

(19)



(11)

EP 4 286 165 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

06.12.2023 Bulletin 2023/49

(51) International Patent Classification (IPC):

B41J 2/14 ^(2006.01)**B41J 2/16** ^(2006.01)(21) Application number: **22211303.7**

(52) Cooperative Patent Classification (CPC):

B41J 2/14209; B41J 2/1609; B41J 2/1623;**B41J 2/1631; B41J 2/1632; B41J 2002/14362;****B41J 2002/14491**(22) Date of filing: **05.12.2022**

(84) Designated Contracting States:

**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL
NO PL PT RO RS SE SI SK SM TR**

Designated Extension States:

BA

Designated Validation States:

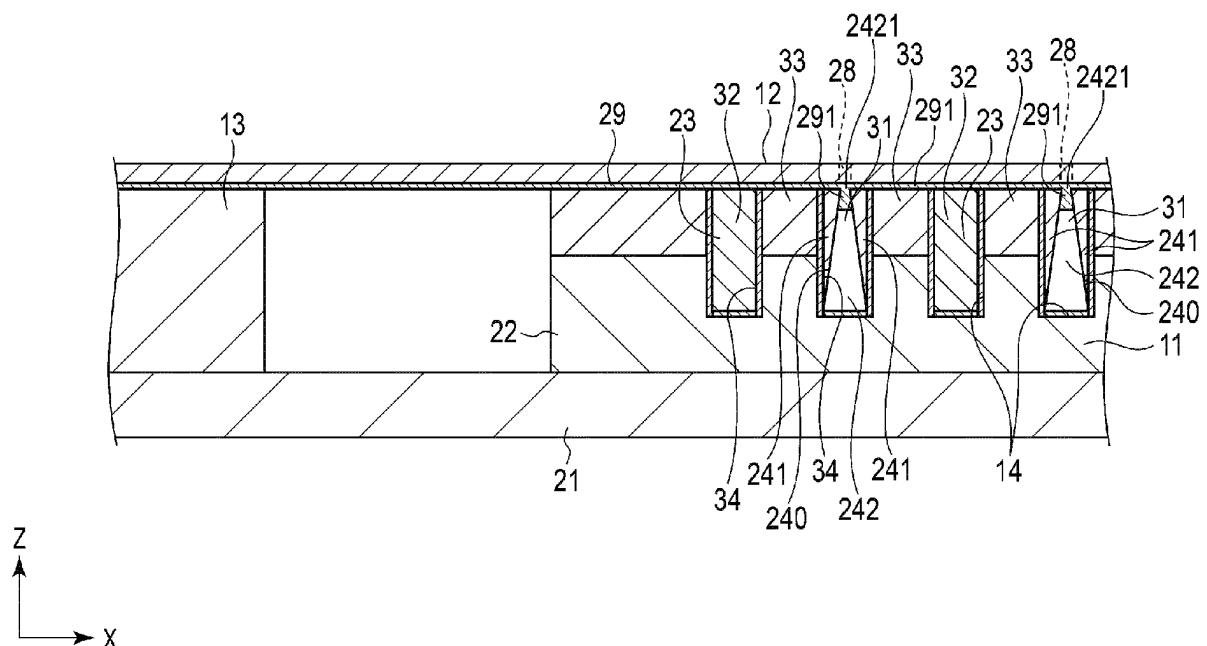
KH MA MD TN(71) Applicant: **Toshiba TEC Kabushiki Kaisha****Tokyo 141-8562 (JP)**

(72) Inventors:

• **Konishi, Tsubasa****Shinagawa-ku 141-8562 (JP)**• **Yokoyama, Shuhei****Shinagawa-ku 141-8562 (JP)**(30) Priority: **03.06.2022 JP 2022090904**(74) Representative: **Bandpay & Greuter****30, rue Notre-Dame des Victoires****75002 Paris (FR)**(54) **LIQUID EJECTION HEAD**

(57) According to one embodiment, a liquid ejection head includes an actuator unit, a nozzle plate, and a diaphragm portion. The actuator unit has grooves constituting a plurality of pressure chambers and a plurality of sidewalls formed between the grooves constituting the pressure chambers. The nozzle plate is disposed to face one side of the plurality of pressure chambers. The dia-

phragm portion has an diaphragm wall that blocks a portion of a communication port of the pressure chamber that communicates with a common chamber of the actuator unit and forms a diaphragm aperture that is decreased in width on the one side in a depth direction of the pressure chamber.

FIG. 4**EP 4 286 165 A1**

Description

FIELD

[0001] Embodiments described herein relate generally to liquid ejection heads.

BACKGROUND

[0002] In recent years, there is a demand for high productivity in an inkjet head, and increasing a speed and increasing an amount of droplets become issues. For example, a shear mode shared-wall type inkjet head has high power and is directed to eject high-viscosity ink and eject a large amount of droplets. In the shear mode shared-wall type inkjet head, the same driving column is shared by two pressure chambers, and 1/3 of the plurality of arranged chambers are commonly driven as pressure chambers at the same time, which is so-called three-cycle driving. In addition, an independent drive head in which, by using both sides of the pressure chamber to be driven as dummy pressure chambers, one pressure chamber is driven by two independent driving columns is developed. For example, a structure in which a large number of grooves are formed in a piezoelectric body, entrance/exit are blocked every other groove, the grooves with the entrance/exit not blocked are used as pressure chambers, and the blocked grooves are used as air chambers to be independently driven is developed.

[0003] In such an inkjet head, ink is replenished from a common liquid chamber to the pressure chamber after ink droplets are ejected. At this time, a phenomenon occurs in which the nozzle overshoots and the meniscus rises. The smaller the flow path resistance of the flow path from the common liquid chamber to the nozzles, the greater the overshoot. If the overshoot is not suppressed, ejection cannot be performed in a stable state of the meniscus. Therefore, in order to increase the speed of the inkjet head, it is required to quickly converge the rising of the meniscus and to ensure stable ejection characteristics.

DISCLOSURE OF THE INVENTION

[0004] To this end, there is provided a liquid ejection head comprising an actuator unit having grooves constituting a plurality of pressure chambers and a plurality of sidewall portions formed between the grooves constituting the pressure chambers, a nozzle plate disposed to face one side of the plurality of pressure chambers and a diaphragm portion having a diaphragm wall that blocks a portion of a communication port of the pressure chamber that communicates with a common chamber of the actuator unit and forms a diaphragm aperture that is decreased in width on the one side in a depth direction of the pressure chamber.

[0005] Preferably, the plurality of grooves and the plurality of sidewall portions are aligned in a first direction.

[0006] Preferably, the diaphragm portion is provided on the sidewall portion and has a diaphragm wall that decreases a width dimension of the communication port in the first direction as compared with a width dimension of an interior of the pressure chamber in the first direction, and a flow path resistance is configured to be larger than the interior of the pressure chamber.

[0007] Preferably, an adhesive layer is provided between the top of the sidewall portion and the nozzle plate.

[0008] Preferably, the diaphragm wall is made of a photosensitive resin.

[0009] Preferably, the diaphragm aperture is a tapered slit where a bottom side of the pressure chamber is increased in width.

[0010] Preferably, the actuator unit has a plurality of air chambers respectively formed between the plurality of pressure chambers.

[0011] Preferably, the pressure chamber and the air chamber are aligned in a first direction and extend respectively in a second direction intersecting with the first direction.

[0012] Preferably, the liquid ejection head is of a side shooter type, in which the diaphragm portions are arranged at both ends of the pressure chamber in the second direction, and each of both ends of the pressure chamber communicates with the common chamber via the diaphragm aperture.

[0013] Preferably, an opening width of an opening end of the diaphragm aperture on the nozzle plate side is configured to be a width capable of holding an uncured adhesive by surface tension.

[0014] The present invention also relates to an inkjet printer comprising the above-described head.

[0015] The present invention further relates to a method for producing a liquid ejection head comprising: a step of forming an actuator base comprising a plurality of grooves; a step of forming pressure chambers in the grooves; a step of forming a diaphragm portion forming a diaphragm aperture that is decreased in width on the one side in a depth direction of the pressure chamber; a step of adhering a nozzle plate on the actuator base.

[0016] Preferably, the step of forming a diaphragm portion comprises: a step of forming a photosensitive resin film of a photosensitive resin in the groove constituting the pressure chamber; and a forming step of forming the photosensitive resin film by exposure and development.

[0017] Preferably, the step of forming the photosensitive resin film comprises: a step of coating the inner wall of the pressure chamber with the photosensitive resin whereby the photosensitive resin film in each groove is formed to have a concave-shaped surface with the center being recessed toward the depth side.

[0018] Preferably, the forming step further comprises: a step of curing a tapered cured region by an exposure process on the concave-shaped surface; and a step of performing a development process to remove an uncured region so that a tapered protrusion and a tapered diaphragm aperture are formed.

DESCRIPTION OF THE DRAWINGS

[0019]

FIG. 1 is a perspective view illustrating an inkjet head according to an embodiment;
 FIG. 2 is an exploded perspective view illustrating a portion of a configuration of the inkjet head;
 FIG. 3 is an enlarged perspective view illustrating a portion of the configuration of the inkjet head;
 FIG. 4 is an enlarged cross-sectional view illustrating a portion of the configuration of the inkjet head;
 FIG. 5 is an enlarged cross-sectional view illustrating a portion of the configuration of the inkjet head;
 FIG. 6 is a view illustrating a method of manufacturing the inkjet head; and
 FIG. 7 is a schematic view illustrating an inkjet printer.

