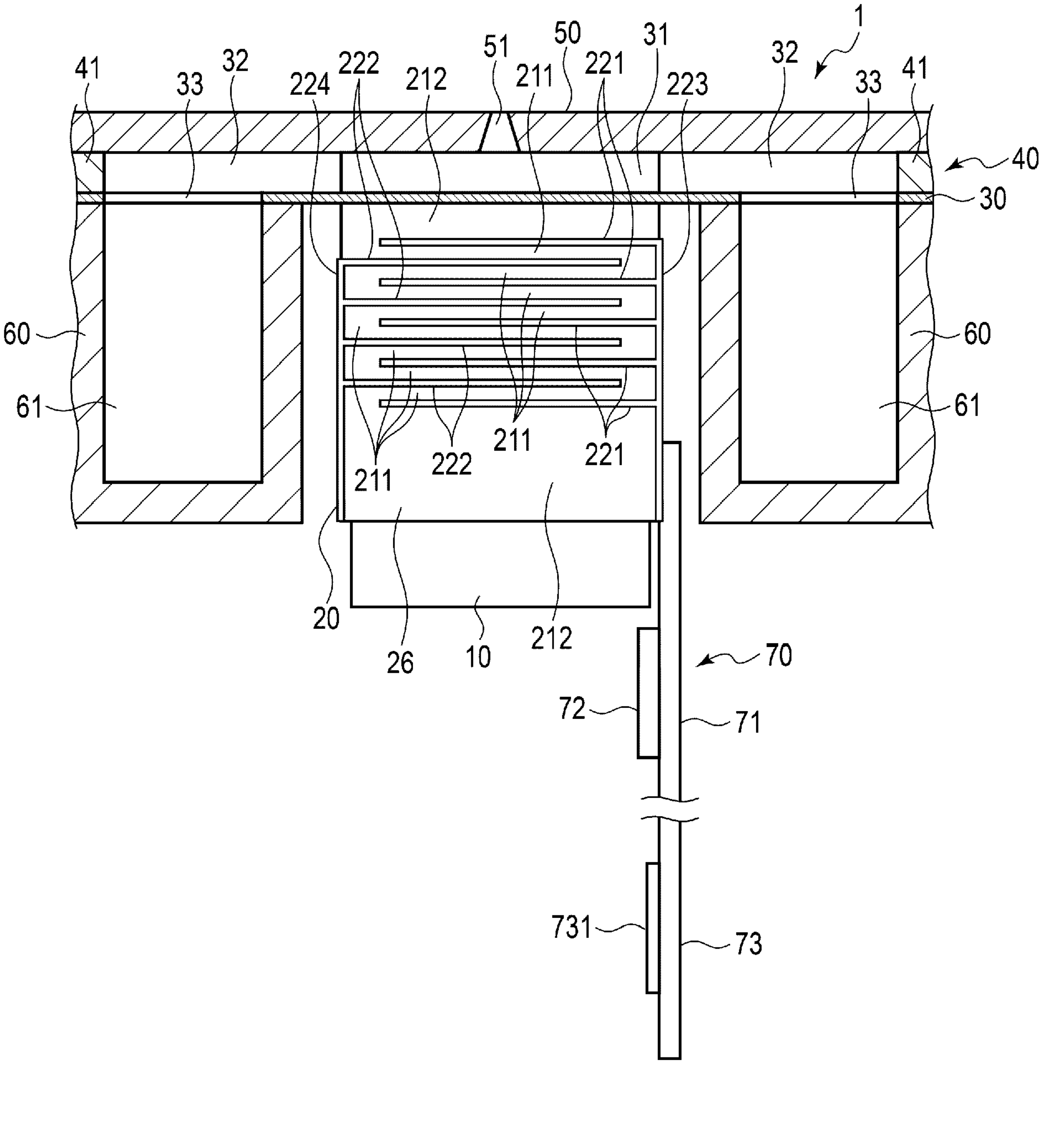
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FIG. 2

