



(11)

EP 4 570 504 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
18.06.2025 Bulletin 2025/25

(51) International Patent Classification (IPC):
B41J 2/14 ^(2006.01) **B41J 2/045** ^(2006.01)
B41J 2/16 ^(2006.01)

(21) Application number: **24201170.8**

(52) Cooperative Patent Classification (CPC):
B41J 2/14274; B41J 2/04548; B41J 2/04581;
B41J 2/04588; B41J 2/1612; B41J 2/1623;
B41J 2002/14491; B41J 2202/11

(22) Date of filing: **18.09.2024**

(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:
GE KH MA MD TN

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(30) Priority: **14.12.2023 JP 2023211452**

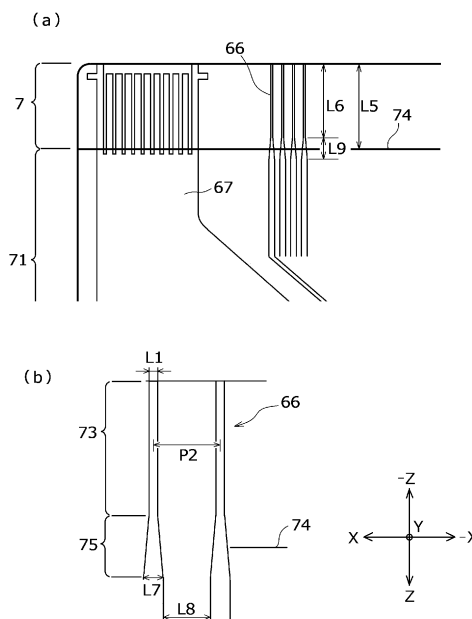
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(54) **LIQUID EJECTION HEAD**

(57) A liquid ejection head according to an embodiment includes a laminated piezoelectric body block and a film substrate. In the laminated piezoelectric body block, a plurality of piezoelectric actuators and pillars are alternately disposed. In the film substrate, a plurality of copper foil interconnects for applying drive waveforms to the respective piezoelectric actuators are formed, and the copper foil interconnects are soldered to terminals of the

respective piezoelectric actuators to be electrically connected thereto. In the copper foil interconnects of the film substrate, an interconnect width changes to a tapered shape before and after a boundary portion of a solder resist region, the interconnect width on a solder resist region side is large, and the interconnect width on a solder connection region side is small.

FIG. 9



Description

FIELD

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

BACKGROUND

[0002] A liquid ejection head that supplies a predetermined amount of liquid to a predetermined position is known. The liquid ejection head is mounted on, for example, an ink jet printer, a 3D printer, or a dispensing device. The ink jet printer ejects droplets of ink from an ink jet head to form an image or the like on a surface of a recording medium. The 3D printer ejects droplets of a shaping material from a shaping material ejection head and cures the droplets to form a three-dimensional shaped object. The dispensing device ejects droplets of a sample and supplies a predetermined amount of the droplets to a plurality of containers or the like.

[0003] The liquid ejection head includes a plurality of channels for ejecting liquid. Each channel includes a nozzle that ejects liquid, a pressure chamber that communicates with the nozzle, and a piezoelectric actuator that changes a volume of the pressure chamber. The liquid ejection head selects a channel for ejecting the liquid from the plurality of channels, and applies a drive waveform to the piezoelectric actuator of the selected channel to eject the liquid.

[0004] The drive waveform is applied to a terminal of the piezoelectric actuator via a copper foil interconnect formed in a flexible interconnect board such as a flexible printed circuit (FPC). The interconnect of each channel disposed in a terminal portion of the flexible interconnect board is connected to the terminal of each piezoelectric actuator by collective soldering. However, for example, since an interconnect width is small for a reason of a fine pitch of the flexible interconnect board, disconnection is likely to occur. In particular, the disconnection is likely to occur at a boundary between a solder-connected region and a region in which a solder resist is applied in the flexible interconnect board.

DISCLOSURE OF THE INVENTION

[0005] To this end, a liquid ejection head, a printer, and a 3-D printer according to appended claims are provided.

DESCRIPTION OF THE DRAWINGS

[0006]

FIG. 1 is an overall configuration diagram of an ink jet printer including an ink jet head according to an embodiment;

FIG. 2 is a perspective view;

FIG. 3 is a partially enlarged cross-sectional view of a

head unit;

FIG. 4 is a partially enlarged cross-sectional view;

FIG. 5 is a partially enlarged plan view;

FIG. 6 is a plan view of a flexible printed interconnect board connected to the head unit;

FIG. 7 is a diagram showing a connection structure between an actuator and the flexible printed interconnect board;

FIG. 8 is a diagram showing the connection structure;

FIG. 9 is a partially enlarged view of the flexible printed interconnect board;

FIG. 10 is a plan view of the flexible printed interconnect board, a flexible printed circuit board, and a printed board connected to one another;

FIG. 11 is a drive circuit of the ink jet head;

FIG. 12 is a waveform diagram of a drive waveform generated by the drive circuit;

FIG. 13 is a diagram showing operations of the actuator to which the drive waveform is applied;

FIG. 14 is a partially enlarged view of a flexible printed interconnect board according to a comparative example; and

FIG. 15 is a partially enlarged view.

DETAILED DESCRIPTION

[0007] In general, according to one embodiment, a liquid ejection head capable of preventing an occurrence of disconnection in a film substrate formed with an interconnect for applying a drive waveform to a piezoelectric actuator is provided.

[0008] A liquid ejection head according to an embodiment includes a laminated piezoelectric body block and a film substrate. In the laminated piezoelectric body block, a plurality of piezoelectric actuators and pillars are alternately disposed. In the film substrate, a plurality of copper foil interconnects for applying drive waveforms to the respective piezoelectric actuators are formed, and the copper foil interconnects are soldered to terminals of the respective piezoelectric actuators to be electrically connected thereto. In the copper foil interconnects of the film substrate, an interconnect width changes to a tapered shape before and after a boundary portion of a solder resist region, the interconnect width on a solder resist region side is large, and the interconnect width on a solder connection region side is small.

[0009] According to the present invention, the width of the copper foil interconnects changes to be a tapered shape around the boundary portion between the solder resist region and the solder connection region. The tapered shape is formed so that the width of each copper foil interconnect becomes smaller toward the solder connection region. In this case, a taper ratio is preferably from 1:10 to 1:8.

[0010] Hereinafter, a liquid ejection head according to an embodiment will be described in detail with reference to the accompanying drawings. In the drawings, the

same components are denoted by the same reference numerals.

[0011] An ink jet printer 10 that prints an image on a recording medium will be described as an example of an image forming apparatus on which the liquid ejection head according to the embodiment is mounted. FIG. 1 shows a schematic configuration of the ink jet printer 10. In the ink jet printer 10, a cassette 12 which accommodates a sheet S which is an example of the recording medium, an upstream conveyance path 13 for the sheet S, a conveyance belt 14 which conveys the sheet S taken out of the cassette 12, a plurality of ink jet heads 100 to 103 which eject droplets of ink toward the sheet S on the conveyance belt 14, a downstream conveyance path 15 for the sheet S, a discharge tray 16, and a control board 17 are disposed inside a housing 11. An operation unit 18, which is a user interface, is disposed on an upper side of the housing 11.

[0012] Image data to be printed on the sheet S is generated by, for example, a computer 200 which is an externally connected device. The image data generated by the computer 200 is sent to the control board 17 of the ink jet printer 10 through a cable 201 and connectors 202 and 203.

[0013] A pickup roller 204 supplies the sheets S one by one from the cassette 12 to the upstream conveyance path 13. The upstream conveyance path 13 includes feed roller pairs 131 and 132 and sheet guide plates 133 and 134. The sheet S is fed to an upper surface of the conveyance belt 14 via the upstream conveyance path 13. An arrow 104 in the drawing indicates a conveyance path of the sheet S from the cassette 12 to the conveyance belt 14.

[0014] The conveyance belt 14 is a mesh-shaped endless belt having a large number of through holes formed in a surface thereof. Three rollers including a drive roller 141 and driven rollers 142 and 143 rotatably support the conveyance belt 14. A motor 205 rotates the conveyance belt 14 by rotating the drive roller 141. The motor 205 is an example of a drive device. Reference numeral 105 in the drawing denotes a rotation direction of the conveyance belt 14. A negative pressure container 206 is disposed on a back surface side of the conveyance belt 14. The negative pressure container 206 is connected to a decompression fan 207. The fan 207 creates a negative pressure inside the negative pressure container 206 by forming an airflow, and causes the sheet S to be adsorbed and held on the upper surface of the conveyance belt 14. Reference numeral 106 in the drawing denotes a flow of the airflow.

[0015] The ink jet heads 100 to 103 as an example of the liquid ejection head are disposed so as to face the sheet S adsorbed and held on the conveyance belt 14 with a slight gap of, for example, 1 mm therebetween. The ink jet heads 100 to 103 separately eject droplets of ink toward the sheet S. The ink jet heads 100 to 103 print an image when the sheet S passes below the ink jet heads 100 to 103. The ink jet heads 100 to 103 have the same

structure except for different colors of the ink to be ejected. The colors of the ink are, for example, cyan, magenta, yellow, and black.

[0016] The ink jet heads 100 to 103 are respectively connected to ink tanks 315 to 318 and ink supply pressure adjusting devices 321 to 324 via ink flow paths 311 to 314. The ink tanks 315 to 318 are disposed above the ink jet heads 100 to 103, respectively. At the time of standby, each of the ink supply pressure adjusting devices 321 to 324 adjusts a pressure inside of each of the ink jet heads 100 to 103 to a negative pressure with respect to an atmospheric pressure, for example, -1.2 kPa, such that the ink does not leak from nozzles 24 (see FIG. 2) of the ink jet heads 100 to 103. During the image formation, the ink in each of the ink tanks 315 to 318 is supplied to each of the ink jet heads 100 to 103 by the ink supply pressure adjusting devices 321 to 324.

[0017] After the image formation, the sheet S is fed from the conveyance belt 14 to the downstream conveyance path 15. The downstream conveyance path 15 includes feed roller pairs 151, 152, 153, and 154 and sheet guide plates 155 and 156 that define a conveyance path for the sheet S. The sheet S is fed from a discharge port 157 to the discharge tray 16 via the downstream conveyance path 15. An arrow 107 in the drawing indicates the conveyance path for the sheet S.