DETAILED DESCRIPTION

[0020] A problem to be solved by the present disclosure is to provide a liquid ejection head capable of ensuring stable ejection characteristics.

[0021] In general, according to one embodiment, a liquid ejection head includes an actuator unit, a nozzle plate, and a diaphragm portion. The actuator unit has grooves constituting a plurality of pressure chambers and a plurality of sidewalls formed between the grooves constituting the pressure chambers. The nozzle plate is disposed to face one side of the plurality of pressure chambers. The diaphragm portion has a diaphragm wall that blocks a portion of the communication port of the pressure chamber that communicates with a common chamber of the actuator unit and forms a diaphragm aperture that is decreased in width on the one side in the depth direction of the pressure chamber.

[0022] Hereinafter, a configuration of an inkjet head 10 which is a liquid ejection head according to a first embodiment will be described with reference to FIGS. 1 to 6. FIG. 1 is a perspective view illustrating the inkjet head according to the first embodiment, and FIG. 2 is an exploded perspective view of a portion of the inkjet head. FIG. 3 is an enlarged perspective view illustrating a portion of the configuration of the inkjet head, and FIGS. 4 and 5 are enlarged cross-sectional views illustrating a portion of the configuration of the inkjet head. FIG. 6 is a view illustrating a method of manufacturing the inkjet head, and FIG. 7 is a schematic view illustrating an inkjet printer which is a liquid ejection device. In the drawings, X, Y, and Z indicate a first direction, a second direction, and a third directions perpendicular to each other, respectively. It is noted that, in the present embodiment, although the directions are described as a reference, such that the parallel direction of nozzles 28 and pressure chambers 31 of the inkjet head 10 is along the X axis, the extending direction of the pressure chambers 31 is along the Y axis, and the liquid ejection direction is along

the Z axis, the present embodiment is not limited thereto.

[0023] The inkjet head 10 illustrated in FIGS. 1 to 5 is a device for ejecting ink and is mounted inside, for example, an inkjet printer. The inkjet head 10 is a shear mode shared-wall type inkjet head. For example, the inkjet head 10 is an independently driven inkjet head in which pressure chambers 31 and air chambers 32 are alternately arranged. The air chamber 32 is an air chamber to which ink is not supplied and does not have the nozzles 28. In this embodiment, the inkjet head 10 is a so-called side shooter type inkjet head.

[0024] The inkjet head 10 has an actuator base 11, a nozzle plate 12 and a frame 13. The actuator base 11 is an example of a base material. An ink chamber 27 is formed inside the inkjet head 10 to which ink which is an example of a liquid is supplied.

[0025] Furthermore, the inkjet head 10 includes components such as a circuit board 17 that controls the inkjet head 10 and a manifold 18 that forms a portion of the path between the inkjet head 10 and an ink tank.

[0026] As illustrated in FIGS. 2 to 5, the actuator base 11 includes a substrate 21 and a pair of actuator units 22.

[0027] The substrate 21 is formed in a rectangular plate shape from ceramics such as alumina. The substrate 21 has a flat mounting surface. The pair of actuator units 22 are joined to the mounting surface of the substrate. A plurality of supply holes 25 and a plurality of discharge holes 26 are formed in the substrate 21.

[0028] As illustrated in FIGS. 2 and 3, a pattern wiring 211 is formed on the substrate 21 of the actuator base 11. The pattern wiring 211 is formed of, for example, a nickel thin film. The pattern wiring 211 has a common pattern or an individual pattern and is configured in a predetermined pattern shape of being connected to an electrode layer 34 formed on the actuator unit 22.

[0029] The supply holes 25 are provided to be aligned in a longitudinal direction of the actuator units 22 in the central portion of the substrate 21 between the pair of actuator units 22. The supply hole 25 communicates with an ink supply portion of the manifold 18. The supply hole 25 is connected to the ink tank via the ink supply portion. The supply hole 25 supplies the ink in the ink tank to the ink chamber 27. It is noted that the supply holes 25 are not limited to a plurality of circular holes as illustrated in FIG. 2, and one long hole which is long in an X direction along the actuator unit 22 may be used.

[0030] The discharge holes 26 are provided to be aligned in two columns with the supply hole 25 and the pair of actuator units 22 being interposed therebetween. The discharge hole 26 communicates with an ink discharge portion of the manifold 18. The discharge hole 26 is connected to the ink tank through the ink discharge portion. The discharge hole 26 discharges the ink in the ink chamber 27 to the ink tank.

[0031] The pair of actuator units 22 are adhered to the mounting surface of the substrate 21. The pair of actuator units 22 are provided on the substrate 21 so as to be aligned in two columns with the supply hole 25 being

interposed therebetween. Each actuator unit 22 is formed of two plate-like piezoelectric bodies made of, for example, lead zirconate titanate (PZT). The two piezoelectric bodies are bonded together so that the polarization directions are opposite to each other in a thickness direction. The actuator unit 22 is adhered to the mounting surface of the substrate 21 with, for example, a thermosetting epoxy adhesive. As illustrated in FIG. 2, the actuator units 22 are arranged in parallel in the ink chamber 27 corresponding to the nozzles 28 aligned in two columns. The actuator unit 22 partitions the ink chamber 27 into a first common chamber 271 to which the supply hole 25 opens and two second common chambers 272 to which the discharge hole 26 opens.

[0032] The width of the actuator unit 22 in the lateral direction is gradually increased from a top surface portion 222 side toward the substrate side. A cross-sectional shape along a direction (lateral direction) perpendicular to the longitudinal direction of the actuator unit 22 is formed in a trapezoidal shape. A side surface portion 221 of the actuator unit 22 has inclined surfaces that are inclined with respect to the second direction and the third direction. The top surface portion 222 of the actuator unit 22 is adhered to the nozzle plate 12 via an adhesive layer 29.

[0033] The actuator unit 22 includes a plurality of pressure chambers 31, a plurality of air chambers 32, and diaphragm portions 240 provided at the entrance/exit of the respective pressure chambers 31. The actuator unit 22 has a plurality of element walls 33 (sidewall portions), and the grooves 14 constituting the pressure chambers 31 and the air chambers 32 are provided between the element walls 33. In other words, the element wall 33 is formed as a driving element between the grooves 14 forming the pressure chamber 31 and the air chamber 32.

[0034] As illustrated in FIGS. 1 to 5, a bottom surface portion of the groove 14 and the main surface of the substrate 21 are connected by the inclined side surface portions 221. The plurality of pressure chambers 31 and the plurality of air chambers 32 are arranged alternately. The pressure chambers 31 and the air chambers 32 extend in a direction crossing the longitudinal direction of the actuator unit 22, and the plurality of pressure chambers 31 and the plurality of air chambers 32 are arranged in parallel in the longitudinal direction (X direction) of the actuator unit 22. That is, the direction in which the plurality of pressure chambers 31 and the plurality of air chambers 32 are arranged is along the X direction. In this embodiment, for example, the groove 14 is configured to have the width dimension in the X direction constant in the depth direction along a Z direction and is configured to have a rectangular cross section perpendicular to a Y direction which is the extension direction.

[0035] It is noted that the shape of the pressure chamber 31 and the shape of the air chamber 32 may be different. The element wall 33 is formed between the pressure chamber 31 and the air chamber 32 to be deformed according to the drive signal to change the volume of the

pressure chamber 31.

[0036] The electrode layers 34 are provided on the inner wall surfaces of the pressure chamber 31 and the air chamber 32 of the actuator base 11, respectively. The electrode layer 34 is formed of, for example, a conductive film such as a nickel thin film. The electrode layer 34 extends from the inner surface portion of the groove 14 onto the substrate 21 and is connected to the pattern wiring 211. For example, the electrode layer 34 is formed at least on the side surface portion of the element wall 33, that is, the sidewall surface of the groove 14 constituting the pressure chamber 31. The electrode layer 34 may be formed on, for example, the side surface portion and the bottom surface portion of the pressure chamber 31.

[0037] The plurality of pressure chambers 31 communicate with the plurality of nozzles 28 of the nozzle plate 12 joined to the top of the element wall 33. That is, the nozzle plate 12 is disposed to face one side of the plurality of pressure chambers 31 in the third direction. Both ends of the pressure chamber 31 in the second direction communicate with the ink chamber 27. That is, one end portion opens to the first common chamber 271 of the ink chamber 27 and the other end portion opens to the second common chamber 272 of the ink chamber 27. Therefore, the ink flows in from the one end portion of the pressure chamber 31 and the ink flows out from the other end portion. At the communication port of the pressure chamber 31 with the ink chamber 27, the diaphragm portion 240 having a diaphragm aperture 242 that is an opening configured to have a higher flow path resistance than the interior of the pressure chamber 31 is formed. As an example, in this embodiment, the diaphragm portions 240 are formed in the communication ports at both ends of the pressure chamber 31 in the extending direction.

[0038] As illustrated in FIGS. 4 and 5, the diaphragm portion 240 is configured to have a shape of decreasing the width in the X direction of the opening of the pressure chamber 31 that communicates with the ink chamber 27. As an example, the diaphragm portion 240 has a pair of protrusions 241 as the diaphragm walls made of a photosensitive resin, and the diaphragm aperture 242 which is a tapered slit decreasing a width on the nozzle plate 12 side is formed between the pair of protrusions 241. In other words, the pair of protrusions 241 form the diaphragm aperture 242 decreasing the width on the nozzle plate side in the depth direction of the pressure chamber 31.

[0039] The protrusion 241 protrudes from the element wall 33 into the groove 14 at the end portion of the pressure chamber 31 in the second direction and blocks a portion of the communication port. In this embodiment, a pair of the element walls 33 constituting both side portions of the pressure chamber 31 in the X direction, that is, the element walls 33 on both sides in the X direction are formed with the protrusions 241 made of a photosensitive resin.

