

Description

TECHNICAL FIELD

[0001] The present invention relates to an inkjet head, and more particularly to a shear mode type inkjet head in which channels and end faces of partition walls made of a piezoelectric material are alternately aligned on a front end face of a head chip and a nozzle plate is joined to the front end face of this head chip.

BACKGROUND

[0002] In regard to an inkjet head that discharges microdroplets from nozzles to hit various recording materials so that an inkjet image can be recorded and formed, performance enabling stable drive at a higher speed has been demanded.

[0003] As the inkjet head, there is known a shear mode type inkjet head that has channels and partition walls made of a piezoelectric material alternately aligned, deforms the partition walls into a V-like shape based on a drive voltage when the drive voltage is applied to electrodes formed on partition wall surfaces facing the inside of the channels, and thereby discharges an ink in the channels from nozzles, and the present inventor has focused on a deforming operation of the partition walls at the time of discharge and examined a factor that inhibits the smooth deforming operation in order to enable faster stable drive in such a shear mode type inkjet head.

[0004] In general, in the shear mode type inkjet head having channels and partition walls made of a piezoelectric material alternately aligned, as shown in FIG. 11, one end of each channel 101 is opened in a front end face 100a of a head chip 100, and openings 101a of the channels 101 and front end faces 102a of partition walls 102 are alternately aligned when the head chip 100 is observed from the front end face 100a. A nozzle plate 200 having nozzles 201 formed at positions associated with the channels 101 is joined to the front end face 100a of this head chip 100 through an adhesive 300.

[0005] FIG. 12 is a view showing the head chip 100 depicted in FIG. 11 from the front end face 100a side. When a predetermined drive voltage is applied to electrodes (not shown) formed on both surfaces of each partition wall 102, each partition wall 102 deforms into a V-like shape as indicated by a solid line from a neutral state indicated by a broken line based on the drive voltage, whereby a pressure required for discharge from each nozzle 201 is given to an ink in each channel 101. Since this deforming operation of each partition wall 102 is actually carried out in very short time, it can be regarded as vibration of each partition wall 102.

[0006] Here, since the front end surface 102a side of each partition wall 102 joined to the nozzle plate 200 is completely secured to the nozzle plate 200 through the adhesive 300 in order to prevent the ink from leaking between the channels 101, vibration energy at the time of the deforming operation of each partition wall 102 concentrates on this secured region. Since the vibration energy concentrating on this secured region is trapped, it is inverted and propagated from the front end face 102a toward a central portion of each partition wall 102, and this energy affects the deforming operation when the same partition wall 102 performs the subsequent deforming operation. As a result, there arises a problem that the smooth deforming operation of each partition wall 102 is inhibited, a drop speed is lowered, and stable drive is difficult at the time of performing high-frequency drive in particular.

[0007] As nozzle plate materials, besides a synthetic resin such as a polyimide, there are metals such as Ni or Cu, Si, glass, and others, any material causes the above-described problem in no small measure as long as the nozzle plate is bonded to the front end face of each partition wall to secure this front end face, but the vibration energy concentrating on the front end face of each partition wall is hardly buffered as hardness of the nozzle plate material rises, and hence the problem becomes particularly prominent in case of the nozzle plate made of metal, Si, or glass as compared with the nozzle plate made of a synthetic resin.

[0008] Thus, the present inventor has examined processing the nozzle plate in order to suppress an influence of the vibration energy at the time of the deforming operation concentrating on the front end face of each partition wall bonded to the nozzle plate.

[0009] As conventional technology of processing a nozzle plate, Patent Literature 1 discloses forming a plurality of pressure fluctuation buffering portions, which are configured to buffer a pressure fluctuation in an ink reservoir and have a small thickness, in an ink discharge surfaces of a nozzle plate.

[0010] Additionally, Patent Literature 2 discloses forming a slit, which is configured to control deformation of a substrate and avoid delamination of a nozzle plate, in an ink discharge surface of the nozzle plate with a substantially equal depth as the nozzle plate.

[0011] Further, Patent Literature 3 discloses that, in an inkjet head that has a flow path plate, an intermediate plate, and a nozzle plate laminated therein and has one wall surface plated on the opposite surface side of the nozzle plate in a chamber as a pressure generating chamber being formed as a diaphragm that vibrates by drive of a piezoelectric material, an air trap portion that avoids crosstalk is formed between chambers of the respective plates.