[0018] Next, a configuration of the ink jet heads 100 to 103 will be described. Hereinafter, the ink jet head 100 will be described with reference to FIGS. 2 to 5, and the ink jet heads 101 to 103 also have the same structure as the ink jet head 100.

[0019] As shown in FIG. 2, the ink jet head 100 includes a head unit 2 as an example of a liquid ejection unit. The head unit 2 includes a nozzle plate 23 which is an example of a nozzle portion. The nozzles 24 of respective ejection channels that eject ink are disposed side by side along a first direction of the nozzle plate 23, for example, an X direction. A nozzle density is set within a range of, for example, 150 dpi to 1200 dpi. The nozzles 24 are not limited to being disposed side by side in one row, but may be disposed side by side in a plurality of rows. The head unit 2 is connected to the ink supply pressure adjusting device 321 in FIG. 1 via the ink flow path 311. A detailed internal configuration of the head unit 2 will be described later.

[0020] The head unit 2 is connected to a flexible printed interconnect board 20. The flexible printed interconnect board 20 is a flexible printed interconnect board using, for example, a resin film. The flexible printed interconnect board 20 is, for example, a flexible printed circuit (FPC). The flexible printed interconnect board 20 is connected to a flexible printed circuit board 21. A drive integrated circuit (IC) 3 (hereinafter, referred to as a drive IC) which is a driver chip is mounted on the flexible printed circuit board 21. The flexible printed circuit board 21 is, for example, a chip on film (COF). The flexible printed circuit board 21 is connected to a printed board 22. The printed board 22 is a hard through-hole board in which an epoxy

resin layer containing glass fibers and a copper interconnect layer are laminated in multiple layers. The drive IC 3 serving as a control unit of the ink jet head 100 temporarily stores data sent from the control board 17 including a CPU serving as a control unit of the ink jet printer 10 via the printed board 22, and applies a drive signal to each ejection channel so as to eject ink at a predetermined timing.

[0021] The flexible printed interconnect board 20 such as an FPC is an example of a film substrate. In FIG. 2, the flexible printed interconnect board 20 and the flexible printed circuit board 21 on which the drive IC 3 is mounted are separate boards, and may be integrated with each other. A detailed configuration of the flexible printed interconnect board 20 will be described later.

[0022] FIGS. 3 to 5 are partial cross-sectional views of the head unit 2. FIG. 4 is a cross-sectional view taken along a line A-A in FIG. 3, and FIG. 5 is a cross-sectional view taken along a line B-B in FIG. 3. The nozzle plate 23 is bonded to one surface of a pressure chamber board 4. The nozzle plate 23 is a rectangular plate formed of a resin such as a polyimide or a metal such as stainless steel. A diaphragm 5 is bonded to one surface of the pressure chamber board 4 on an opposite side from the nozzle plate 23. The diaphragm 5 has flexibility to be deformed when an external force is applied. The diaphragm 5 is a thin plate made of a metal such as nickel or stainless steel. The material of the diaphragm 5 may be other than a metal, such as a polyimide film.

[0023] A pressure chamber 42 is formed in the pressure chamber board 4. The pressure chambers 42 of the respective ejection channels are disposed side by side at positions of the respective nozzles 24 and separately communicate with the nozzles 24. The pressure chamber board 4 is formed of a metal such as stainless steel. The pressure chamber 42 is formed by, for example, forming a rectangular opening penetrating a second direction, for example, a Z direction, in the pressure chamber board 4 and closing openings on both sides with the nozzle plate 23 and the diaphragm 5.

[0024] The pressure chamber 42 communicates with a guide flow path 43 having a narrowed portion, and further communicates with an ink supply manifold 45 via an ink supply port 44 which is an opening hole penetrating the diaphragm 5. The guide flow path 43 is formed in a groove shape in a third direction, for example, a Y direction on one surface of the pressure chamber board 4 on a diaphragm 5 side for each pressure chamber 42. The ink supply manifold 45 is formed in a frame 46 bonded to one surface of the diaphragm 5. The ink supply manifold 45 extends in the X direction and communicates with the pressure chamber 42 of each channel via the ink supply port 44 and the guide flow path 43 of each channel. The ink supply manifold 45 serving as a common ink chamber communicates with the ink flow path 311 (see FIGS. 1 and 2).

[0025] Actuators 6 of the respective ejection channels are disposed side by side at positions facing the pressure

chambers 42 of the respective ejection channels with the diaphragm 5 sandwiched between the actuator 6 and the pressure chamber 42. An end surface of the actuator 6 of each ejection channel in a -Z direction is bonded to the diaphragm 5 constituting a part of a partition wall of the pressure chamber 42 by, for example, an adhesive. The actuator 6, which is an example of a piezoelectric actuator, is a laminated piezoelectric actuator formed by alternately laminating a piezoelectric body 61 such as a piezoelectric element, a first internal electrode 62, and a second internal electrode 63 in a layered manner (particularly, see FIG. 3). The piezoelectric body 61 is disposed such that polarization directions are opposite to each other in, for example, the Z direction, and are deformed in a d33 mode. The piezoelectric body 61 is formed of a lead-containing piezoelectric material such as lead zirconate titanate (PZT) or a lead-free piezoelectric material such as potassium sodium niobate.

[0026] The first internal electrode 62 and the second internal electrode 63 are conductive films formed on main surfaces of the piezoelectric body 61. The first internal electrode 62 and the second internal electrode 63 are formed of a conductive material that can be fired, such as silver palladium. The first internal electrodes 62 of the actuator 6 are formed up to one side surface of the actuator 6 in the Y direction, and are connected to an individual electrode 64 which is an external electrode formed on the corresponding side surface. The second internal electrodes 63 are formed up to the other side surface of the actuator 6 in a -Y direction, and are connected to a common electrode 65 which is an external electrode formed on the corresponding side surface. A dummy layer 68 is made of the same material as the piezoelectric body 61. However, the dummy layer 68 is not provided with an internal electrode and is not deformed since an electric field is not applied thereto. The individual electrode 64 and the common electrode 65 are formed of, for example, Ni, Cr, or Au.

[0027] In particular, as shown in FIG. 4, pillars 60 are disposed between the actuators 6 of the respective ejection channels via grooves 69. The pillar 60 is disposed at a position corresponding to a partition wall 40 between the adjacent pressure chambers 42. The drive actuators 6 and dummy actuators serving as the pillars 60 are collectively formed using the common piezoelectric body 61, the first internal electrodes 62, the second internal electrodes 63, the individual electrode 64, and the common electrode 65, and the grooves 69 are formed, thereby forming a laminated piezoelectric body block 600 having a comb tooth shape. The dummy layer 68 positioned on a base end side of the actuator 6 serves as a base that connects the actuators 6 and the pillars 60 that are alternately adjacent to each other. The laminated piezoelectric body block 600 is fixed by bonding end surfaces in the Z direction to a surface of a board 47.

[0028] The individual electrode 64 of the actuators 6 of the laminated piezoelectric body block 600 is separated for each channel in the X direction which is a depth

direction in FIG. 3, and is connected to an individual interconnect 66 of the flexible printed interconnect board 20 (see FIG. 5). The flexible printed interconnect board 20 includes a resin film 26 as a base material, the individual interconnects 66, and a solder resist layer 27. The individual interconnect 66 will be described in detail later. Although not shown, the common electrode 65 of the actuators 6 connected to each other by using, for example, a portion of the dummy layer 68 is led out to an individual electrode 64 side by using, for example, side surfaces of the pillars 60 positioned at both ends of the laminated piezoelectric body block 600, or by extending the piezoelectric bodies 61 of the pillars 60 positioned at both ends of the laminated piezoelectric body block 600, and is connected to a common interconnect formed on the flexible printed interconnect board 21.

[0029] Next, a connection structure between the actuator 6 and the flexible printed interconnect board 20 will be described in detail with reference to FIGS. 6 to 10. FIG. 6 is a plan view of the flexible printed interconnect board 20. FIG. 7 is a diagram in which the actuator 6 and the flexible printed interconnect board 20 are extracted from FIG. 3. FIG. 8 is a diagram in which the actuator 6 and the flexible printed interconnect board 20 are extracted from FIG. 5. FIG. 9 is a partially enlarged view of the flexible printed interconnect board 20. FIG. 10 is a plan view of the flexible printed interconnect board 20, the flexible printed circuit board 21, and the printed board 22 connected to one another.

[0030] As shown in FIG. 6, the individual interconnect 66 of the flexible printed interconnect board 20 is formed for each ejection channel from a solder connection region 7, which is a terminal portion on a side connected to the actuator 6, to a terminal portion 70 on a side connected to the flexible printed circuit board 21. In FIG. 6, for convenience of drawing, the number of the individual interconnects 66 is illustrated to be small, but the number of the individual interconnects 66 is the same as the number of the actuators 6 to be driven. Each individual interconnect 66 is formed of a copper foil on a surface of the resin film 26 as the base material. A solder resist region 71 (see FIG. 6) of each individual interconnect 66 is covered with the solder resist layer 27 (see FIG. 7) formed by applying a solder resist resin such as epoxy. Instead of applying the solder resist resin, a cover layer made of a resin film may be attached to a copper foil surface of the flexible printed interconnect board 20, and the attached region may be used as the solder resist region. When a tip end of the flexible printed interconnect board 20 on which the solder resist layer 27 is formed is subjected to electrolytic plating with solder, a surface of each individual interconnect 66 in the solder connection region 7 is plated with solder 72 (solder plating) (see FIG. 8). Instead of the electrolytic plating, cream solder may be attached to the solder connection region 7, and the surface of the individual interconnect 66 in the solder connection region 7 may be covered with the solder by heating. The solder is used for soldering described later. Similarly, a common

interconnect 67 is formed from the solder connection region 7 to the terminal portion 70 on the surface of the resin film 26, and the solder connection region 7 is covered with solder by solder plating or the like. In order to reduce current concentration when the plurality of actuators 6 are simultaneously charged and discharged, the common interconnect 67 has an interconnect width larger than that of the individual interconnect 66 and is formed in a pair on both sides of the flexible printed interconnect board 20 in the X direction. The pair of common interconnects 67 are connected to both sides of the laminated piezoelectric body block 600, and are commonly connected to the common electrodes 65 of the actuators 6 connected to one another by using, for example, a portion of the dummy layer 68. The interconnect width of the individual interconnect 66 varies depending on a location as described later, and is formed within a range of 22 μm to 84 μm , for example. The interconnect width of the common interconnect 67 is, for example, 0.8 mm. A thickness of the individual interconnect 66 and the common interconnect 67 is, for example, 8 μm .