[0040] For example, the protrusion 241 may be formed

over the entire length in the third direction which is the depth direction of the groove 14 of the pressure chamber 31 and may be formed partially in the third direction. Moreover, the protrusions 241 may be formed by forming a photosensitive resin, for example, on the bottom surface of the groove 14 in addition to the side surface of the groove 14. That is, the protrusions 241 on both sides may have a configuration of being continuous at the bottom of the groove 14.

[0041] The protrusion 241 is a wall member that increases the flow path resistance at the entrance/exit of the pressure chamber 31 and suppresses the entering of the adhesive 291 from the end portion on the nozzle plate 12 side. For example, each of the protrusions 241 provided on both side portions of each communication port of the pressure chamber 31 has a rectangular cross-section perpendicular to the third direction. Each of the pair of protrusions 241 is formed in a tapered shape in which the top side has a larger protrusion amount than the bottom side in the depth direction. That is, the facing surfaces of the pair of protrusions 241 are inclined so that the top sides thereof are close to each other, and the interval between the facing surfaces is gradually increased in width on the bottom side. The top side of the protrusion 241 denotes an adhesion side with respect to the nozzle plate 12. The bottom side of the protrusion 241 denotes a position away from the adhesive side with respect to the nozzle plate 12.

[0042] The groove 14 constituting the pressure chamber 31 is not completely covered by the protrusion 241, and the diaphragm aperture 242 allowing the pressure chamber 31 to communicate with the first common chamber 271 and the second common chamber 272 is formed between the pair of protrusions 241 on both sides. The diaphragm aperture 242 has a slit shape extending in the third direction which is the depth direction of the pressure chamber 31, and the opening width in the first direction is configured to be smaller than the width of the interior of inside the pressure chamber 31 in the first direction, so as to be configured to be smaller than the flow path cross-sectional area of the pressure chamber 31.

[0043] In addition, an opening width of an opening end 2421 on the nozzle plate 12 side of the diaphragm aperture 242 is configured to be such a width that the uncured adhesive 291 can be held at the opening end 2421 by surface tension.

[0044] For example, by forming a photosensitive resin film 244 on an inner walls of the pressure chamber 31 and the air chamber 32, and after that, curing the portions constituting the protrusions 241 by exposure processing, the diaphragm portion 240 is formed. That is, the communication ports at both ends in the second direction are partially blocked by the protrusions 241 to form the diaphragm portions 240 in which the flow path resistance is increased.

[0045] It is noted that, if the flow path resistance of the diaphragm portion 240 is too large, the replenishment of the ink to the pressure chamber 31 after the ejection of

the ink droplets is to be delayed, so that the speeding up is hindered. In addition, the rising of the meniscus varies depending on an ink viscosity, an ejection volume, a drive frequency, and the like. Therefore, the shape of the protrusion 241 and the dimension and position of the diaphragm aperture 242 are set so as to provide the flow path resistance according to ink replenishment conditions and the meniscus rising characteristics. In addition, the protrusion 241 and the diaphragm aperture 242 may have any dimensions as long as the opening width of the opening end 2421 of the diaphragm aperture 242 on the nozzle plate 12 side can be decreased to suppress the inflow of the adhesive 291, and the dimensions are set according to conditions such as viscosity of the adhesive 291. It is noted that the diaphragm portions 240 on both sides may have different configurations.

[0046] The air chamber 32 is blocked by the nozzle plate 12 joined to the top on one side in the third direction. Both ends of the plurality of air chambers 32 in the second direction are blocked by the cover portions 23 made of, for example, a photosensitive resin material. That is, both ends of the air chamber 32 are separated from the ink chambers 27 by arranging the cover portions 23 between the first common chamber 271 of the ink chamber 27 and one end side of the air chamber 32 in the second direction and between the second common chamber 272 and the other end side of the air chamber 32 in the second direction, respectively. For this reason, the air chamber 32 constitutes an air chamber into which the ink does not flow.

[0047] For example, the cover portion 23 is formed by coating both end portions of the air chamber 32 with a photosensitive resin and, after that, curing the target portion in the same process as or a different process from the formation of the protrusion 241.

[0048] The nozzle plate 12 is formed of, for example, a rectangular polyimide film. The nozzle plate 12 faces the mounting surface of the actuator base 11. The plurality of nozzles 28 are formed in the nozzle plate 12 so as to penetrate the nozzle plate 12 in the thickness direction.

[0049] The plurality of nozzles 28 are provided in the same number as the pressure chambers 31 and arranged to face the pressure chambers 31, respectively. The plurality of nozzles 28 are aligned along the first direction and arranged in two columns corresponding to the pair of actuator units 22. Each nozzle 28 is configured in a tubular shape with each axis extending in the third direction. For example, although the nozzle 28 have a constant diameter, the nozzle 28 may have a shape of decreasing a diameter toward a central portion or a distal end portion. The nozzles 28 are arranged to face an intermediate portion in the extending direction of the pressure chambers 31 formed in the pair of actuator units 22 and communicate with the pressure chambers 31, respectively. The nozzles 28 are arranged one by one at positions corresponding to between both end portions of each pressure chamber 31, for example, at the center in

the longitudinal direction.

[0050] The frame 13 is formed in a rectangular shape made of, for example, a nickel alloy. The frame 13 is interposed between the mounting surface of the actuator base 11 and the nozzle plate 12. The frame 13 is adhered to the mounting surface of the actuator base 11 and the nozzle plate 12, respectively. That is, the nozzle plate 12 is attached to the actuator base 11 via the frame 13.

[0051] The manifold 18 is joined to the opposite side of the actuator base 11 from the nozzle plate 12. Inside the manifold 18, an ink supply portion which is a flow path communicating with the supply hole 25 and an ink discharge portion which is a flow path communicating with the discharge hole 26 are formed.

[0052] The circuit board 17 is a film carrier package (FCP). The circuit board 17 has a flexible resin film 51 on which a plurality of wirings are formed and a drive IC 52 connected to the plurality of wirings of the film 51. The drive IC 52 is electrically connected to the electrode layer 34 via the wiring of the film 51 and the pattern wiring 211.

[0053] The ink chamber 27 surrounded by the actuator base 11, the nozzle plate 12, and the frame 13 is formed inside the inkjet head 10 configured as described above. That is, the ink chamber 27 is formed between the actuator base 11 and the nozzle plate 12. For example, the ink chamber 27 is partitioned into three portions in the second direction by the two actuator units 22 and includes the two second common chambers 272 as common chambers to which the discharge holes 26 open and the first common chamber 271 as a common chamber to which the supply holes 25 open. The first common chamber 271 and the second common chamber 272 communicate with the plurality of pressure chambers 31.

[0054] In the inkjet head 10 configured as described above, the ink circulates between the ink tank and the ink chamber 27 through the supply hole, the pressure chamber, and the discharge hole. For example, the drive IC 52 applies a drive voltage to the electrode layer 34 of the pressure chamber 31 via the wiring of the film 51 in response to a signal input from the control unit of the inkjet printer to cause a potential difference to occur between the electrode layer 34 of the pressure chamber 31 and the electrode layer 34 of the air chamber 32, so that the element wall 33 is selectively deformed in a shear mode. By deforming the element wall 33 formed between the pressure chamber 31 and the air chamber 32 according to the drive signal, the volume of the pressure chamber 31 is changed.

[0055] Due to the shear mode deformation of the element wall 33, the volume of the pressure chamber 31 provided with the electrode layer 34 is increased, and the pressure is decreased. Accordingly, the ink in the ink chamber 27 flows into the pressure chamber 31.

[0056] In a state where the volume of the pressure chamber 31 is increased, the drive IC 52 applies a drive voltage having a reverse potential to the electrode layer 34 of the pressure chamber 31. Accordingly, since the element wall 33 undergoes shear mode deformation, the

volume of the pressure chamber 31 in which the electrode layer 34 is provided is decreased, and the pressure is increased. As a result, the ink in the pressure chamber 31 is pressurized and ejected from the nozzle 28.

[0057] As a method of manufacturing the inkjet head 10, first, a piezoelectric member forming the plurality of grooves 14 is attached to a plate-like substrate 21 with an adhesive or the like, and after that, a machining process using a dicing saw, a slicer, or the like is performed to mold the actuator base 11 having a predetermined outer shape. It is noted that, for example, a block-shaped base member having a thickness corresponding to a plurality of sheets may be formed in advance and, after that, divided to manufacture a plurality of sheets of the actuator bases 11 having a predetermined shape.

[0058] Subsequently, the electrode layer 34 and the pattern wiring 211 are formed on the inner surfaces of the grooves 14 constituting the pressure chambers 31 and the air chambers 32 and the surface of the substrate 21. As described above, the electrode layer 34 and the pattern wiring 211 are formed at predetermined locations on the surface of the actuator base 11, respectively.

[0059] Subsequently, the diaphragm portion 240 which is a communication port having a higher flow path resistance than the interior of the pressure chamber 31 is formed at the end portion of the pressure chamber 31. For example, the method of forming the diaphragm portion 240 includes a film forming process of forming a photosensitive resin film 244 of a photosensitive resin in the groove 14 constituting the pressure chamber 31 and a forming process of forming the photosensitive resin film 244 by exposure and development.