[0012] However, the technologies in Patent Literatures 1 to 3 do not disclose a shear mode type inkjet head that drives

each partition wall made of a piezoelectric material, and they do not disclose technology of processing the nozzle plate in order to suppress an influence of vibration energy during the deforming operation concentrating on the front end face of each partition wall joined to the nozzle plate in the shear mode type inkjet head.

5 Prior Art Documents

Patent Documents

[0013]

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Patent Document 1: JP-A-2005-14618
Patent Document 2: JP-A-2007-331245
Patent Document 3: JP-A-2011-25657

15 SUMMARY OF THE INVENTION

[0014] As a result of keenly examining the above-described problem, the present inventor has found out that an influence of vibration energy at the time of a deforming operation concentrating on a front end face of each partition wall can be suppressed by forming air groove portions on a joint face of a nozzle plate relative to the front end face of the partition wall, thereby bringing the present invention to completion.

[0015] That is, it is an object of the present invention to provide an inkjet head which is of a shear mode type that a front end face of each partition wall made of a piezoelectric material is joined to a nozzle plate, the inkjet head being capable of improving a drop speed and performing stable drive at a high speed by suppressing an influence of vibration energy at the time of a deforming operation concentrating on the front end face of the partition wall.

25 **[0016]** Other objects according to the present invention will become apparent based on the following description.

[0017] The above object can be attained by each of the following inventions.

[0018] 1. An inkjet head comprising: a head chip in which a plurality of channels and a plurality of partition walls at least partially containing piezoelectric material are alternately aligned and which exerts a pressure for discharging an ink in the channels by a deforming operation of the partition walls based on a drive voltage; and a nozzle plate joined to a front end face of the head chip through an adhesive, front end faces of the partition walls facing the nozzle plate through the adhesive, wherein the nozzle plate has air groove portions concaved from a joint surface of the head chip at positions on the joint surface facing front end faces of the partition walls.

[0019] 2. The inkjet head according to 1, wherein the air groove portions are provided along a height direction of the partition walls.

35 **[0020]** 3. The inkjet head according to claim 2, wherein each of the air groove portions is longer than a height dimension of the channels on the front end face of the head chip.

[0021] 4. The inkjet head according to 1, 2, or 3, wherein liquid chambers communicating with nozzles and having a larger diameter than the nozzles are concaved on the joint surface of the nozzle plate relative to the head chip, and a depth of each air groove portion is equal to or shallower than a depth of each liquid chamber.

[0022] 5. The inkjet head according to any one of 1 to 4, wherein the nozzle plate is bonded to the head chip in a state that the adhesive has partially entered the air groove portions.

[0023] 6. The inkjet head according to any one of 1 to 5, wherein the nozzle plate is made of Si, metal, or glass.

45 **[0024]** According to the present invention, it is possible to provide the inkjet head which is of a shear mode type that a front end face of each partition wall made of a piezoelectric material is joined to a nozzle plate, the inkjet head being capable of improving a drop speed and performing stable drive at a high speed by suppressing an influence of vibration energy at the time of a deforming operation concentrating on the front end face of the partition wall.

50 BRIEF DESCRIPTION OF THE DRAWINGS

[0025]

55 FIG. 1(a) is a perspective view of a shear mode type inkjet head according to the present invention partially showing a cross section thereof, and FIG. 1 (b) is a longitudinal cross-sectional of the same;
FIG. 2 is a view showing the inkjet head according to the present invention from a nozzle surface;
FIG. 3 is a partially enlarged view showing a cross section taken along a line (iii)-(iii) in FIG. 2;
FIG. 4 is a view showing another conformation of an air groove portion;

FIGS. 5(a) to (d) are views for explaining an example of a method for manufacturing a nozzle plate of the inkjet head according to the present invention;

FIGS. 6(a) to (e) are views for explaining an example of the method for manufacturing the nozzle plate of the inkjet head according to the present invention;

FIG. 7 is a view showing an inkjet head according to another embodiment of the present invention from a nozzle surface;

FIG. 8 is a view showing an inkjet head according to still another embodiment of the present invention from a nozzle surface;

FIG. 9 is a view showing an inkjet head according to yet another embodiment of the present invention from a nozzle surface;

FIG. 10 is a view for explaining a comparative example;

FIG. 11 is a partial cross-sectional view of a conventional shear mode type inkjet head; and

FIG. 12 is a view for explaining a deforming operation of each partition wall by using a conventional shear mode type inkjet head.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0026] The present invention will be described below in detail however the present invention is not limited by the description below.