[0031] A lead portion 73 (see FIG. 9) of the individual interconnect 66 to overlap a surface of the individual electrode 64 of the actuator 6 has an interconnect width L1 smaller than a pillar width L2 of the actuator 6 in the X direction (see FIG. 8). Further, in the X direction, a width L3 after the solder plating is also preferably smaller than the pillar width L2 of the actuator 6. The individual interconnects 66 are disposed in parallel at equal intervals such as at a pitch P2 such that a center line of the lead portion 73 overlaps a center line of a pillar surface of the facing actuator 6.

[0032] The individual interconnect 66 has the interconnect width changed in a tapered shape before and after a boundary portion 74 of the solder resist region 71. The interconnect width is larger on a solder resist region 71 side and smaller on a solder connection region 7 side in the X direction. That is, the individual interconnect 66 has a tapered portion 75 in which the interconnect width increases from the lead portion 73 toward the solder resist region 71. As described above, in the laminated piezoelectric body block 600, the actuator 6 and the pillar 60 are alternately disposed, and the individual interconnect 66 is not connected to the pillar 60, and thus, the interconnect width can be increased using an empty space. As in an example of a size to be described later, the interconnect width in the X direction can be three times or more as compared with that of the lead portion 73. The boundary portion 74 of the solder resist region 71 passes through the tapered portion 75. The boundary portion 74 of the solder resist region 71 is preferably positioned so as to straddle a center portion of the tapered portion 75 in the Z direction. More preferably, the boundary portion 74 is positioned at a half length of the tapered portion 75 in the Z direction. A portion of the lead portion 73 of the individual interconnect 66 closer to the -Z direction is connected to the individual electrode 64 of the actuator 6 (see FIG. 7). Accordingly, in the portion 75 in

which the interconnect width of the individual interconnect 66 changes in the tapered shape, the change in the tapered shape is ended on the solder resist region 71 side with respect to the lead portion 73 soldered to the individual electrode 64 of the actuator 6.

[0033] As an example of the size of each configuration, when the pillar width L2 of the actuator 6 and a pillar width L4 of the pillar 60 are both 52.5 μm and a pitch P1 between the alternately disposed actuator 6 and pillar 60 is 84.5 μm in the X direction, the interconnect width L1 of the lead portion 73 of the individual interconnect 66 is 22 μm and the pitch P2 is 169 μm which is the same as a pitch between the actuators 6. A width L5 of the solder connection region 7 in the Z direction is 1350 μm from an edge of the flexible printed interconnect board 20, and a length L6 of the lead portion 73 of the individual interconnect 66 in the Z direction is 1075 μm . The lead portion 73 is formed to have the same interconnect width without changing the interconnect width in the X direction.

[0034] In the tapered portion 75 following the lead portion 73 in the Z direction, an interconnect width L7 in the X direction after changing to the tapered shape is 84 μm . An interconnect interval L8 in the X direction between the adjacent individual interconnects 66 is 85 μm . A length L9 of the tapered portion 75 in the Z direction is 550 μm . A taper ratio in this case is about 1:9. The boundary portion 74 of the solder resist region 71 passes through the half length (= 275 μm) of the tapered portion 75 in the Z direction. The individual interconnect 66 in the solder connection region 7 is subjected to the solder plating to have a thickness of 10 μm .

[0035] The flexible printed interconnect board 20 is positioned such that the center line of the lead portion 73 of the individual interconnect 66 overlaps the center line of the pillar surface of the facing actuator 6, the solder 72 is melted by heating, and the lead portions 73 of the individual interconnects 66 and the individual electrodes 64 of the actuators 6 are collectively solder-connected. For example, as shown in FIG. 7, the actuator 6 having a length L10 of 1700 μm in the Y direction is solder-connected to overlap the pillar surface in the Z direction in a range where a length L11 of the lead portion 73 of the individual interconnect 66 is 660 μm . The flexible printed interconnect board 20 generally has a thermal expansion coefficient different from that of the actuator 6. Since the flexible printed interconnect board 20 normally has a thermal expansion coefficient larger than that of the actuator 6, the flexible printed interconnect board 20 may be made smaller in size in advance in consideration of deformation due to heat during the solder connection, and the center line of the lead portion 73 of the individual interconnect 66 may be intended to exactly overlap and be bonded to the center line of the pillar surface of the facing actuator 6 by thermal expansion during the soldering.

[0036] The interconnect width L1 (for example, 22 μm) of the lead portion 73 of the individual interconnect 66 in the X direction is smaller than the pillar width L2 (for

example, 52.5 μm) of the actuator 6 in the X direction, and the width after the solder plating with a thickness of 10 μm is also smaller than the pillar width of the actuator 6. Therefore, the excess solder 72 is prevented from wrapping around the side surface of the actuator 6 when being heated, and for example, the first internal electrode 62 and the second internal electrode 63 are prevented from being electrically connected. Further, the flowing solder 72 is prevented from attaching to the adjacent pillar 60. As described above, in a case where the pillar 60 is formed by the dummy actuator, when the solder 72 flows to the pillar 60 and is electrically connected to the individual interconnect 66, conduction may occur, which is however can be prevented.

[0037] In the present embodiment, the solder used for soldering is supplied by plating or the like in advance the individual interconnect 66 of the solder connection region 7 which is an electrode at the tip end of the flexible printed interconnect board 20, but the solder may be supplied from the actuator 6 side by attaching the solder to the electrode 64 of the actuator 6. Both the electrode at the tip end of the flexible printed interconnect board 20 and the electrode 64 of the actuator 6 may be covered with the solder, so that the solder may be supplied from both the electrode at the tip end of the flexible printed interconnect board 20 and the electrode 64 of the actuator 6.

[0038] As shown in FIG. 10, the individual interconnects 66 and the common interconnects 67 led out to the terminal portions 70 overlap a terminal portion 8 of the flexible printed circuit board 21 and are connected to individual interconnects 81 and common interconnects 82 of the flexible printed circuit board 21, respectively. Since the pitch of the individual interconnects 66 on a terminal portion 70 side is smaller than that on the solder connection region 7 side in the X direction, the individual interconnects 66 are fixed by an anisotropic conductive film (ACF), an anisotropic conductive paste (ACP), a non-conductive film (NCF), a non-conductive paste (NCP), or the like instead of the solder connection, and are anisotropically connected in a thickness direction.

[0039] The flexible printed circuit board 21 is a flexible film substrate formed using a synthetic resin film such as a polyimide. The drive IC 3 is, for example, a driver chip formed on a silicon semiconductor substrate. On the flexible printed circuit board 21, the individual interconnects 81, the common interconnects 82, input interconnects 83, a power supply interconnect 84 with a voltage V1, a power supply interconnect 85 with a voltage V2, and a ground interconnect 86 are formed. The individual interconnects 81 led out from the drive IC 3 are output interconnects of the drive waveform generated by the drive IC 3. On the other hand, the input interconnects 83 led out of the drive IC 3 are formed up to a terminal portion 87 on the side connected to the printed board 22. Since the drive IC 3 can be controlled by serial communication, the number of the input interconnects 83 can be smaller than the number of the individual interconnects 81 as the output interconnects.

[0040] The power supply interconnect 84 with the voltage V1, the power supply interconnect 85 with the voltage V2, and the ground interconnect 86 are separately connected to the drive IC 3. The power supply interconnect 84 with the voltage V1, the power supply interconnect 85 with the voltage V2, and the ground interconnect 86 are separately formed up to the terminal portion 87 on the side connected to the printed board 22. The individual interconnects 81, the common interconnects 82, the input interconnects 83, the power supply interconnect 84 with the voltage V1, the power supply interconnect 85 with the voltage V2, and the ground interconnect 86 are formed of, for example, a copper foil. Although not shown, each interconnect of the flexible printed circuit board 21 is covered with a solder resist layer except for a mounting region of the drive IC 3 and the like, the terminal portions 8 and 87, and the like.

[0041] Control lines 91, a power supply interconnect 92 with the voltage V1, a power supply interconnect 93 with the voltage V2, and a ground interconnect 94 are separately formed in a terminal portion 9 of the printed board 22. The control line 91 is connected to the input interconnects 83 of the flexible printed circuit board 21. The power supply interconnect 92 with the voltage V1 is connected to the power supply interconnect 84 of the flexible printed circuit board 21. The power supply interconnect 93 with the voltage V2 is connected to the power supply interconnect 85 of the flexible printed circuit board 21. The ground interconnect 94 is connected to the ground interconnect 86 and the common interconnects 82 of the flexible printed circuit board 21. To the control line 91, a signal such as print data, for selectively driving each actuator 6 sent from the control board 17 including the CPU which is the control unit of the ink jet printer 10 is given. The drive voltage V1 is applied to the power supply interconnect 92 by a power supply 95. The drive voltage V2 is applied to the power supply interconnect 93 by a power supply 96. The ground interconnect 94 is connected to a ground (GND) on the control board 17 of the ink jet printer 10, for example.

[0042] Next, a control system of the ink jet head 100 will be described. FIG. 11 is a circuit diagram of the control system of the ink jet head 100. As shown in FIG. 11, the actuators 6 (#1 ch, #2 ch, ... #n ch) of the respective ejection channels connect the individual electrodes 64 to output terminals of drive drivers D (that is, drive circuits) of the drive IC 3 via the individual interconnects 66 and 81. Further, the actuators 6 connect the common electrodes 65 to a common potential via the common interconnects 67 and 82. The common potential is, for example, a ground (GND). The power supply 95 with the drive voltage V1 and the power supply 96 with the drive voltage V2 applied to the actuators 6 are connected to the drive IC 3.

[0043] Next, an ink ejection operation will be described with reference to FIGS. 12 and 13. Each drive driver D of the drive IC 3 applies a drive waveform to the individual electrode 64 of each actuator 6 using the drive voltages

V1 and V2 and the ground (GND). The voltage V1 is, for example, 20 V. The voltage V2 is, for example, 10 V. The ground (GND) is, for example, 0 V. The actuator 6 to be driven is based on, for example, print data.