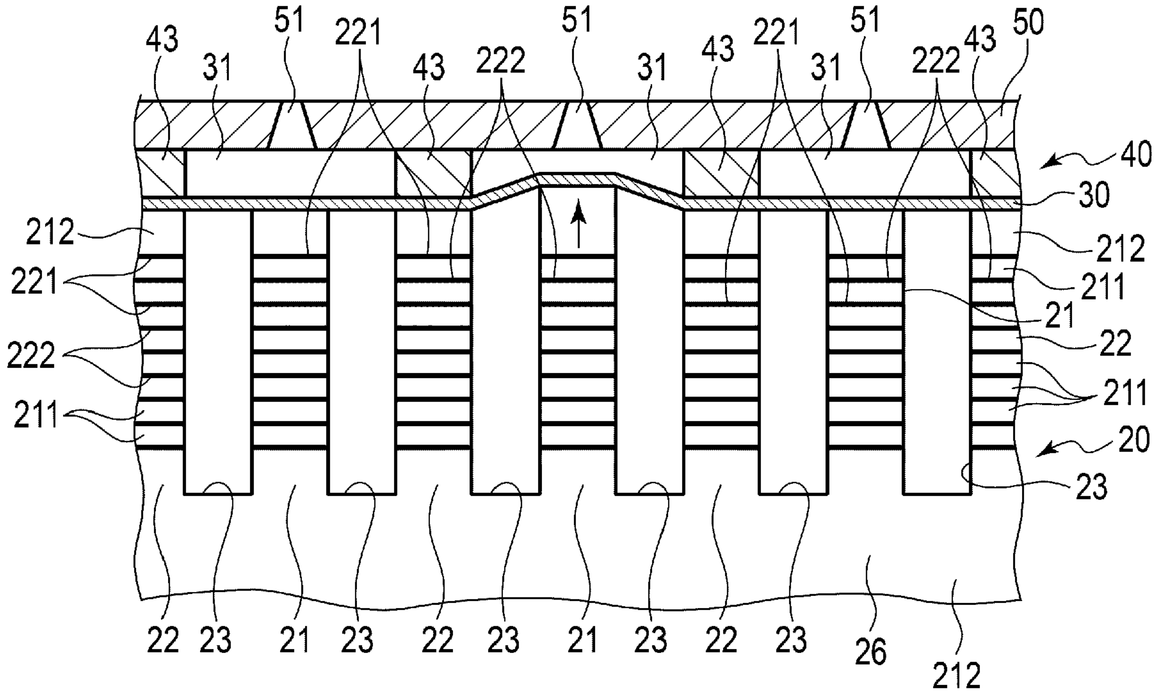
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FIG. 3