[0060] As a film forming process, first, as illustrated in Act 11 in FIG. 6, the photosensitive resin film 244 is formed by coating the inner wall of the pressure chamber 31 with the photosensitive resin. At this time, by controlling a coating amount of the photosensitive resin, the shape of the photosensitive resin on the exposure surface is formed to have a concave shape. A surface 2440 on the top side of the photosensitive resin film 244 in each groove 14 is formed to have a concave shape with the center being recessed toward the bottom side.

[0061] Subsequently, as a forming process, the photosensitive resin films 244 at both end portions of the pressure chamber 31 are molded by exposure and development. For example, in the present embodiment, as an example, by curing a tapered cured region 2441 by an exposure process on the surface 2440 having a concave shape, and after that, by performing a development process to remove an uncured region 2442, the tapered protrusion 241 and the tapered diaphragm aperture 242 are formed. It is noted that, in the forming process, a baking process may be performed at a necessary timing.

[0062] For example, as an exposure process, as illustrated in Act 11, an exposure mask 245 is placed on the top side of the element wall 33, and exposure is performed from the top side through the exposure mask 245, so that exposing is performed to the depth of the bottom

of the groove 14. For example, the exposure mask 245 has a pattern shape having a non-exposed portion 2451 corresponding to the dimensions of the top side of the diaphragm aperture 242. As an example, by setting the exposure direction in the depth direction of the pressure chamber 31, the protrusions 241 on both sides can be exposed and molded at the same time. At this time, since the surface 2440 of the photosensitive resin film 244 on the top side on which the exposure light is incident is configured in a concave shape, if the ultraviolet light which is the exposure light is incident parallel to the Z direction from the top side, the light progresses in the direction of dispersion, so that an uncured region which is increased in width in a tapered shape toward the bottom is formed. That is, since the incident surface 2440 has a concave shape, the boundary surface between the cured region 2441 and the uncured region 2442 has an inclined shape so that the bottom side expands.

[0063] After that, by washing away unnecessary unexposed resin with a developing solution, as illustrated in Act 13, the tapered protrusion 241 is formed by the photosensitive resin film 244 at the entrance/exit of the pressure chamber 31, and the diaphragm aperture 242 which is narrowed at the top and is widened toward the bottom is formed between the protrusions 241 on both sides, so that the diaphragm portion 240 is formed.

[0064] It is noted that, in the film forming process of the diaphragm portion 240 and the forming process by exposure and development, the film forming process of coating both ends of the air chamber 32 with the photosensitive resin and the forming process by exposure and development are performed at the same time, so that the cover portion 23 blocking the air chamber 32 may be formed at the same time as the diaphragm portion 240. Alternatively, the cover portion 23 may be formed in a separate process before forming the diaphragm portion 240 or after forming the diaphragm portion 240.

[0065] Then, the actuator base 11 is assembled to the manifold 18, and the frame 13 is stacked to one surface of the substrate 21 of the actuator base 11 with a thermoplastic resin adhesive sheet.

[0066] Then, the surfaces of the assembled frame 13, the top of the element wall 33 of the actuator unit 22, and the protrusions 241 on the nozzle plate 12 side are polished so as to be the same surface. Then, the nozzle plate 12 is adhered to the polished surfaces of the top of the element wall 33, the frame 13, and the protrusion 241. For example by coating the surface of the nozzle plate 12 facing the pressure chambers 31 with the adhesive 291 to form the adhesive layer 29, the nozzles 28 are positioned to face each other, and after being stacked, by curing the adhesive 291, the adhesive layer 29 is joined. At this time, since the diaphragm aperture 242 on the nozzle plate 12 side is configured to have a small width, the before-cured adhesive 291 can be prevented from entering the interior through the diaphragm aperture 242. As described above, the nozzle plate 12 is joined to the actuator unit 22, and the adhesive layer

29 is provided between the element wall 33 and the nozzle plate 12. In addition, as illustrated in FIG. 1, the inkjet head 10 is completed by connecting the drive IC 52 and the circuit board 17 to the pattern wiring 211 formed on the main surface of the substrate 21 via a flexible printed circuit board.

[0067] Hereinafter, an example of an inkjet printer 100 including the inkjet head 10 will be described with reference to FIG. 7. The inkjet printer 100 includes a housing 111, a medium supply unit 112, an image forming unit 113, a medium discharge unit 114, a conveying device 115, and a control unit 116.

[0068] The inkjet printer 100 is a liquid ejection device that performs an image forming process on paper P by ejecting a liquid such as the ink while conveying a recording medium such as paper P which is an ejection target along a predetermined conveyance path A from the medium supply unit 112 through the image forming unit 113 to the medium discharge unit 114.

[0069] The housing 111 constitutes an outer shell of the inkjet printer 100. A discharge port for discharging the paper P to the outside is provided at a predetermined position of the housing 111.

[0070] The medium supply unit 112 includes a plurality of paper feed cassettes and is configured to be able to stack and hold a plurality of sheets of the paper P of various sizes.

[0071] The medium discharge unit 114 includes a paper discharge tray configured to hold the paper P discharged from the discharge port.

[0072] The image forming unit 113 includes a support unit 117 that supports the paper P and a plurality of head units 130 arranged above the support unit 117 so as to face each other.

[0073] The support unit 117 includes a convey belt 118 provided in a loop shape in a predetermined region for image formation, a support plate 119 supporting the convey belt 118 from the back side, and a plurality of belt rollers 120 provided on the back side of the convey belt 118.

[0074] During the image formation, the support unit 117 supports the paper P on a holding surface which is the upper surface of the convey belt 118 and feeds the convey belt 118 at a predetermined timing by the rotation of the belt roller 120 to convey the paper P to a downstream side.

[0075] The head unit 130 includes a plurality of (four colors of) inkjet heads 10, ink tanks 132 as liquid tanks mounted on the respective inkjet heads 10, connection flow paths 133 connecting the inkjet heads 10 and the ink tanks 132, and circulation pumps 134 that is a circulation unit. The head unit 130 is a circulation type head unit that constantly circulates the liquid in the ink tank 132, the pressure chamber 31, the air chamber 32, and the ink chamber 27 built inside the inkjet head 10.

[0076] In this embodiment, four inkjet heads 10 of cyan, magenta, yellow, and black, and ink tanks 132 that respectively contain the inks of these colors are provided.

The ink tank 132 is connected to the inkjet head 10 by the connection flow path 133. The connection flow path 133 includes a supply flow path connected to the supply port of the inkjet head 10 and a recovery flow path connected to the discharge port of the inkjet head 10.

[0077] In addition, the ink tank 132 is also connected to a negative pressure control device such as a pump (not illustrated). The negative pressure control device controls the pressure inside the ink tank 132 according to a water head value of the inkjet head 10 and the ink tank 132, so that the ink supplied to each nozzle 28 of the inkjet head 10 is formed to have a meniscus having a predetermined shape.

[0078] The circulation pump 134 is, for example, a liquid feed pump configured with a piezoelectric pump. The circulation pump 134 is provided in the supply flow path. The circulation pump 134 is connected to a drive circuit of the control unit 116 by wiring and is configured to be controllable under the control of a CPU (Central Processing Unit). The circulation pump 134 circulates the liquid in a circulation flow path including the inkjet head 10 and the ink tank 132.

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

[0080] Each of the plurality of guide plate pairs 121 includes a pair of plate members arranged to face each other with the paper P being conveyed interposed therebetween to guide the paper P along the conveyance path A.

[0081] The conveying rollers 122 are driven and rotated under the control of the control unit 116 to convey the paper P along the conveyance path A to the downstream side. It is noted that sensors for detecting the state of conveyance of the paper are arranged at various locations along the conveyance path A.

[0082] The control unit 116 includes a control circuit such as a CPU as a controller, a ROM (Read Only Memory) that stores various programs, a RAM (Random Access Memory) that temporarily stores various variable data, an image data, and the like, and an interface unit for inputting data from the outside and outputting data to the outside.

[0083] In the inkjet printer 100 configured as described above, if a print instruction by a user operating the operation input unit at the interface is detected, for example, the control unit 116 drives the conveying device 115 to convey the paper P and outputs a print signal to the head unit 130 at a predetermined timing, so that the inkjet head 10 is driven. As an ejection operation, the inkjet head 10 transmits a drive signal to the drive IC 52 according to the image signal corresponding to the image data and applies a drive voltage to the electrode layer 34 of the pressure chamber 31 through the wiring to selectively

drive the element wall 33 of the actuator unit 22, so that an image is formed on the paper P held on the convey belt 118 by ejecting the ink from the nozzles 28. In addition, as the liquid ejection operation, the control unit 116 drives the circulation pump 134 to circulate the liquid in the circulation flow path passing through the ink tank 132 and the inkjet head 10. Due to the circulation operation, by driving the circulation pump 134, the ink in the ink tank 132 passes through the ink supply portion of the manifold 18 and is supplied from the supply hole 25 to the first common chamber 271 of the ink chamber 27. This ink is supplied to the plurality of pressure chambers 31 and the plurality of air chambers 32 of the pair of actuator units 22. The ink flows through the pressure chamber 31 into the second common chamber 272 of the ink chamber 27. This ink is discharged from the discharge hole 26 to the ink tank 132 through the ink discharge portion of the manifold 18.

[0084] According to the above-described embodiment, the ejection stability can be improved by forming the diaphragm at the entrance/exit of the pressure chamber 31. In addition, in the diaphragm portion 240, openings that open to the first common chamber 271 and the second common chamber 272 which are common chambers of the pressure chambers 31 are smaller than the cross-sectional area of the flow path of the pressure chambers 31. Therefore, the rising of the meniscus is reduced if the inkjet head 10 ejects the liquid. Therefore, the meniscus recovers quickly, and thus, the influence on the next bullet can be reduced, so that the ejection stability can be improved.