[0044] FIG. 12 is an example of the drive waveform applied to the actuator 6. As shown in FIG. 12, when the actuator 6 in which a ground potential is applied to the common electrode 65 is driven, the voltage V2 is applied to the individual electrode 64 to be in a standby state. When the voltage V2 is applied, an electric field is applied in a direction of a polarization axis of the piezoelectric body 61, and as shown in (a) in FIG. 13, the actuator 6 extends in a lamination direction (Z direction) and a volume of the pressure chamber 42 is reduced. The above is performed prior to an ink ejection timing. Thereafter, a potential of the individual electrode 64 is first lowered to the ground (GND) at the ink ejection timing (time t1 in FIG. 12), whereby the extended actuator 6 returns to an original state, that is, relatively contracts, and the volume of the pressure chamber 42 relatively expands, as shown in (b) in FIG. 13. As the volume of the pressure chamber 42 expands, the ink flows into the pressure chamber 42 via the guide flow path 43.

[0045] Then, for example, when the voltage V2 is applied to the individual electrode 64 at a time t2 in FIG. 12 after 1/2 of a pressure vibration cycle of the head unit 2 elapses, as shown in (c) in FIG. 13, the actuator 6 extends in the lamination direction (Z direction) and the volume of the pressure chamber 42 is relatively reduced, whereby droplets R of ink are ejected from the nozzle 24. Then, for example, after 1/2 of the pressure vibration cycle of the head unit 2 elapses, the voltage V1 is applied to the individual electrode 64 at a time t3 in FIG. 12, and is returned to the voltage V2 at a time t4 after a predetermined time elapses. The volume of the pressure chamber 42 is reduced and restored by the expansion ((d) in FIG. 13) and restoration ((a) in FIG. 13) of the actuator 6 at this time, and a residual vibration due to this operation is attenuated. Thus, the volume of the pressure chamber 42 changes in accordance with a longitudinal vibration of the actuator 6 in the lamination direction, and the ink can be ejected.

[0046] As described above, in the flexible printed interconnect board 20, the interconnect width of the individual interconnect 66 changes in the tapered shape before and after the boundary portion 74 of the solder resist region 71, and the interconnect width on the solder resist region 71 side larger. Accordingly, even if the interconnect width of the lead portion 73 connected to the individual electrode 64 of the actuator 6 is reduced, the interconnect width is increased so as to straddle the boundary portion 74 of the solder resist region 71, thereby preventing disconnection. Even if the interconnect width changes before and after the boundary portion 74 of the solder resist region 71, the disconnection is likely to occur when the interconnect width does not change in tapered shapes as in FIGS. 14 and 15. For example, as shown in FIG. 14, when a non-tapered interconnect width con-

version unit is located at a boundary between the solder resist region 71 and the solder connection region 7 or in the solder resist region 71, the thinner interconnect is likely to be disconnected when the flexible printed interconnect board 20 is curved. In addition, as shown in FIG. 15, when a non-tapered interconnect width conversion unit is located on a side of a region where the solder plating is performed, the solder which is plated on a thicker interconnect is likely to cause a short circuit.

[0047] As described above, according to the above-described embodiment, it is possible to prevent an occurrence of the disconnection in the flexible printed interconnect board 20 in which the individual interconnects 66 for applying the drive waveform to the actuator 6 are formed of the copper foil.

[0048] The actuator 6 is not limited to a laminated type in which a plurality of piezoelectric bodies 61 are laminated. The actuator 6 may be formed of a single layer of the piezoelectric body 61. The operation of the actuator when the drive voltage is applied is not limited to the longitudinal vibration. Further, the embodiment is not limited to a drop-on-demand piezoelectric method, and may be applied to a continuous method.

[0049] In the above-described embodiment, the ink jet head 100 of the ink jet printer 10 is described as an example of the liquid ejection head, but the liquid ejection head may be a shaping material ejection head of a 3D printer or a sample ejection head of a dispensing device.

[0050] That is, the liquid ejection head of the above-described embodiment can be expressed as follows.

(1) A liquid ejection head including:

a laminated piezoelectric body block in which a plurality of piezoelectric actuators and pillars are alternately disposed; and

a film substrate in which a plurality of copper foil interconnects for applying drive waveforms to the respective piezoelectric actuators are formed, and the copper foil interconnects are soldered to terminals of the respective piezoelectric actuators to be electrically connected thereto, in which

in the copper foil interconnects of the film substrate, an interconnect width changes to a tapered shape before and after a boundary portion of a solder resist region, the interconnect width on a solder resist region side is large, and the interconnect width on a solder connection region side is small.

(2) In the copper foil interconnects, an interconnect width of a lead portion soldered to the terminal of the piezoelectric actuator is smaller than a pillar width of the piezoelectric actuator and changes to the tapered shape to be equal to or larger than the pillar width of the piezoelectric actuator, and the boundary portion of the solder resist region

straddles a center portion of a portion where the interconnect width changes to the tapered shape.

(3) The solder resist region is formed by covering a surface of a copper foil of the film substrate with a resin film.

(4) The solder resist region is formed of a resin applied to a surface of a copper foil of the film substrate.

(5) The soldered portion of the copper foil interconnect is outside the solder resist region and is subjected to solder plating.

(6) In a portion in which the interconnect width changes to the tapered shape, the interconnect width is increased by utilizing a fact that the pillar is provided between the adjacent piezoelectric actuators.

(7) In the portion in which the interconnect width changes to the tapered shape, the change is ended on the solder resist region side with respect to the lead portion soldered to the terminal of the piezoelectric actuator.

[0051] The embodiments have been presented by way of example 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 gist of the disclosure. The embodiments and the modifications thereof are included in the scope and the gist of the disclosure, and are included in a scope of the disclosure disclosed in the claims and equivalents thereof.

Claims

1. A liquid ejection head (100-103) comprising:

a laminated piezoelectric body block (600) in which a plurality of piezoelectric actuators (6) and pillars (60) are alternately disposed; and a film substrate in which a plurality of copper foil interconnects for applying drive waveforms to the respective piezoelectric actuators are formed, and the copper foil interconnects are soldered to terminals of the respective piezoelectric actuators to be electrically connected thereto, wherein

in the copper foil interconnects of the film substrate, an interconnect width changes to a tapered shape before and after a boundary portion (74) of a solder resist region (71), the interconnect width on a solder resist region side is large, and the interconnect width on a solder connection (7) region side is small.

2. The head according to claim 1, wherein

- in the copper foil interconnects, an interconnect width of a lead portion soldered to the terminal of the piezoelectric actuator is smaller than a pillar width of the piezoelectric actuator and changes to the tapered shape to be equal to or larger than the pillar width of the piezoelectric actuator, and the boundary portion of the solder resist region straddles a center portion of a portion where the interconnect width changes to the tapered shape. 5 10
3. The head according to claim 1 or 2, wherein the solder resist region is formed by covering a surface of a copper foil of the film substrate with a resin film. 15
4. The head according to claim 1 or 2, wherein the solder resist region is formed of a resin applied to a surface of a copper foil of the film substrate. 20
5. The head according to any one of claims 1 to 4, wherein the soldered portion of the copper foil interconnect is outside the solder resist region and is subjected to solder plating. 25
6. The head according to any one of claims 1 to 5, wherein a taper ratio of the interconnect width having a tapered shape before and after the boundary portion (74) of a solder resist region (71) is from 1:10 to 1:8. 30
7. The head according to any one of claims 1 to 6, wherein the actuator (6) is formed by alternatively laminating a piezoelectric body (61) a first internal electrode (62) and a second internal electrode (63) in a layered manner. 35
8. The head according to any one of claims 1 to 7, wherein the liquid ejection head includes a plurality of channels, each channel including a nozzle that ejects liquid, a pressure chamber that communicates with the nozzle, and the piezoelectric actuator that changes a volume of the pressure chamber. 40 45
9. The head according to claim 8, wherein the liquid ejection head is configured to select a channel for ejecting the liquid from the plurality of channels, and applies a drive waveform to the piezoelectric actuator of the selected channel. 50
10. The head according to any one of claims 8 or 9, wherein the copper foil interconnects are individual interconnects for each ejection channel. 55
11. An ink jet printer comprising a head according to any one of claims 1 to 10.
12. A 3D printer comprising a head according to any one of claims 1 to 10.