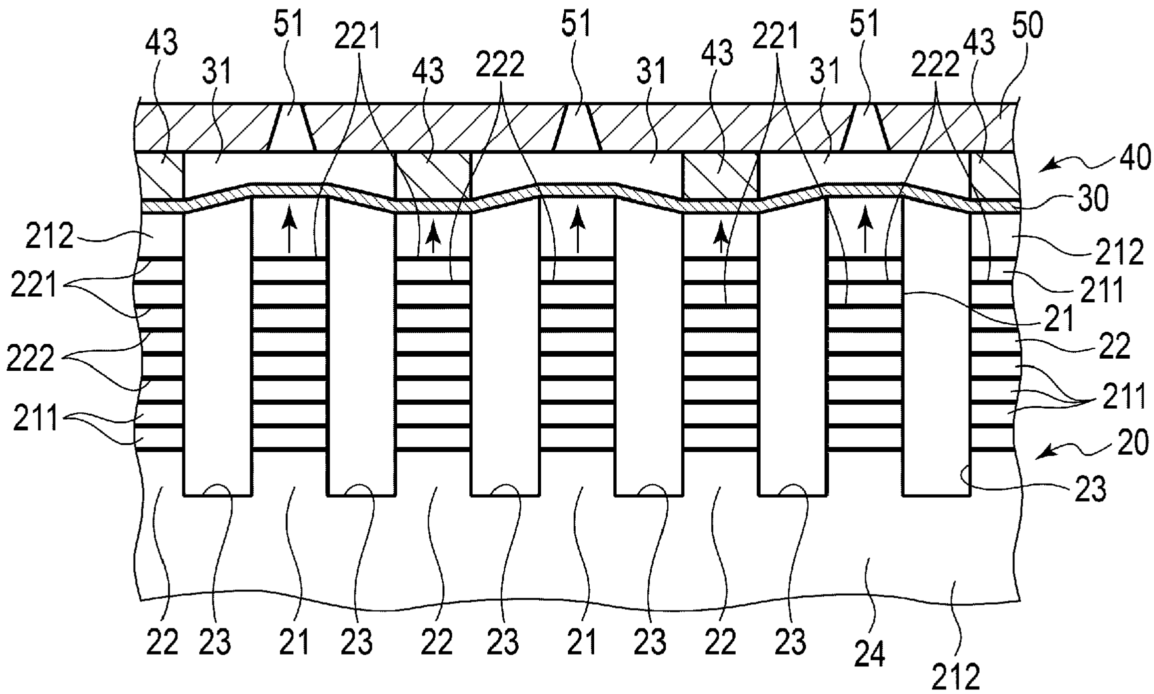
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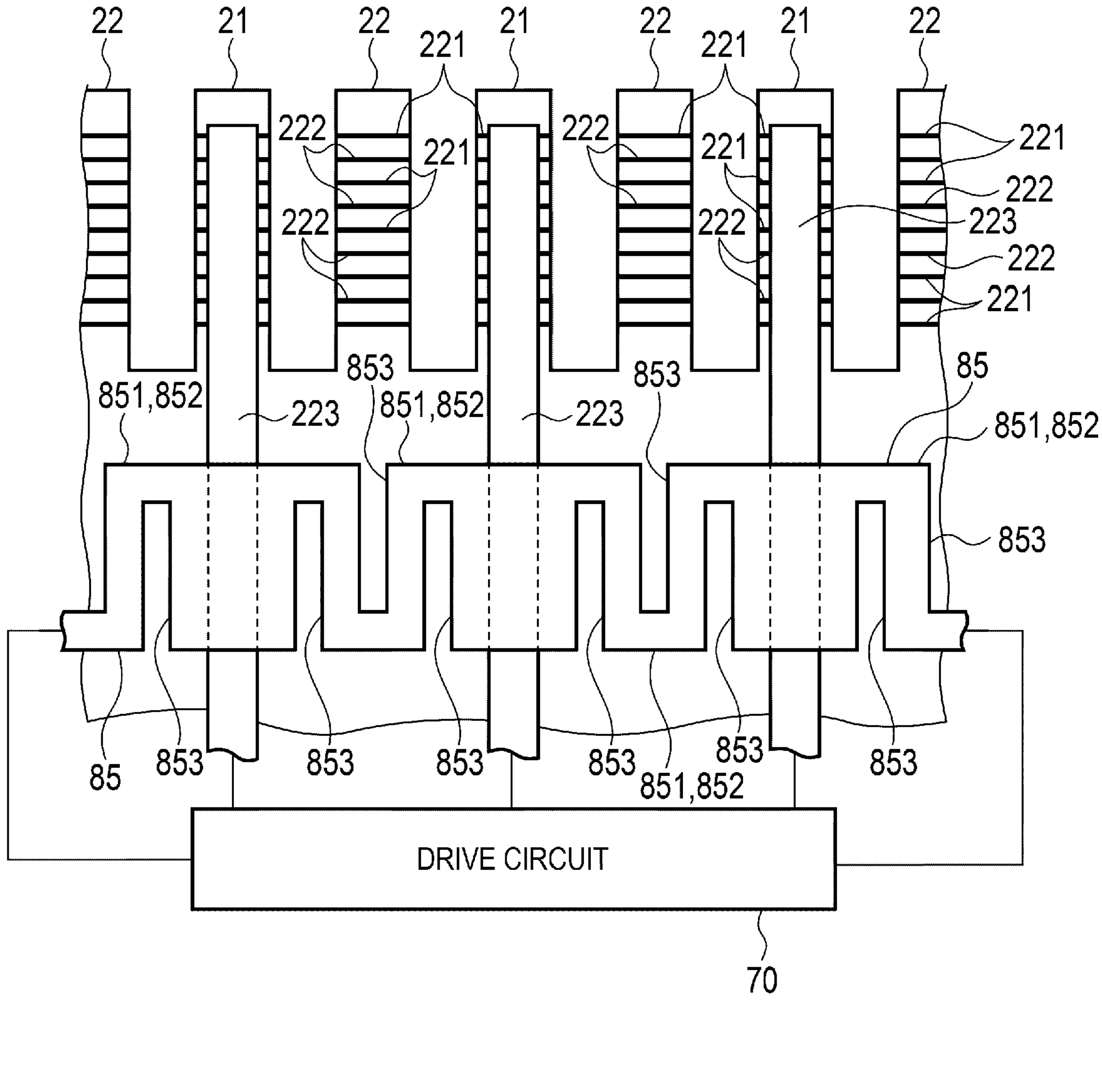
FIG. 4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DRIVE CIRCUIT
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FIG. 5