[0085] In addition, in the inkjet head 10, by narrowing the upper portion of the slit-shaped diaphragm aperture 242 of the diaphragm portion 240 by using a photosensitive resin, the flow of the adhesive 291 can be suppressed, and the productivity can be improved. That is, for example, if the nozzle plate 12 is to be joined to the actuator unit 22, the diaphragm portion 240 may be filled with excess adhesive 291, so that printing defects may occur, and the productivity may be deteriorated. However, by sufficiently reducing the opening width of the opening end 2421 of the diaphragm aperture 242 on the nozzle plate 12 side, the flow of the adhesive 291 can be suppressed, so that the printing defects can be suppressed.

[0086] In addition, according to the above-described embodiment, the diaphragm portion 240 can be formed by forming the photosensitive resin film 244 in the groove 14 of the actuator unit 22 and performing patterning by an exposure process, and the diaphragm portion 240 can be formed cheaply and easily with a small number of processes. Furthermore, since the thickness and shape of the protrusion 241 can be selected relatively freely by exposure and development, the flow path resistance of the diaphragm portion can be easily designed freely. In addition, by forming the surface of the photosensitive resin film 244 to have a concave shape, the tapered diaphragm aperture 242 can be easily formed. In the above-described embodiment, since the side surface portion

221 of the actuator unit 22 constitutes the inclined surface, restriction of the exposure direction is small, and the exposure and development processes are facilitated.

[0087] It is noted that the present disclosure is not limited to the above-described embodiment as it is and can be embodied by modifying constituent elements without departing from the scope of the present disclosure at the implementation stage.

[0088] In the above-described embodiment, the diaphragm portion 240 increasing the flow path resistance has a configuration of having the pair of protrusions 241 formed on the wall surfaces of the element walls 33 on both sides of the pressure chamber 31, but the shape of the diaphragm portion 240 is not limited thereto. For example, the protrusion may be formed on a portion of the pressure chamber 31 on the nozzle plate 12 side. For example, although the diaphragm aperture 242 has a slit shape extending in the third direction which is the depth direction of the pressure chamber, the diaphragm aperture 242 may extend in other directions or may have other shapes including a circular shape and an oval shape.

[0089] For example, the diaphragm aperture 242 is not limited to an example in which the bottom side is tapered to expand gradually. As an example, the opening width on both sides in the depth direction, that is, the bottom side opposite to the opening end 2421 may be configured to be smaller than the central portion. Alternatively, a configuration in which the opening end 2421 of a portion of the area on the nozzle plate 12 side may be decreased in width and the other area on the bottom side may have a constant opening width larger than the opening end 2421 may be used.

[0090] In addition, the diaphragm portion 240 on both sides may have different configurations. For example, the diaphragm portion 240 may be formed at least one communication port of the pressure chamber 31 communicating with the common chambers 271 and 272 on both sides by the protrusion 241, so that the effects of improving the ejection performance and enabling the diaphragm portion 240 to be easily manufactured at a low cost can be obtained.

[0091] In addition, although the cover portion 23 and the protrusion 241 are formed inside the grooves 14 forming the pressure chambers 31 and the air chambers 32 so as to partially fill the grooves 14, the shape is not limited thereto. For example, on the side surface of the actuator, the cover portion 23 that blocks the air chamber 32 and, for example, the protrusion 241 that blocks a portion of the communication port of the pressure chamber 31 may be formed outside the grooves 14 forming the pressure chamber 31 and the air chamber 32, and the diaphragm portion 240 may be formed outside the grooves 14 and the element wall 33.

[0092] In the above-described embodiment, an example in which the actuator unit 22 having the plurality of grooves 14 is arranged on the main surface portion of the substrate 21 is illustrated, but the present disclosure is not limited thereto. For example, a configuration in

which the actuator is provided on the end face of the substrate 21 may be used. In addition, the number of nozzle columns is not limited to that of the above-described embodiment, and may be configured to have one column or three or more columns.

[0093] In addition, in the above-described embodiment, the actuator base 11 having the stacked piezoelectric bodies made of a piezoelectric member on the substrate 21 is exemplified, but the present disclosure is not limited thereto. For example, the actuator base 11 may be formed only by a piezoelectric member without using a substrate. In addition, instead of using two piezoelectric members, one piezoelectric member may be used. In addition, the air chamber 32 may communicate with the first common chamber 271 and the second common chamber 272 which are common chambers. In addition, a supply side and a discharge side may be configured reversed, or may be configured to be switchable.

[0094] In addition, in the above-described embodiment, as an example, a circulation type inkjet head in which one side of the pressure chamber 31 in the second direction is the supply side, the other side in the second direction is the discharge side, and the first common chamber fluid flows in from one side of the pressure chamber and flows out from the other side is exemplified, the present disclosure is not limited thereto. For example, the inkjet head may be of a non-circulation. In addition, for example, the configuration in which the common chambers on both sides of the pressure chamber 31 may be the supply side and the fluid flows in from both sides may be used. That is, the fluid may flow in from both sides of the pressure chamber 31 and flow out from the nozzle 28 arranged in the center of the pressure chamber 31. Even in this case, by providing the diaphragm portions 240 at the communication ports serving as entrances on both sides of the pressure chamber 31, the flow path resistance is increased, and the ejection efficiency can be improved. In addition, the configuration of the diaphragm portions 240 formed at both ends may be different.

[0095] In addition, in the above-described embodiment, an example in which the diaphragm portions 240 are formed at both ends of the pressure chamber 31 in the extending direction is illustrated, but the present disclosure is not limited thereto, and the diaphragm portion 240 may be formed only on one side of the entrance/exit on both sides communicating with the common chambers 271 and 272 at both ends of the pressure chamber 31. For example, the diaphragm portion 240 having a higher flow path resistance than that of the interior of the pressure chamber 31 may be formed at one end portion, and a configuration in which the other end portion has the same flow path resistance as the interior of the pressure chamber 31 and the cross-sectional area of the communication port is the same as the cross-sectional area of the interior of the pressure chamber 31 may be used.

[0096] In the above-described embodiment, the side shooter type in which both sides of the pressure chamber

31 communicate with the ink chamber is exemplified, but the present disclosure is not limited thereto. For example, an end shooter type in which only one side of the pressure chamber 31 communicates with the ink chamber 27 may be used.

[0097] In addition, in the above-described embodiment, an example in which the protrusions 241 are formed on both side portions has been described, but the present disclosure is not limited thereto. For example, the protrusion 241 may be formed only on one element wall 33.

[0098] In the above-described embodiment, an example is illustrated in which the diffusion direction of exposure light is set by forming the photosensitive resin film 244 having a concave-shaped surface, but the present disclosure is not limited thereto. For example, the exposure depth and the cured region may be set by setting the exposure direction to be oblique with respect to the depth direction of the grooves 14.

[0099] In addition, for example, the liquid to be ejected is not limited to printing ink, and a device that ejects a liquid containing conductive particles for forming a wiring pattern of a printed wiring board may be used.

[0100] In addition, in the above-described embodiment, an example in which the inkjet head is used in a liquid ejection device such as an inkjet printer is illustrated, but the present disclosure is not limited thereto. The present disclosure can also be used in, for example, 3D printers, industrial manufacturing machines, and medical applications, and it is possible to reduce the size, weight, and cost.

[0101] According to at least one embodiment described above, it is possible to provide a liquid ejection head and a method for manufacturing the liquid ejection head capable of ensuring stable ejection characteristics.

[0102] 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 inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the scope of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope of the inventions.

Claims

1. A liquid ejection head comprising:

an actuator unit (22) having grooves (14) constituting a plurality of pressure chambers (31) and a plurality of sidewall portions (33) formed between the grooves constituting the pressure chambers;
a nozzle plate (12) disposed to face one side of

the plurality of pressure chambers; and
a diaphragm portion (240) having an diaphragm wall (241) that blocks a portion of a communication port of the pressure chamber that communicates with a common chamber of the actuator unit and forms a diaphragm aperture (242) that is decreased in width on the one side in a depth direction of the pressure chamber.

2. The head according to claim 1,

wherein the plurality of grooves and the plurality of sidewall portions are aligned in a first direction,
wherein the diaphragm portion is provided on the sidewall portion and has a diaphragm wall that decreases a width dimension of the communication port in the first direction as compared with a width dimension of an interior of the pressure chamber in the first direction, and a flow path resistance is configured to be larger than the interior of the pressure chamber, and
wherein an adhesive layer is provided between the top of the sidewall portion and the nozzle plate.

3. The head according to claim 2,

wherein the diaphragm wall is made of a photosensitive resin, and
wherein the diaphragm aperture is a tapered slit where a bottom side of the pressure chamber is increased in width.

4. The head according to any one of claims 1 to 3,

wherein the actuator unit has a plurality of air chambers respectively formed between the plurality of pressure chambers,
wherein the pressure chamber and the air chamber are aligned in a first direction and extend respectively in a second direction intersecting with the first direction, and
wherein the liquid ejection head is of a side shooter type, in which the diaphragm portions are arranged at both ends of the pressure chamber in the second direction, and each of both ends of the pressure chamber communicates with the common chamber via the diaphragm aperture.

5. The head according to any one of claims 1 to 4, wherein an opening width of an opening end of the diaphragm aperture on the nozzle plate side is configured to be a width capable of holding an uncured adhesive by surface tension.

6. An inkjet printer comprising a head according to any

one of claims 1 to 5.