FIG. 1

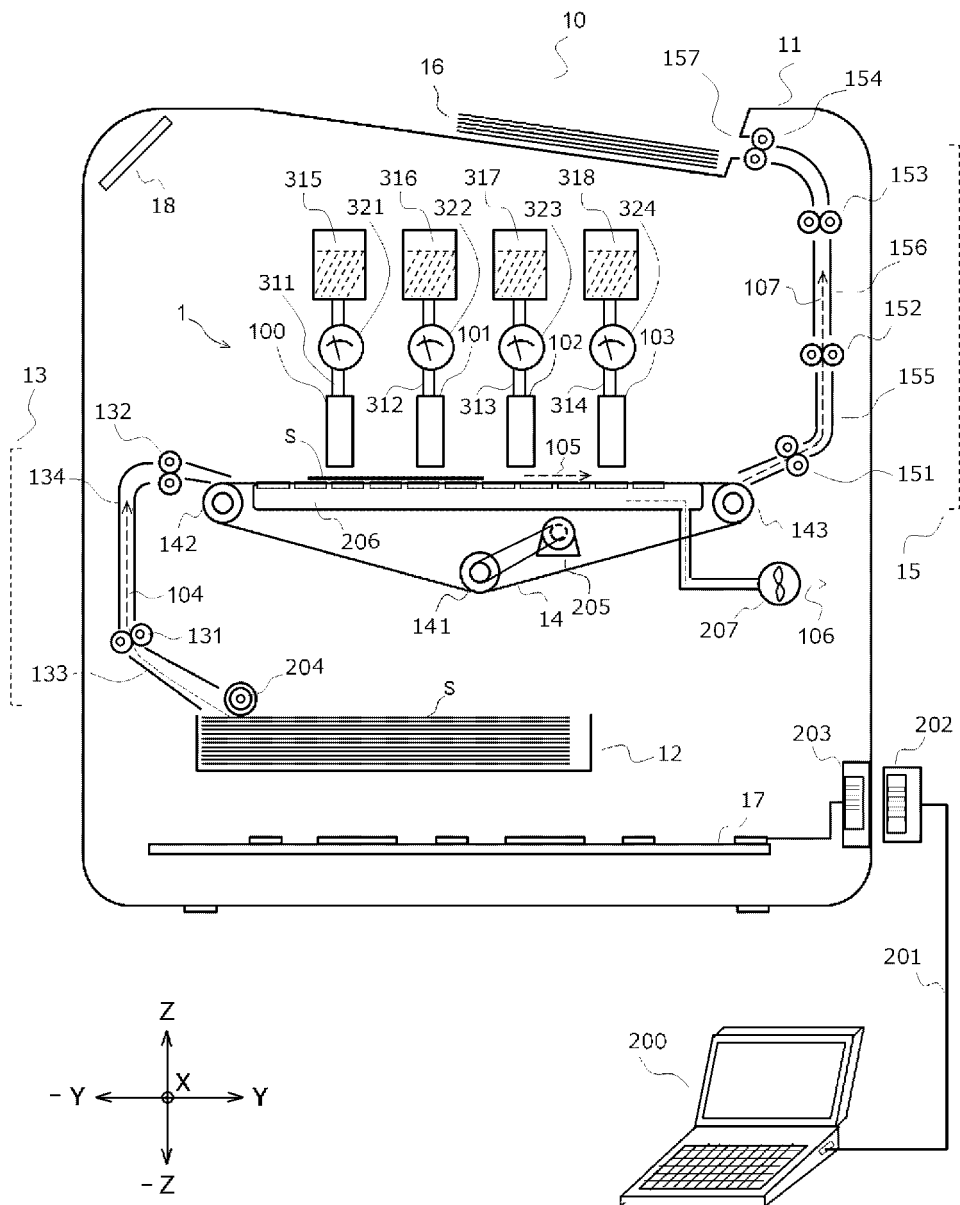


FIG. 2

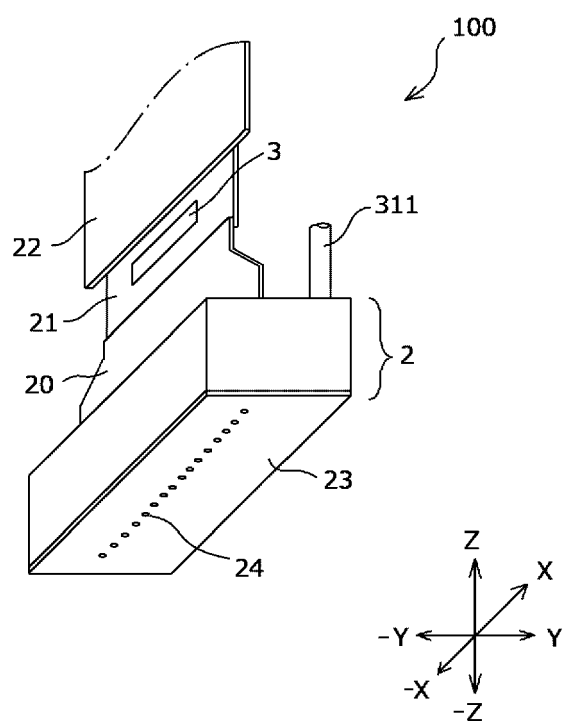


FIG. 3

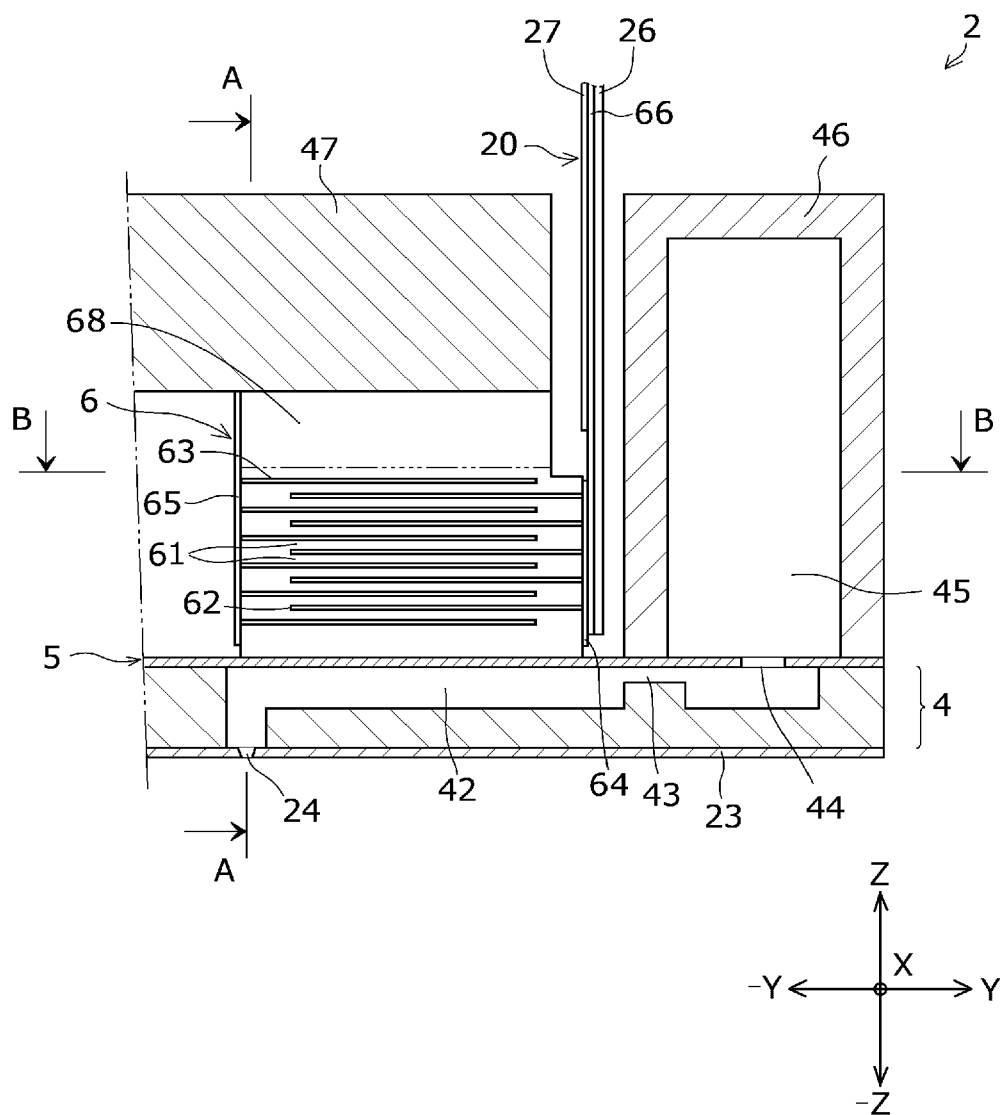


FIG. 4

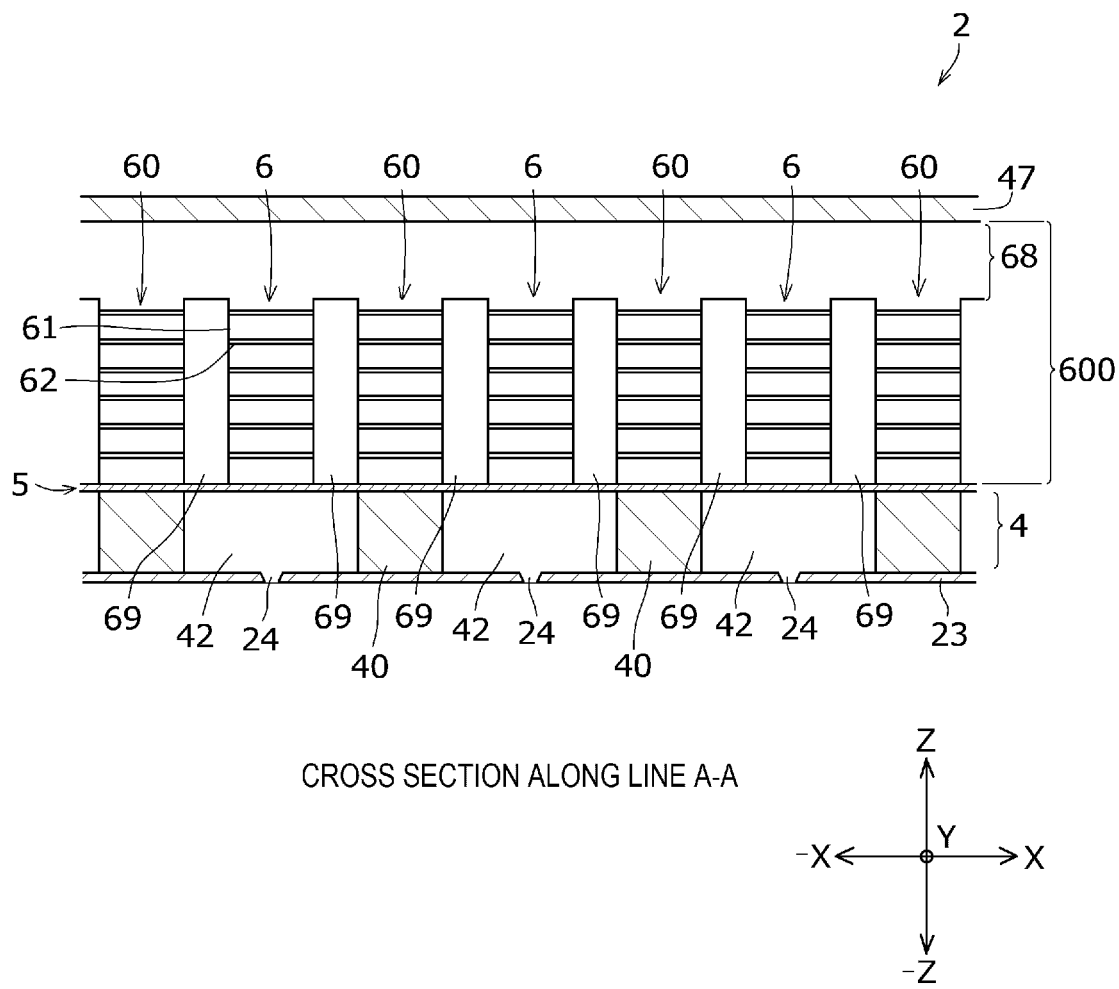
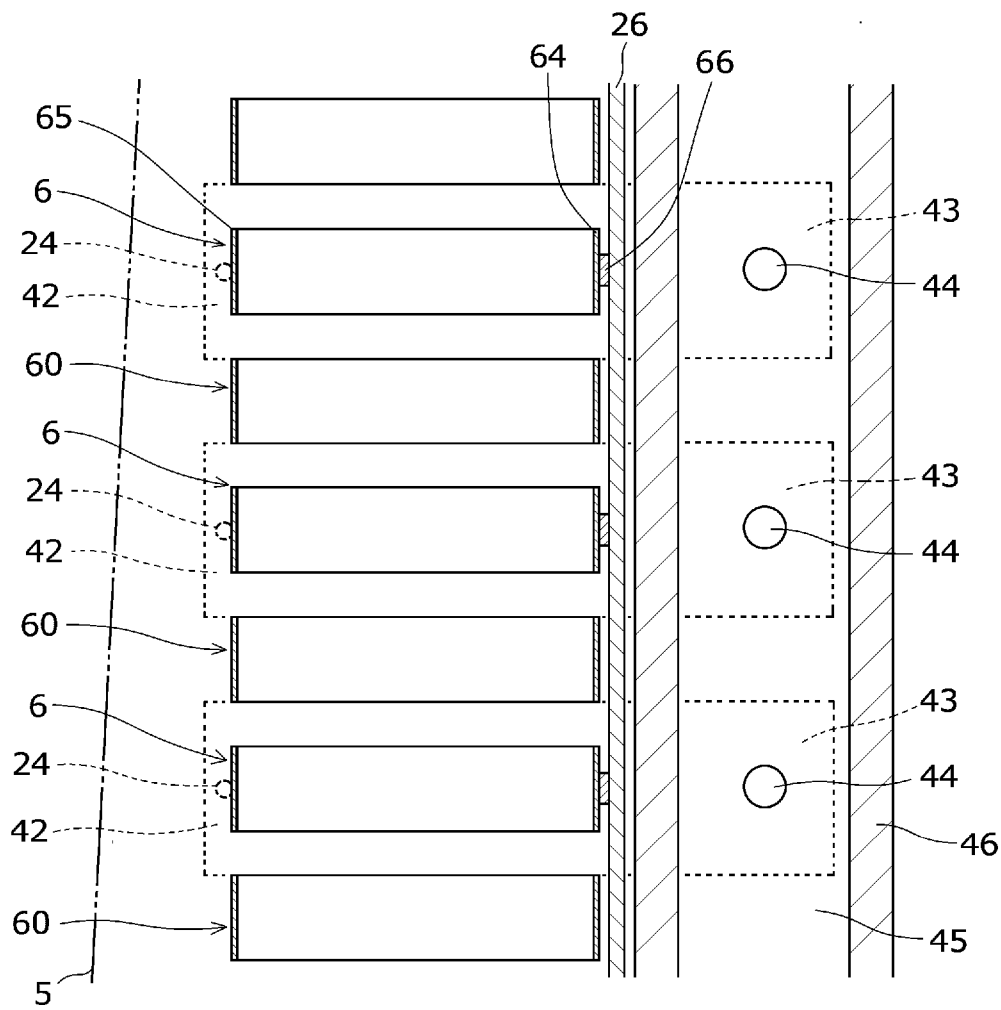