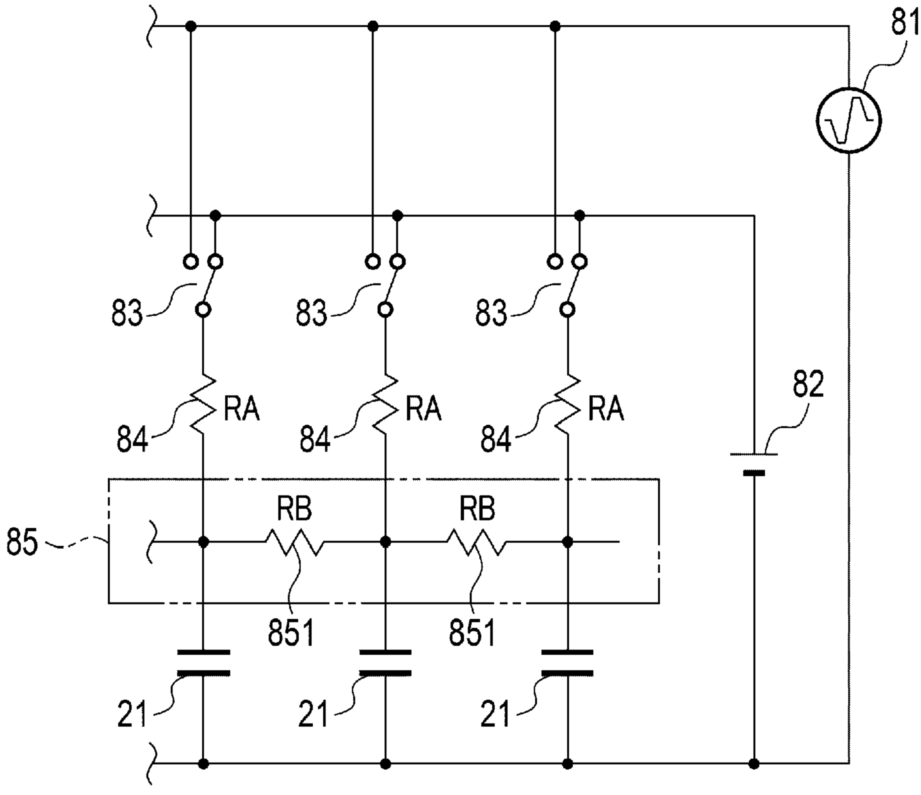
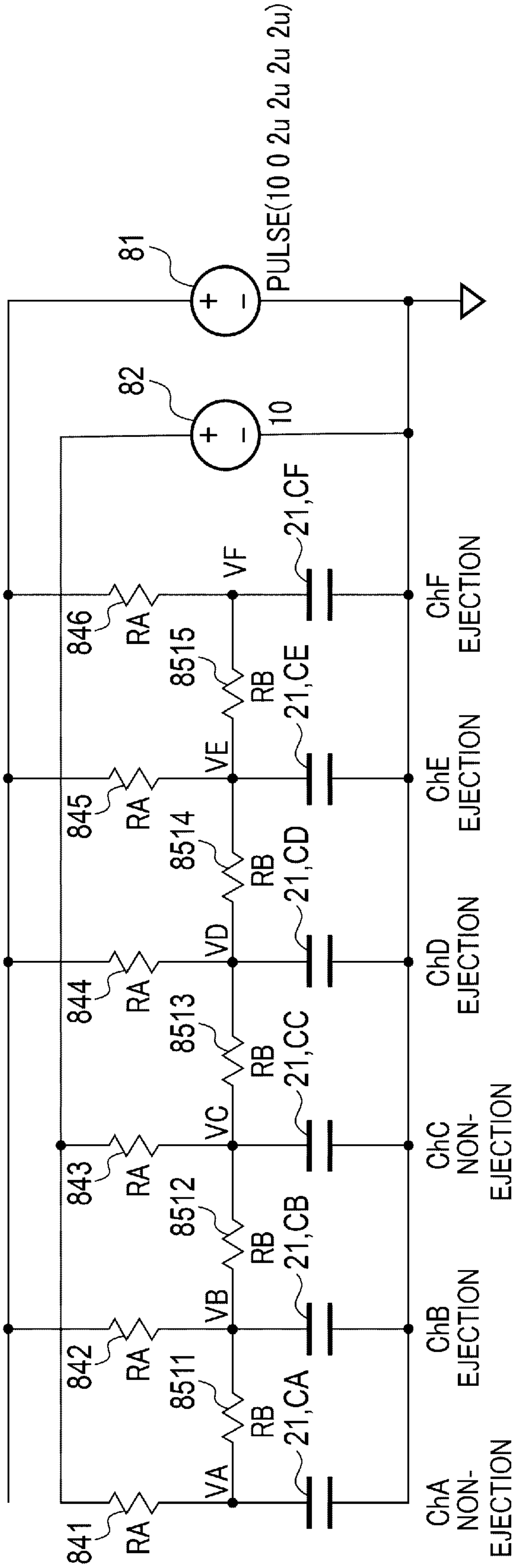