7. A method for producing a liquid ejection head comprising:

5

a step of forming an actuator base (11) comprising a plurality of grooves (14);

a step of forming pressure chambers (31) in the grooves;

a step of forming a diaphragm portion forming a diaphragm aperture (242) that is decreased in width on the one side in a depth direction of the pressure chamber;

10

a step of adhering a nozzle plate on the actuator base (11).

15

8. The method for according to claim 7, wherein the step of forming a diaphragm portion comprises:

a step of forming a photosensitive resin film (244) of a photosensitive resin in the groove (14) constituting the pressure chamber (31); and

20

a forming step of forming the photosensitive resin film (244) by exposure and development.

25

9. The method for according to claim 8, wherein the step of forming the photosensitive resin film (244) comprises:

a step of coating the inner wall of the pressure chamber (31) with the photosensitive resin whereby the photosensitive resin film (244) in each groove (14) is formed to have a concave-shaped surface (2440) with the center being recessed toward the depth side.

30

35

10. The method for according to claim 8 or 9 wherein the forming step further comprises :

a step of curing a tapered cured region (2441) by an exposure process on the concave-shaped surface (2440); and

40

a step of performing a development process to remove an uncured region (2442) so that a tapered protrusion (241) and a tapered diaphragm aperture (242) are formed.

45

50

55

FIG. 1

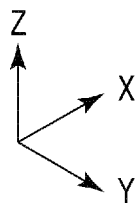
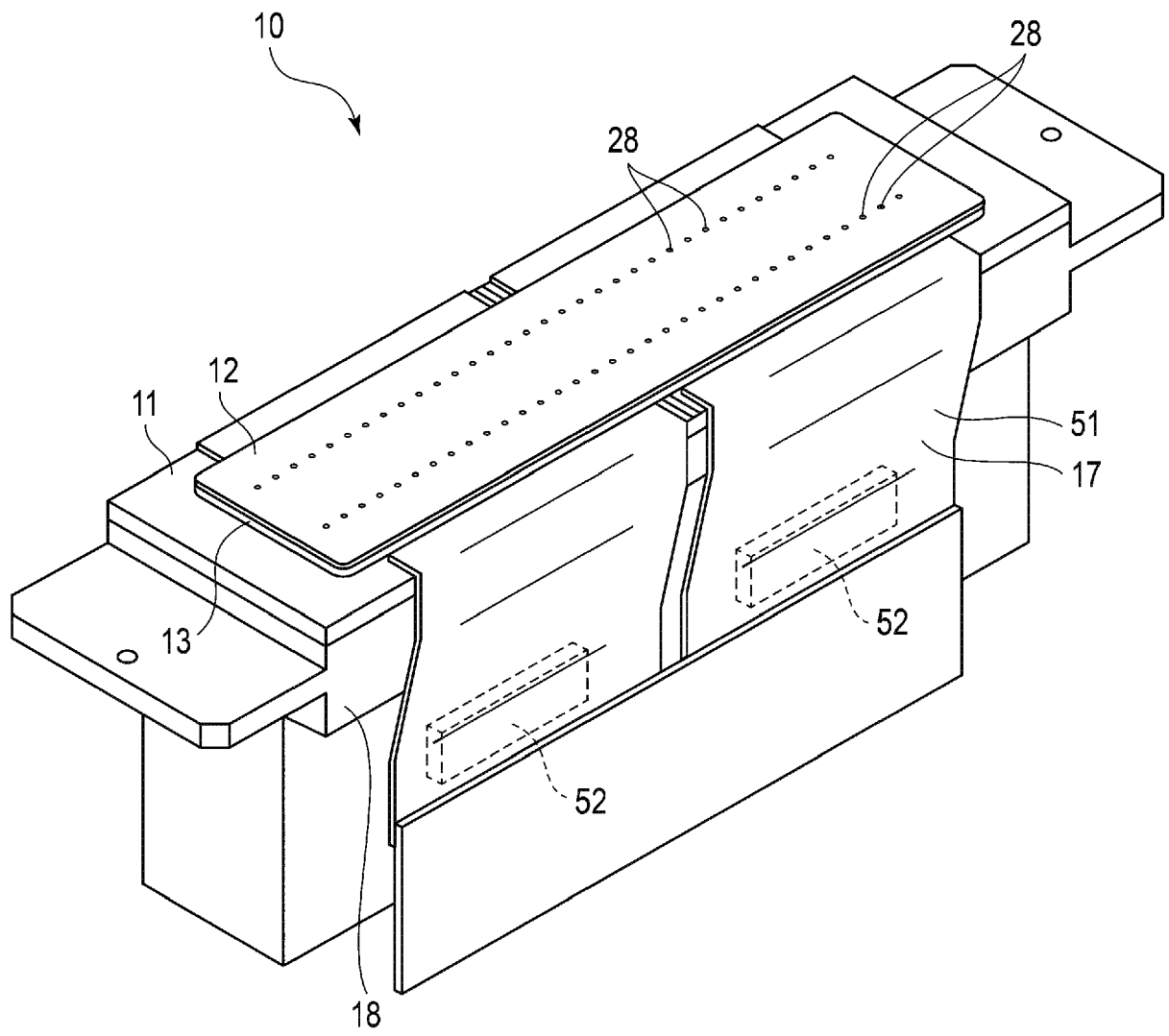