[0027] FIG. 1 shows an example of a shear mode type inkjet head, and (a) is a perspective view showing a cross section of a part thereof whilst (b) is a cross-sectional view of the same.

[0028] In an inkjet head 1, reference numeral 11 denotes a channel substrate. On the channel substrate 11, a plurality of channels 12 formed into a narrow groove shape and a plurality of partition walls 13 are alternately aligned. A cover substrate 14 is provided on an upper surface of the channel substrate 11 so as to close the upper side of all the channels 12, thereby forming a head chip 10.

[0029] A nozzle plate 20 is joined to a front end face 10a (an end face facing an ink discharge direction in the head chip 10) of the head chip 10 through an adhesive. One end of each channel 12 communicates with the outside through a nozzle 21 formed in the nozzle plate 20. In this nozzle plate 20, a surface of the nozzle plate 20 facing a direction along which an ink is discharged from each nozzle 21 is a nozzle surface, and its opposite surface is a joint surface 20a relative to the head chip 10.

[0030] A front end face 13a of each partition wall 13 is arranged to be level with the front end face 10a of the head chip 10. Therefore, the front end face 13a of the each partition wall 13 is opposite to the joint surface 20a of the nozzle plate 20 through the adhesive.

[0031] The other end of each channel 12 is gradually narrowed with respect to the channel substrate 11, and it communicates with a common flow path 15 that is opened and formed in the cover substrate 14 and common to the respective channels 12. The common flow path 15 is further closed by a plate 16, and the ink is supplied from an ink supply tube 18 into the common flow path 15 and each channel 12 through an ink supply opening 17 formed in the plate 16.

[0032] Each partition wall 13 is made of a piezoelectric material such as PZT that is electromechanical converting means. Here, for example, both an upper wall portion 131 and a lower wall portion 132 are made of a polarized piezoelectric material, and a polarization direction of the upper wall portion 131 is opposite to that of the lower wall portion 132, but a portion denoted by, e.g., reference numeral 131 alone may be made of the polarized piezoelectric material, and including this portion in at least part of the partition wall 13 can suffice. The partition walls 13 and the channels 12 are alternately aligned. Therefore, one partition wall 13 is shared by the channels 12 and 12 provided on both right and left sides thereof.

[0033] A drive electrode (not shown) is formed in each channel 12 from wall surfaces of both the partition walls 13 and 13 to a bottom surface of the channel 12. When a predetermined drive voltage is applied to the drive electrodes on both surfaces sandwiching the partition wall 13 therebetween, the partition wall 13 deforms into a V-like shape with a joint surface of the upper wall portion 131 and the lower wall portion 132 as a boundary based on this drive voltage. Pressure waves are generated in each channel 12 by the deforming operation of this partition wall 13, and a pressure required for discharge from each nozzle 21 is given to an ink in this channel 12.

[0034] The nozzle plate 20 will now be further explained with reference to FIG. 2 and FIG. 3. FIG. 2 is a view showing the inkjet head 1 from the nozzle surface side, and FIG. 3 is a cross-sectional view taken along a line (iii)-(iii) in FIG. 2.

[0035] In the present invention, a material that is generally used for a nozzle plate can be used for the nozzle plate 20, and there is, e.g., a synthetic resin, metal, or glass. In particular, a nozzle plate made of Si, metal, or glass is preferable. Since a nozzle plate made of each of these materials is harder than a nozzle plate made of a synthetic resin, vibration energy concentrating on a secured region of each partition wall 13 and the nozzle plate 20 is apt to be trapped during the deforming operation of the partition wall 13, and the vibration energy concentrating on the secured region greatly affects the subsequent deforming operation of this partition wall 13. Therefore, in the present invention, when

the nozzle plate 20 is made of Si, metal, or glass, a later-described vibration energy buffering effect during the deforming operation of the partition wall 13 can be prominently obtained.