FIG. 5



CROSS SECTION ALONG LINE B-B

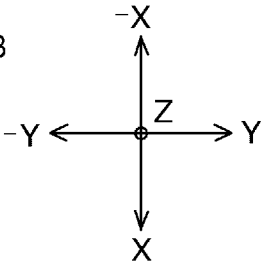


FIG. 6

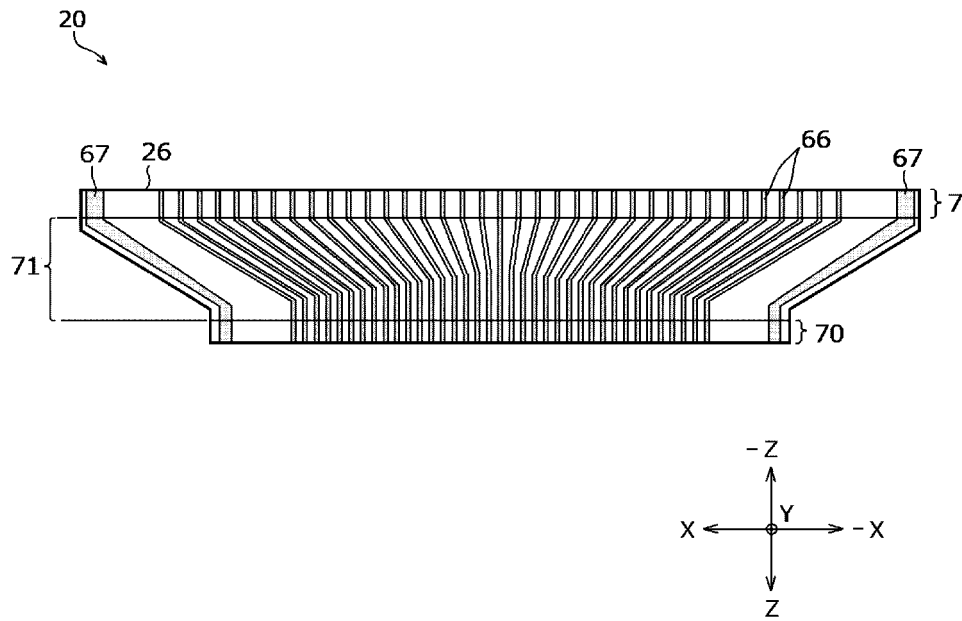


FIG. 7

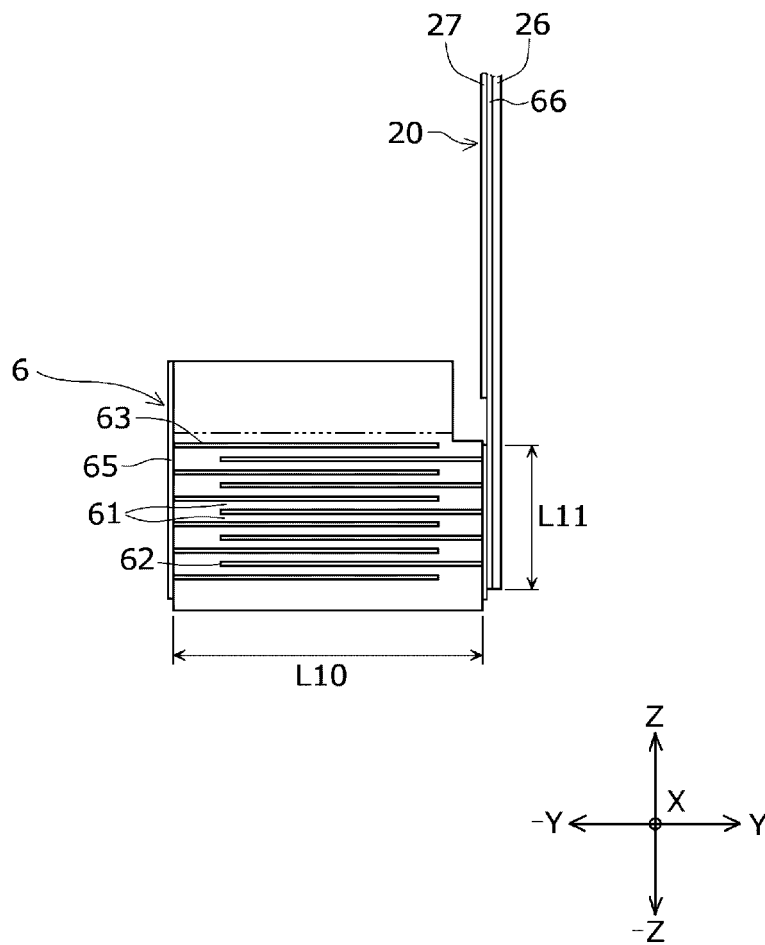


FIG. 8

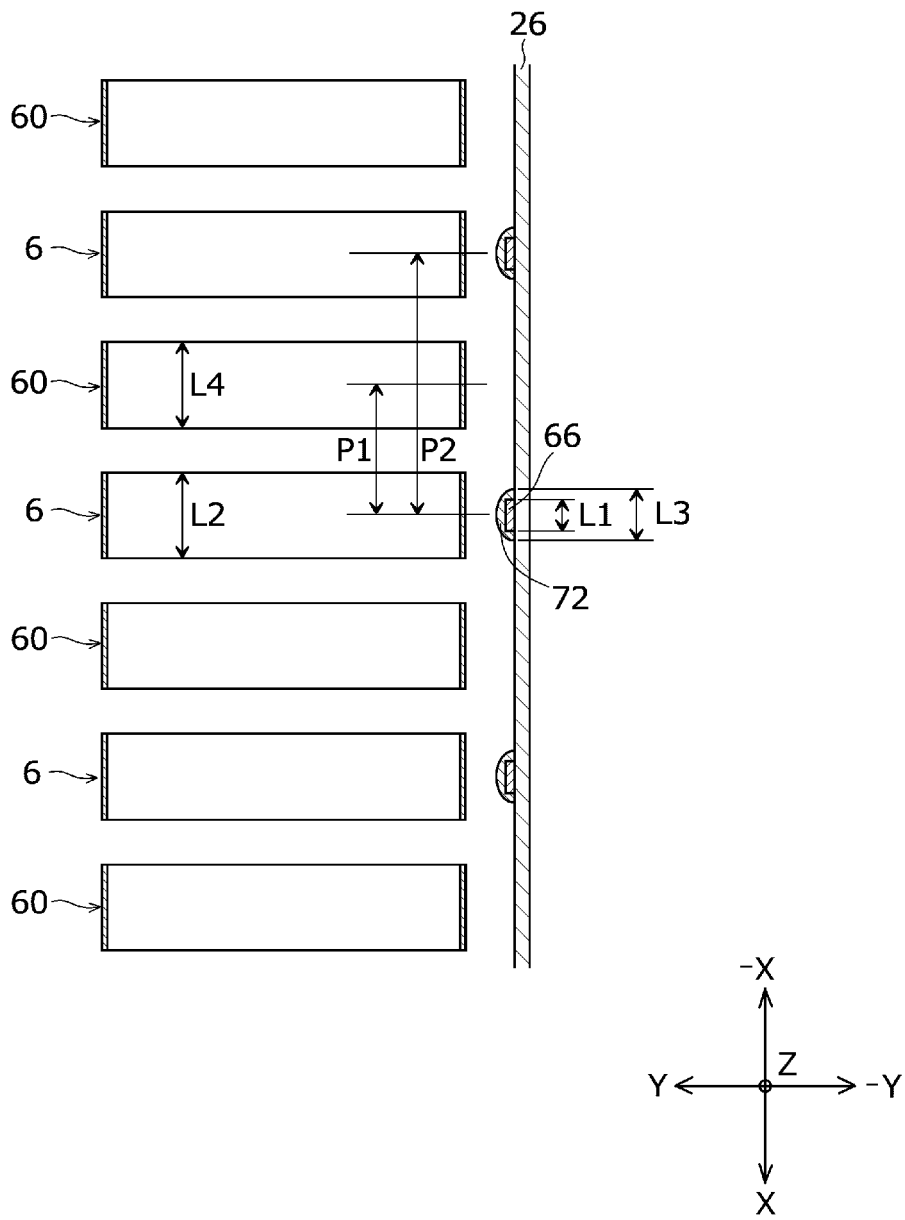


FIG. 9

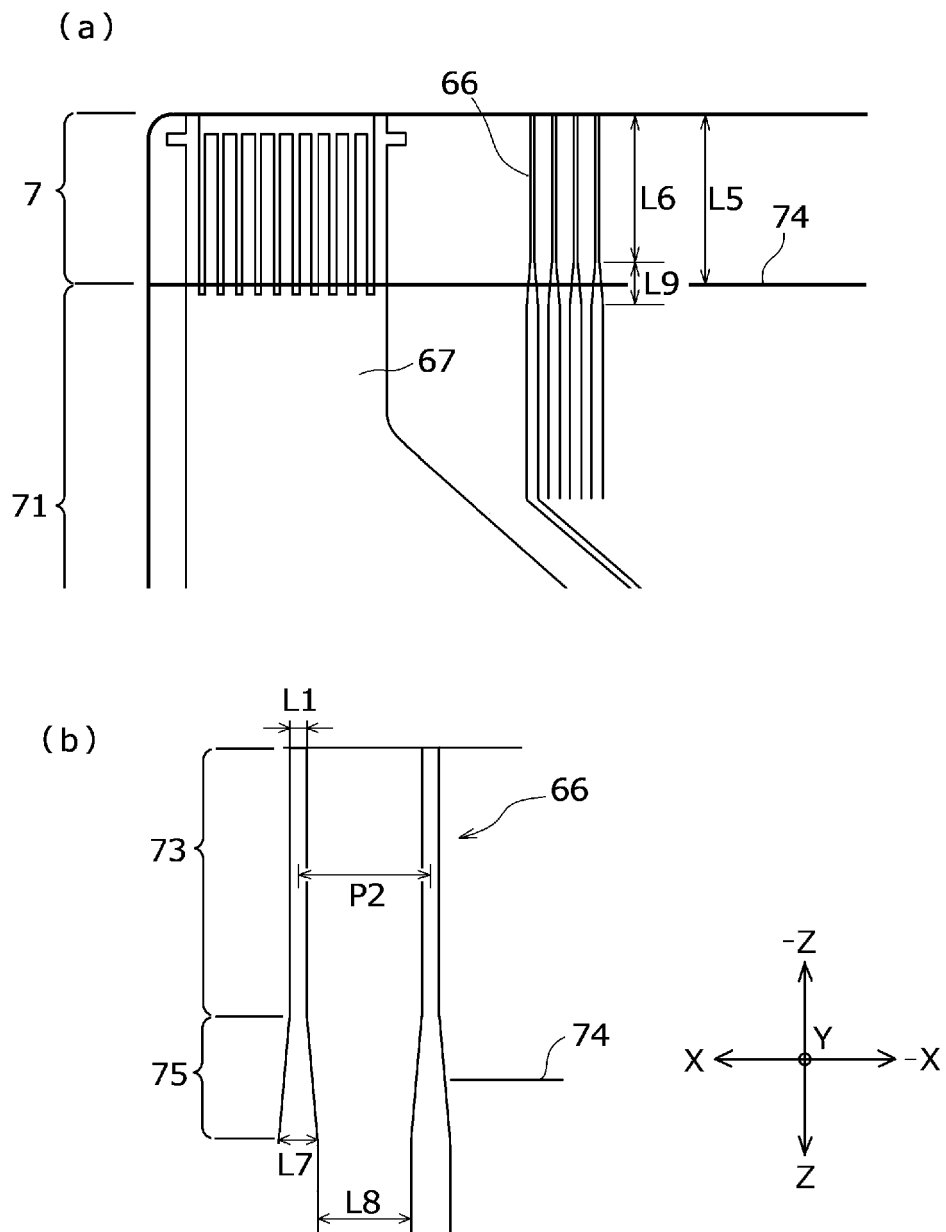


FIG. 10