FIG. 6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VD
VE
VF
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21,CB
21,CC
21,CD
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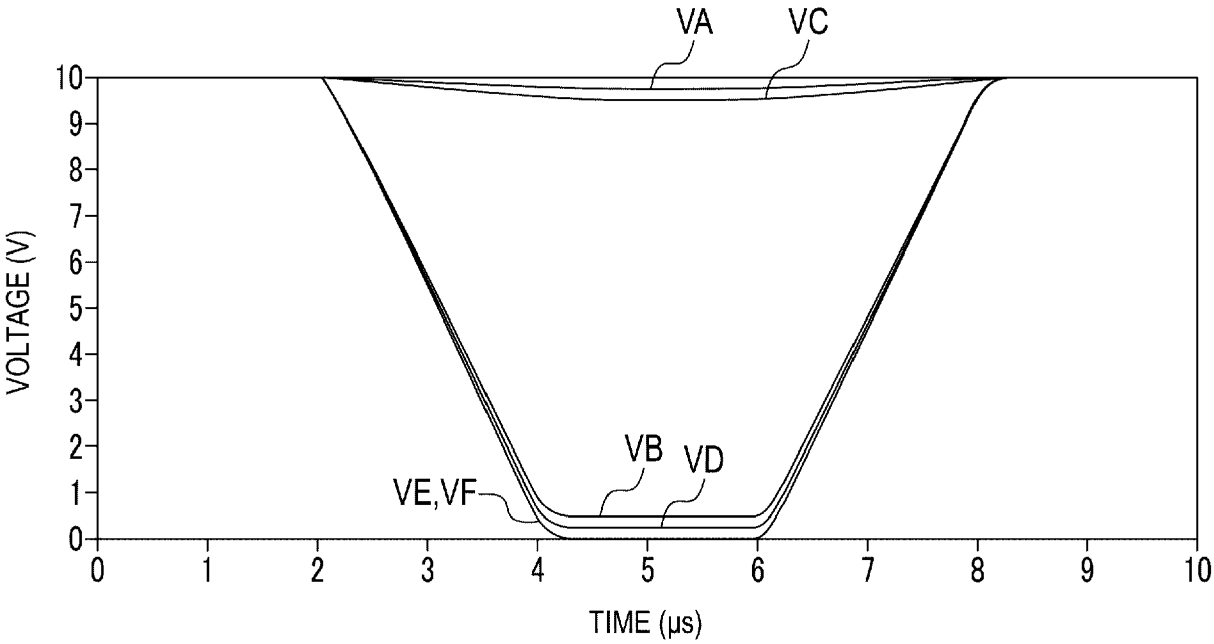
ChB EJECTION
ChC NON-EJECTION
ChD EJECTION
ChE EJECTION
ChF EJECTION