FIG. 2

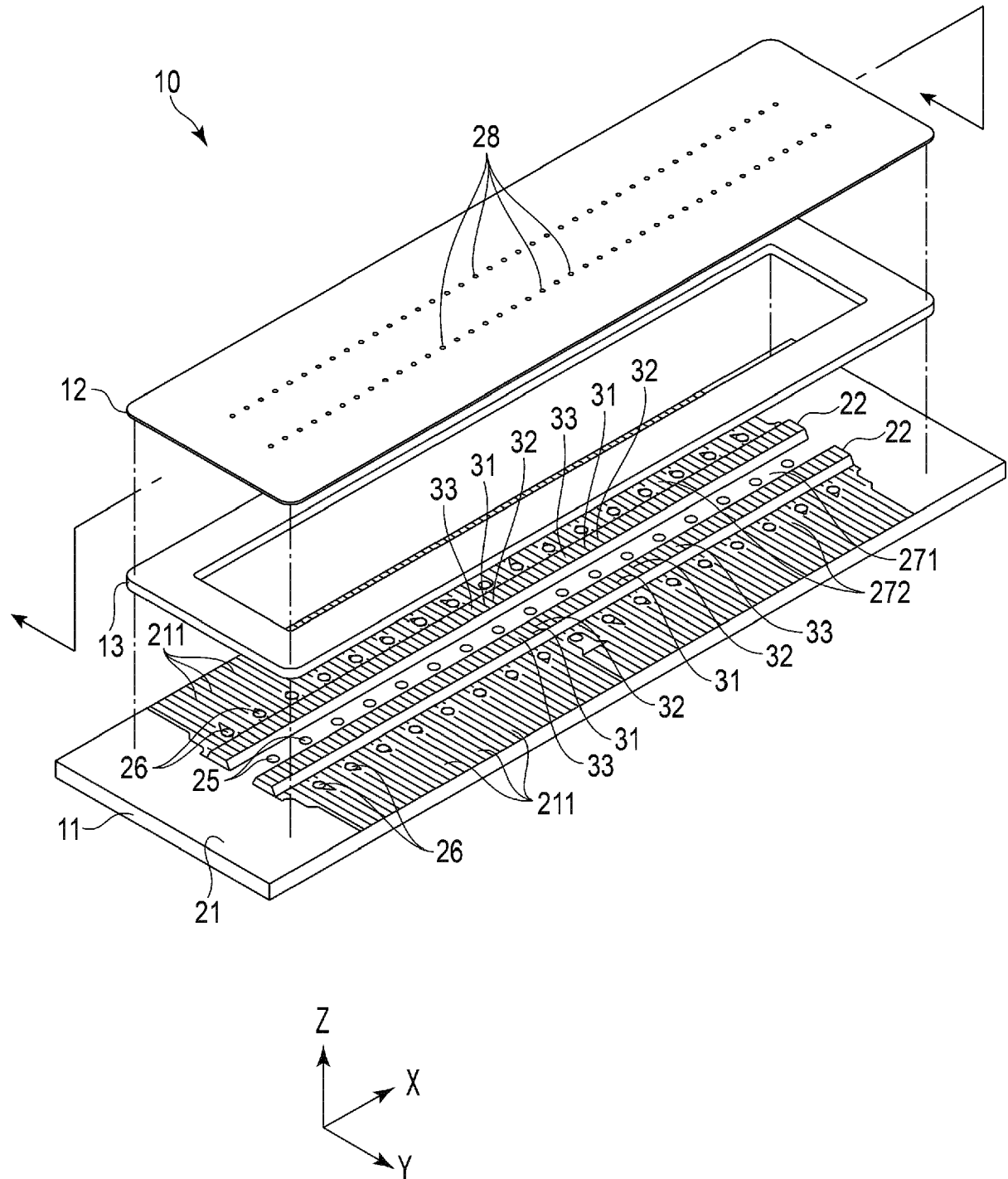


FIG. 3

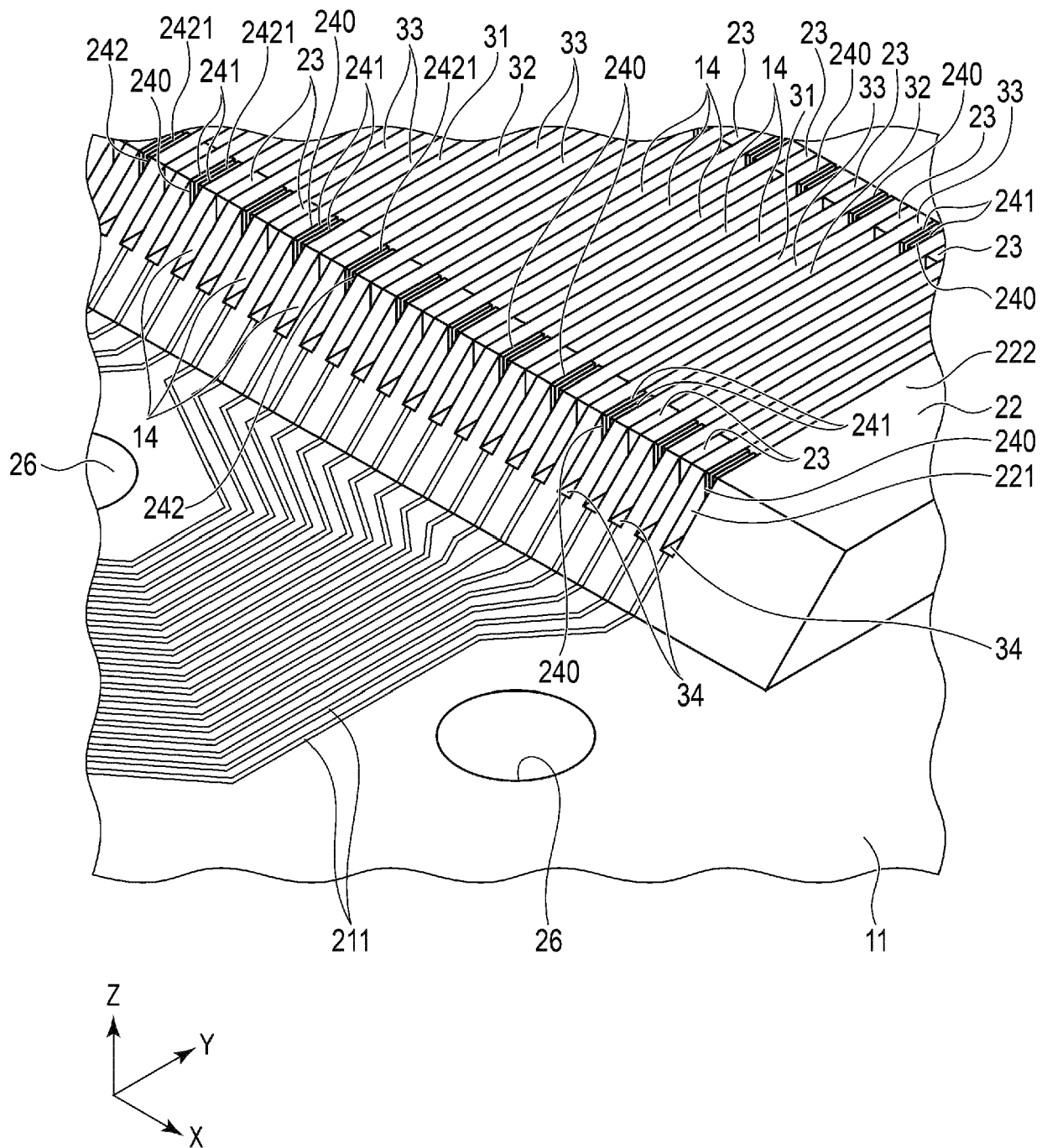


FIG. 4

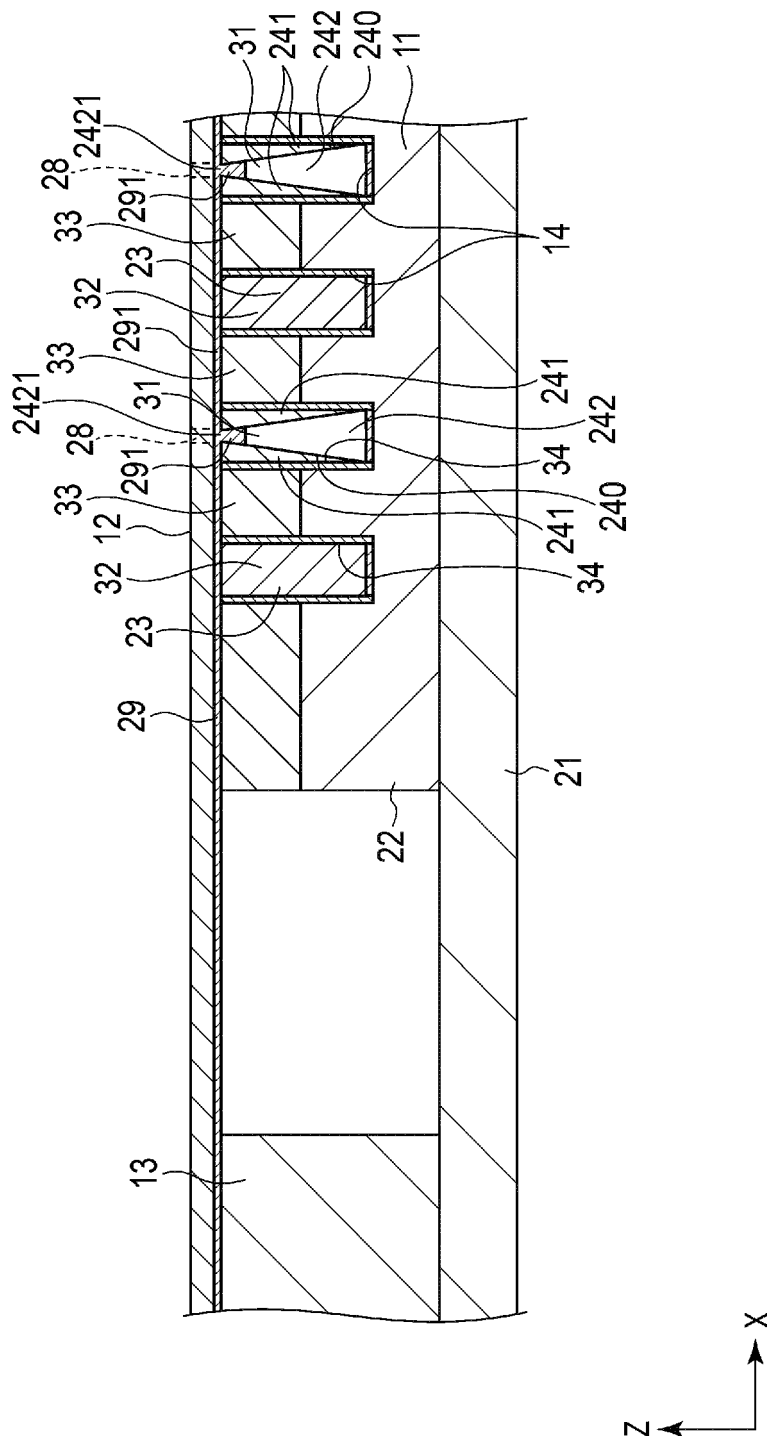


FIG. 5

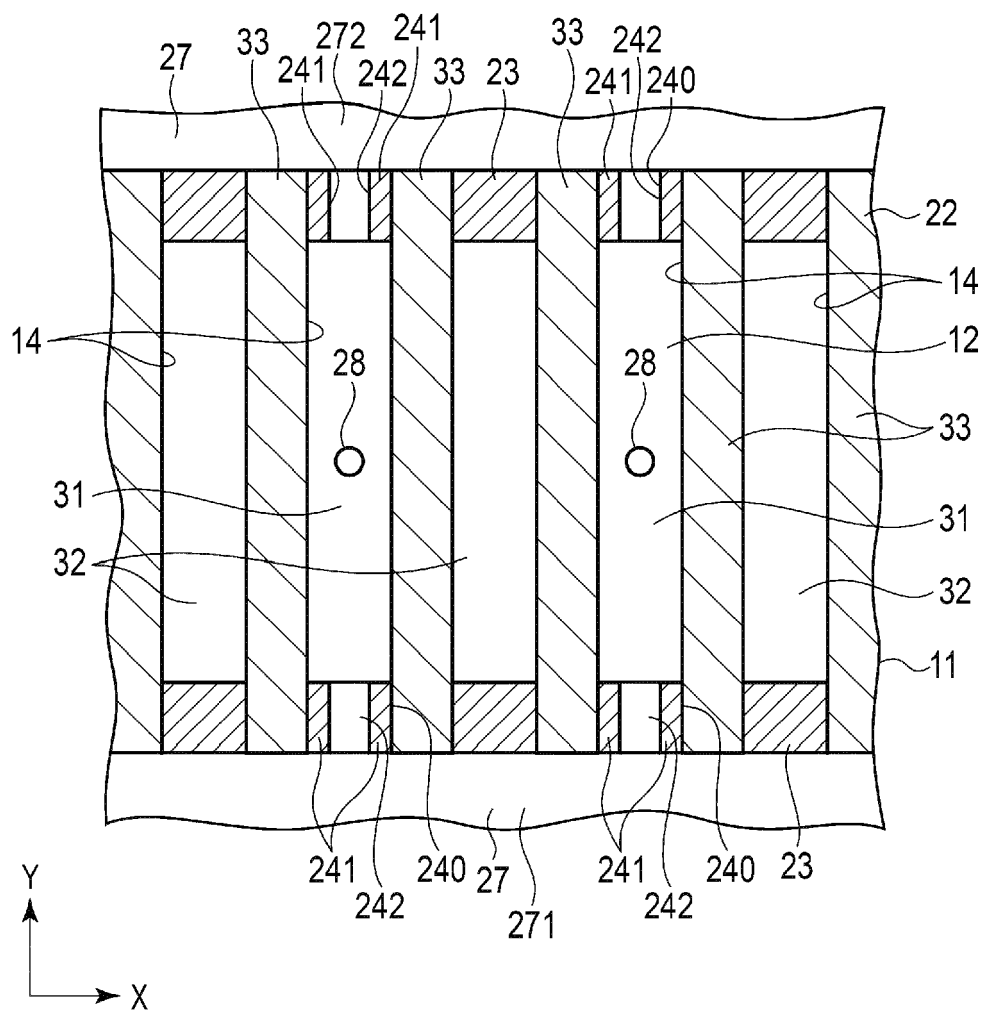


FIG. 6

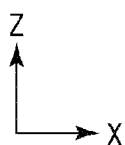
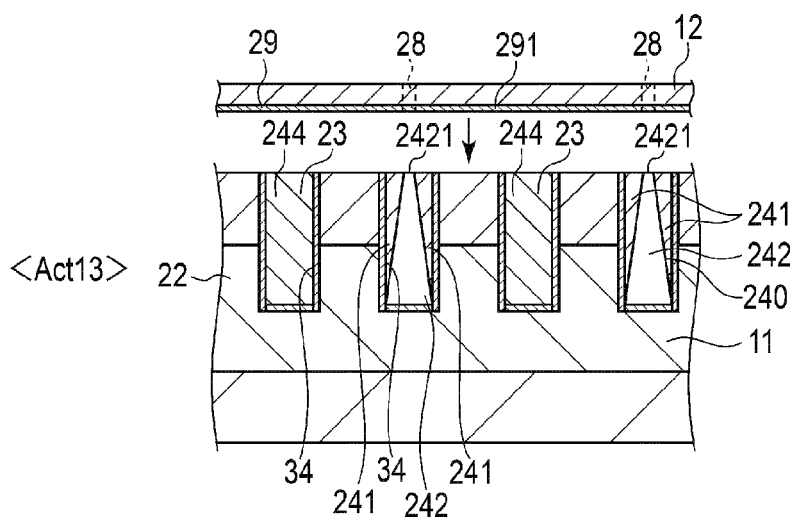
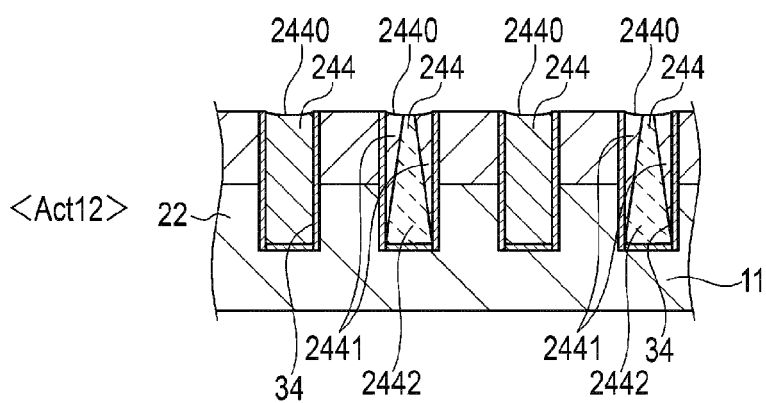
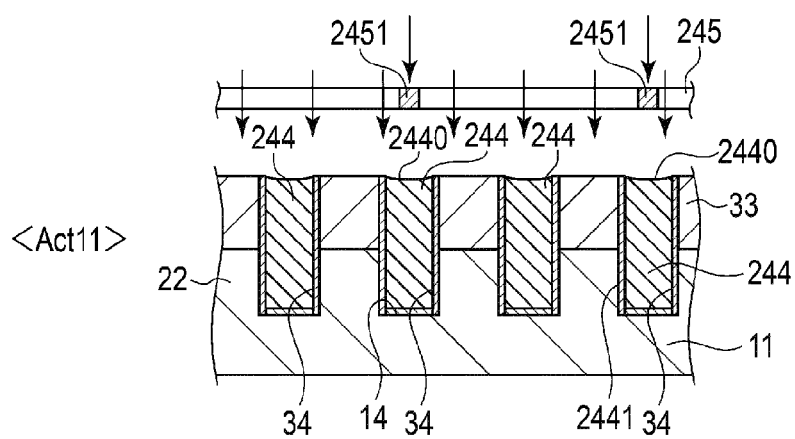
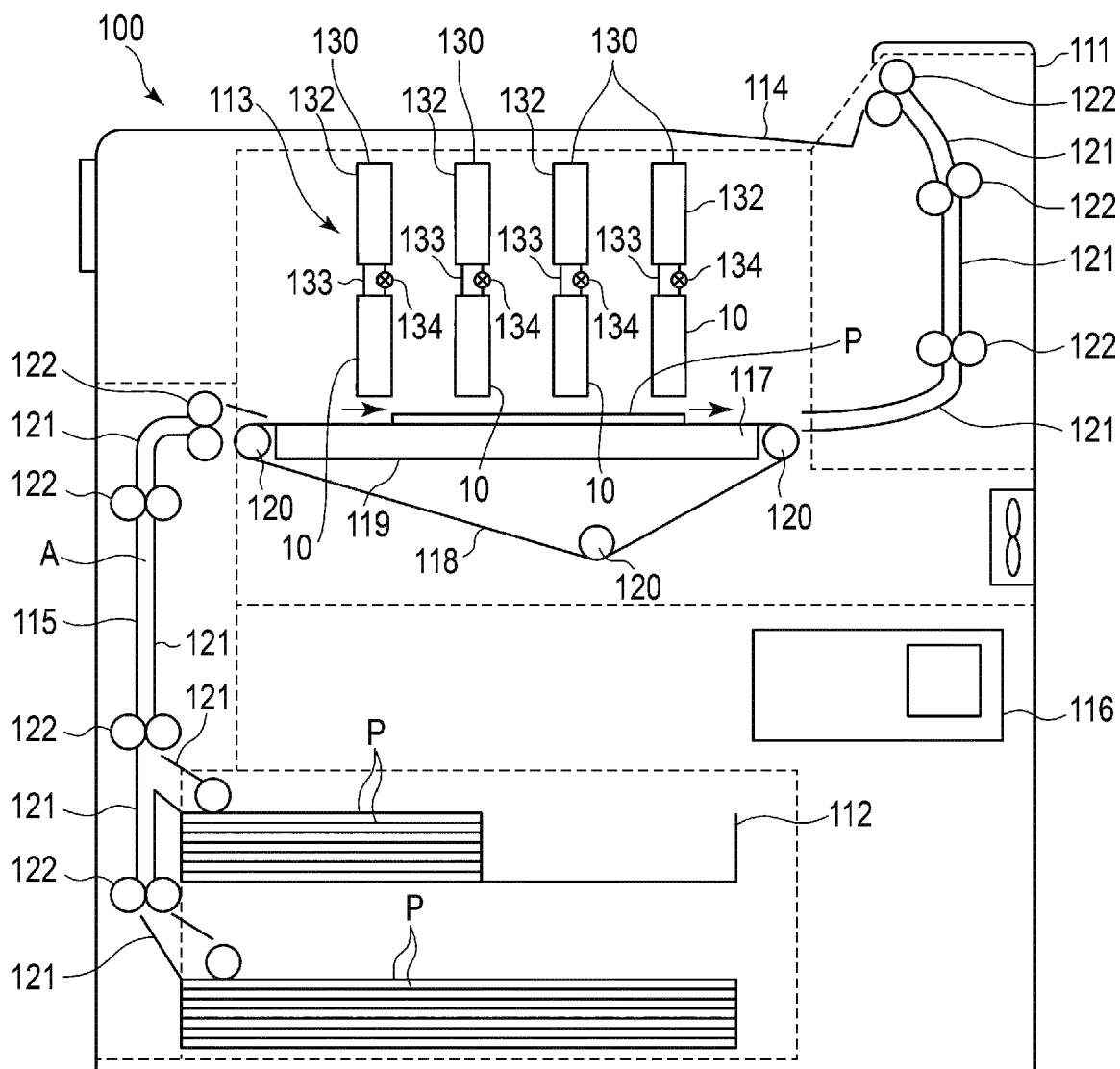


FIG. 7





EUROPEAN SEARCH REPORT

Application Number

EP 22 21 1303

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	JP 2016 159441 A (SII PRINTEK INC) 5 September 2016 (2016-09-05) * paragraph [0051]; figure 5 *	1-10	INV. B41J2/14 B41J2/16
A	US 2015/109373 A1 (HORIGUCHI SATOSHI [JP]) 23 April 2015 (2015-04-23) * paragraphs [0048], [0049]; figure 3 *	1-10	
A	US 2020/290354 A1 (SHIMOSATO MASASHI [JP]) 17 September 2020 (2020-09-17) * paragraph [0028]; figure 2 *	1-10	
			TECHNICAL FIELDS SEARCHED (IPC)
			B41J
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		29 September 2023	Öztürk, Serkan
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			
T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 22 21 1303

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

29-09-2023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2016159441 A	05-09-2016	NONE	
US 2015109373 A1	23-04-2015	CN 104553325 A	29-04-2015
		GB 2521512 A	24-06-2015
		JP 6295058 B2	14-03-2018
		JP 2015077737 A	23-04-2015
		US 2015109373 A1	23-04-2015
US 2020290354 A1	17-09-2020	CN 111688356 A	22-09-2020
		EP 3708372 A1	16-09-2020
		JP 7149879 B2	07-10-2022
		JP 2020146904 A	17-09-2020
		US 2020290354 A1	17-09-2020