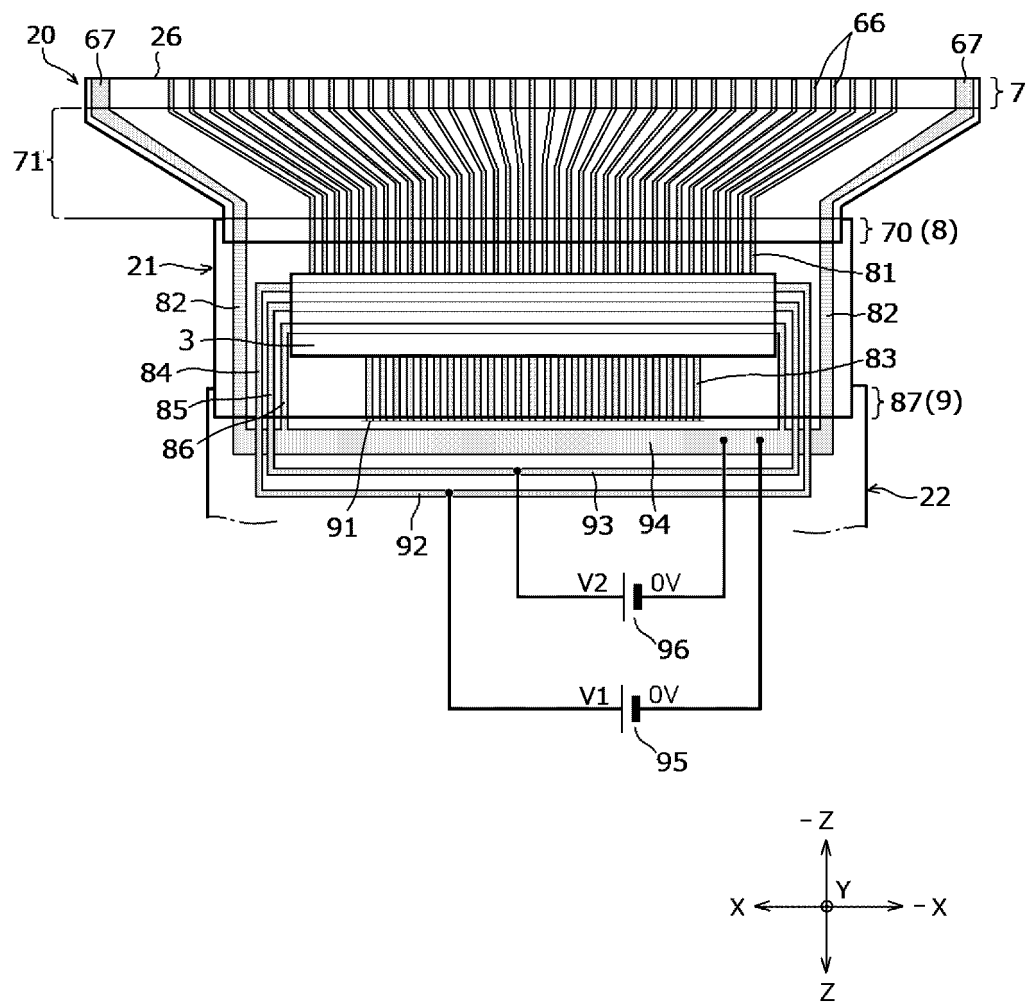


FIG. 11

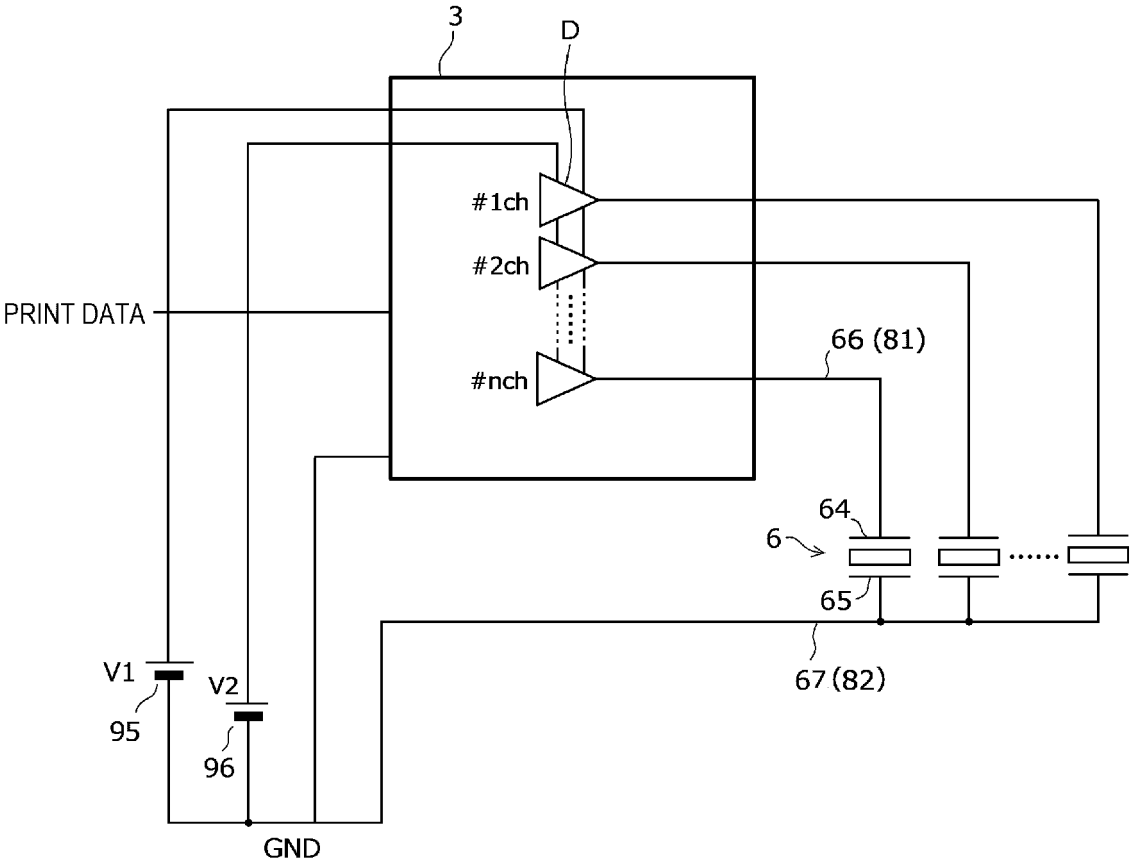


FIG. 12

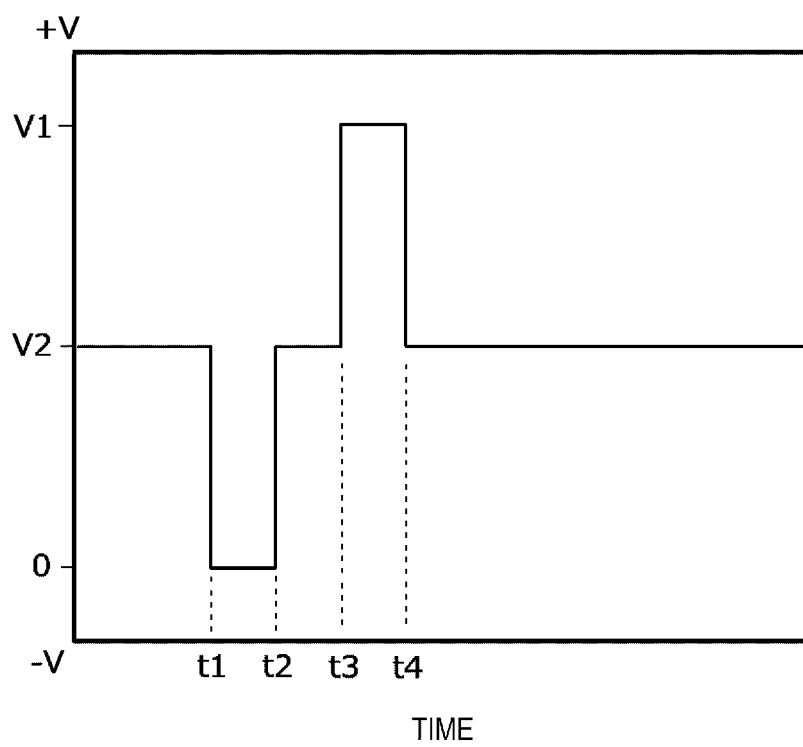


FIG. 13

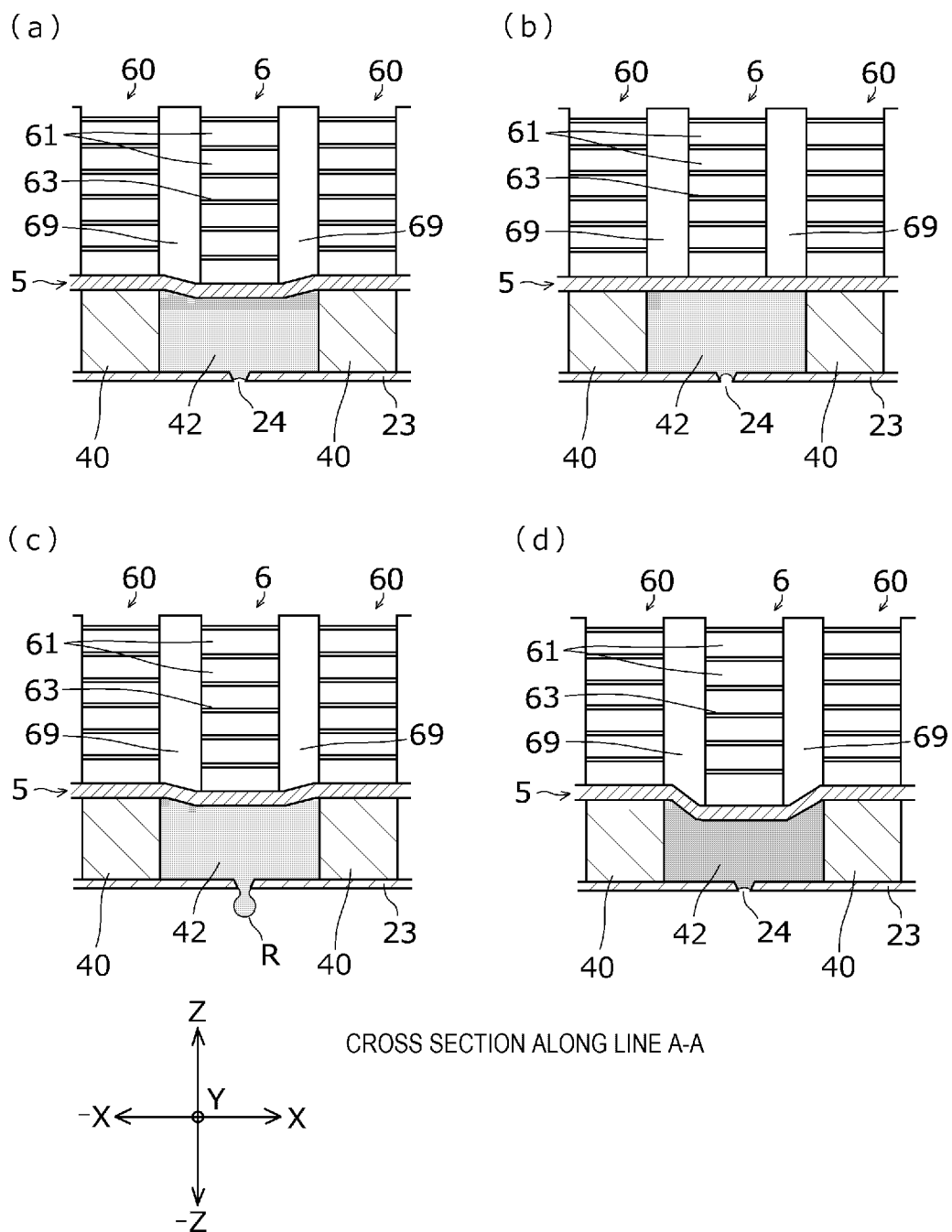


FIG. 14

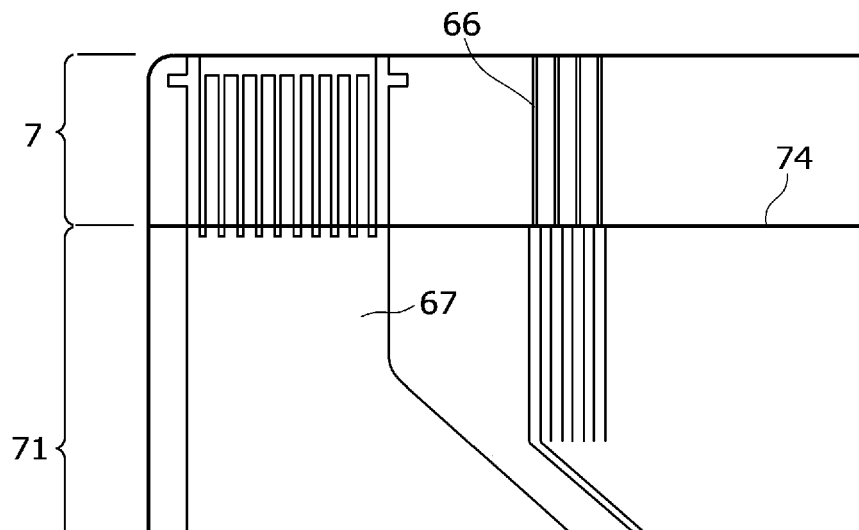
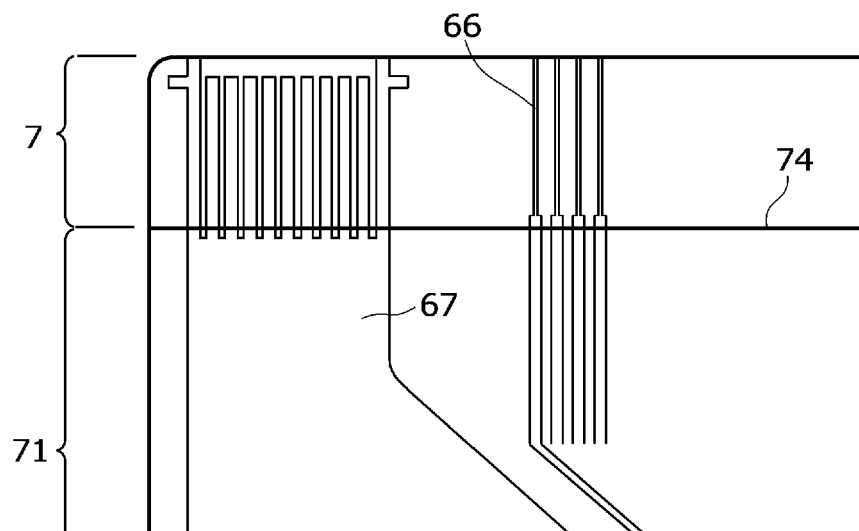


FIG. 15





EUROPEAN SEARCH REPORT

Application Number

EP 24 20 1170

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			B41J
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		10 February 2025	Öztürk, Serkan
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10-02-2025

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