FIG. 7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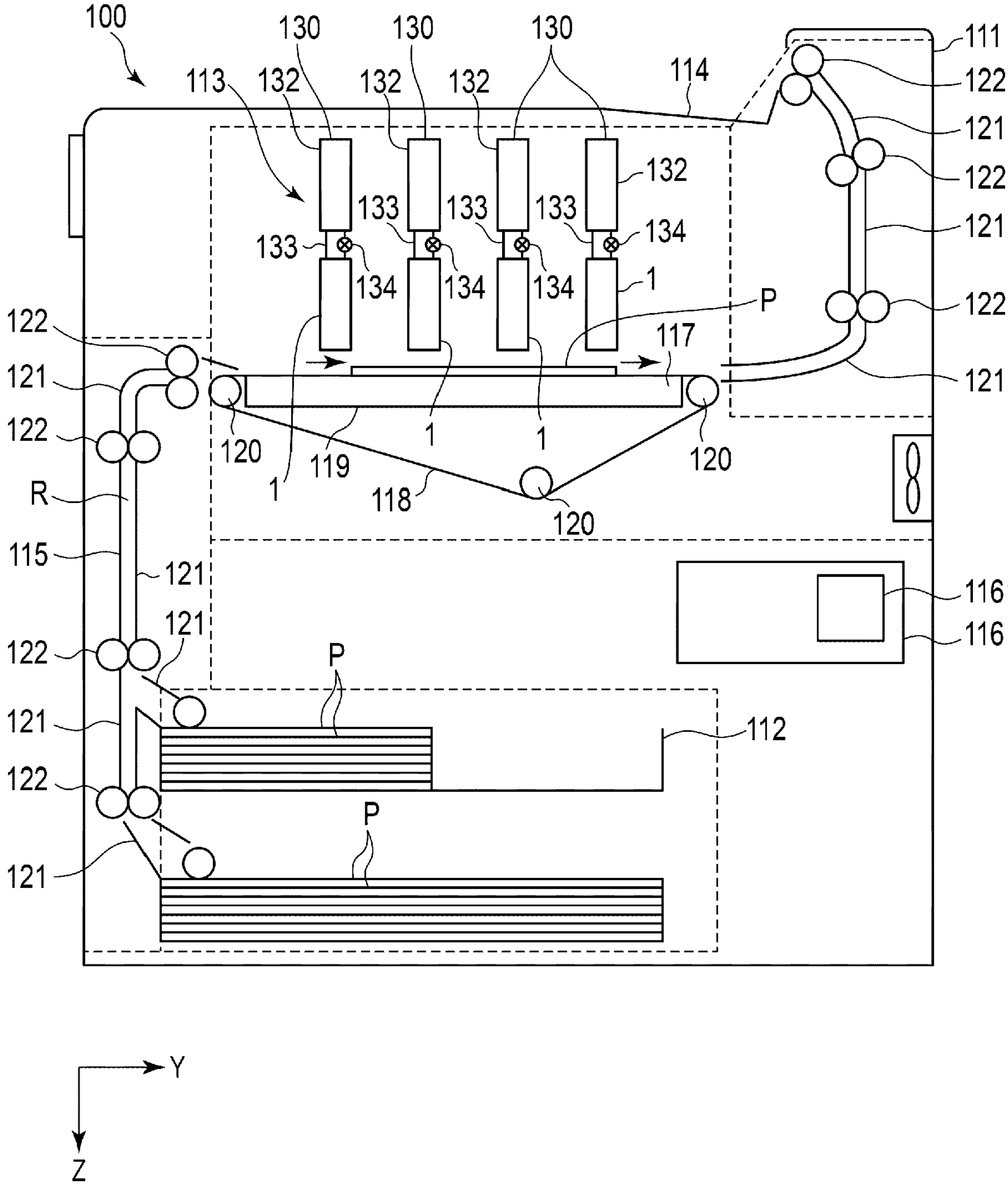
TIME (μs)

FIG. 8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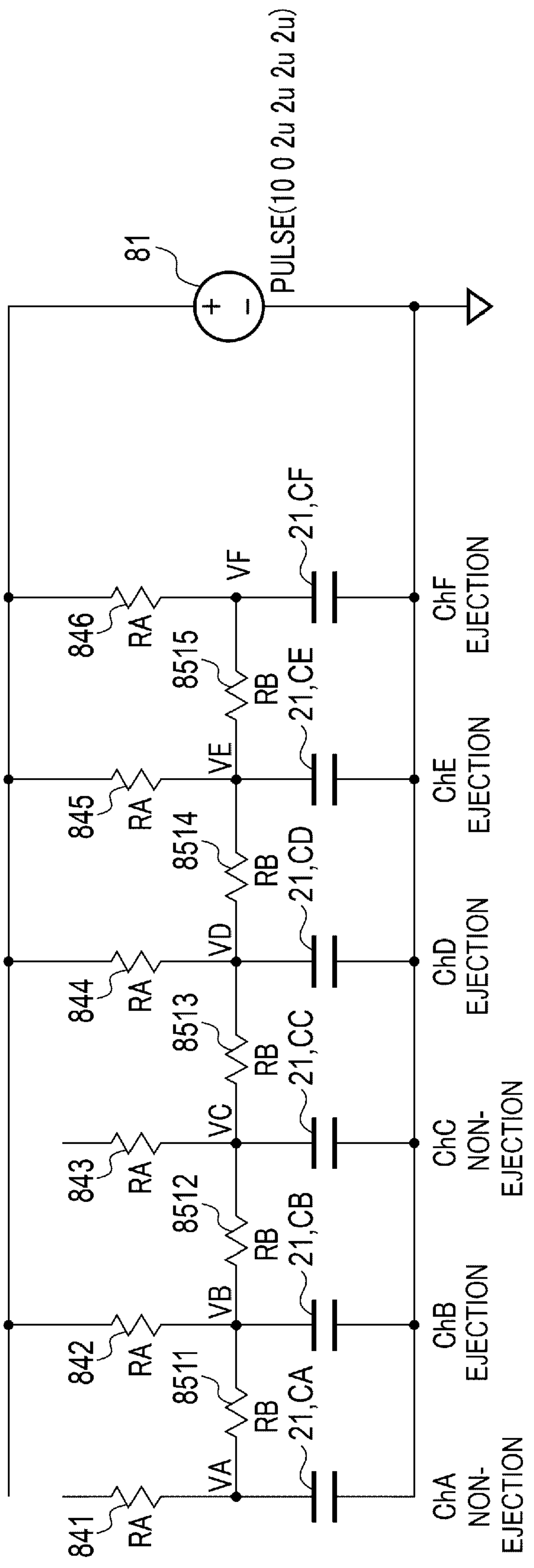
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ChC NON-EJECTION
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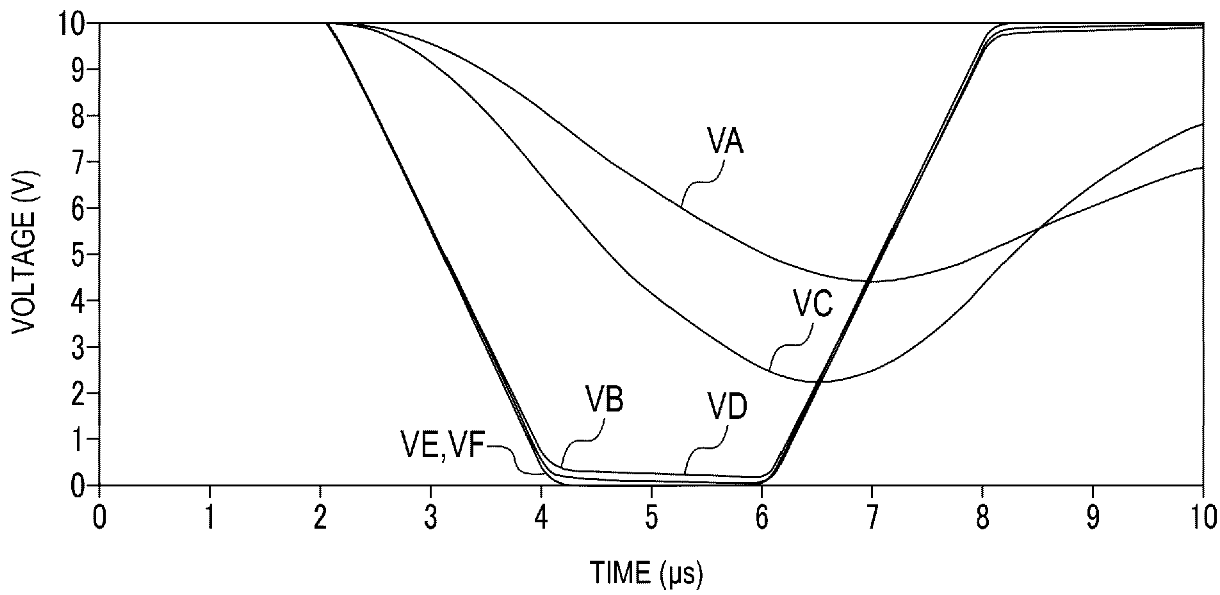
ChF EJECTION

FIG. 9

FIG. 10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TIME (μs)
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VC
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VD
VE, VF

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EUROPEAN SEARCH REPORT

Application Number
EP 24 17 4724

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 3 159 168 A1 (KONICA MINOLTA INC [JP]) 26 April 2017 (2017-04-26) * figure 2 *	1-8, 10-15	INV. B41J2/14
A	WO 2012/029678 A1 (KONICA MINOLTA IJ TECHNOLOGIES [JP]; KOBAYASHI HIDEYUKI [JP]) 8 March 2012 (2012-03-08) * the whole document *	1-15	
A	JP 2023 042968 A (TOSHIBA TEC KK) 28 March 2023 (2023-03-28) * figure 3 *	1-15	
A	JP 2013 193323 A (RICOH CO LTD) 30 September 2013 (2013-09-30) * figure 3 *	1-15	

TECHNICAL FIELDS SEARCHED (IPC)
B41J

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	24 September 2024	Bardet, Maude

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24-09-2024

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 3159168 A1	26-04-2017	EP 3159168 A1	26-04-2017
		JP 6558174 B2	14-08-2019
		JP 2017056697 A	23-03-2017
WO 2012029678 A1	08-03-2012	JP 2013233471 A	21-11-2013
		WO 2012029678 A1	08-03-2012
JP 2023042968 A	28-03-2023	NONE	
JP 2013193323 A	30-09-2013	NONE	

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