[0036] In regard to the nozzle plate made of metal, Ni, an Ni/Co alloy, Cu, stainless, or the like can be used. In case of adopting the nozzle plate made of each of these metals, it is possible to process each nozzle 21 as well as a later-described liquid chamber or an air groove portion by an electroforming method. In case of the nozzle plate made of glass, each nozzle 21, the liquid chamber, the air groove portion, and others can be processed by sandblasting. Further, in case of the nozzle plate made of a synthetic resin such as polyimide, a laser processing method can be mainly adopted.

[0037] In this embodiment, an example using the nozzle plate 20 made of Si is shown. Since the nozzle plate 20 made of Si can be fabricated by using a semiconductor manufacturing process, highly accurate processing is possible, and the nozzle plate 20 with a high accuracy can be easily fabricated.

[0038] Each air groove portion 23 is formed in the nozzle plate 20 at a position facing the front end face 13a of each partition wall 13 on the joint surface 20a relative to the head chip 10 at a predetermined depth from the joint surface 20a.

[0039] Each air groove portion 23 is placed between the channels 12 adjacent to each other so as to be associated with the front end face 13a of each partition wall 13 joined to the nozzle plate 20 through the adhesive 30. Each air groove portion 23 is independent from the other air groove portions 23. Each air groove portion 23 is formed into a narrow groove shape extending along a height direction (a direction that is parallel to the nozzle surface and orthogonal to an alignment direction of the channels 12, which is an up-and-down direction in FIG. 2) of each partition wall 13, but it does not penetrate to the nozzle surface side. Each air groove portion 23 is closed by the front end face 10a of the head chip 10 including the front end face 13a of each partition wall 13 through the adhesive 30, whereby an air chamber having air included therein is formed.

[0040] Since each air groove portion 23 forming the air chamber having the air included therein by joining to the head chip 10 is provided at a region where the front end face 13a of each partition wall 13 on the joint surface 20a of the nozzle plate 20 is joined through the adhesive 30, when the vibration energy at the time of the deforming operation of each partition wall 13 concentrates on the secured region of the front end face 13a of the partition wall 13 and the nozzle plate 20, air included in the air groove portion 23 absorbs and buffers the vibration energy. As a result, the vibration energy concentrating on the secured region of the front end face 13a of each partition wall 13 and the nozzle plate 20 can be prevented from being reflected toward a central portion of this partition wall 13, and an influence of this partition wall 13 when it deforms for subsequent discharge can be reduced.

[0041] Further, since the influence of the vibration energy on the deforming operation of the partition wall 13 for subsequent discharge due to the deforming operation of the partition wall 13 can be suppressed, behaviors of an ink meniscus can be stabilized, and a time until the subsequent discharge can be shortened. As a result, high-frequency drive can be stably carried out.

[0042] As conditions for a width of each air groove portion 23, this width must be formed so as to be narrower than a width of each partition wall 13 (a thickness along the alignment direction of the channels 12), and it is not greater than the width of the partition wall 13, but the vibration energy buffering effect may not be possibly sufficiently exercised when the width is extremely narrow, and hence setting this width to 5 μm or more is preferable.

[0043] Further, a length L of each air groove portion 23 is preferably longer than a height dimension H (a dimension in a direction that is parallel to the nozzle surface and orthogonal to the alignment direction of the channels 12) of each channel 12 on the front end face 10a of the head chip 10. When this length is longer than the height dimension H of each channel 12, the vibration energy along the entire height direction of each partition wall 13 can be effectively absorbed and buffered.

[0044] Furthermore, as conditions for a depth of each air groove portion 23, this depth must be shallower than a thickness of the nozzle plate 20, but strength of the nozzle plate 20 can be reduced when each air groove portion 23 is too deeply formed. Although a specific depth differs depending on each nozzle plate material, it is preferable to set this depth to be not greater than 90% of the thickness of the nozzle plate 20 when the nozzle plate 20 is made of Si.

[0045] As shown in FIG. 3, when each liquid chamber 22 that communicates with the nozzle 21 and has a larger diameter than that of the nozzle 21 is formed in the nozzle plate 20 on the joint surface 20a relative to the head chip 10, it is preferable to form the depth of each air groove portion 23 to be equal to or shallower than a depth of this liquid chamber 22 so as to meet the conditions in view of maintaining durability of the nozzle plate 20.

[0046] It is to be noted that the liquid chamber 22 is formed into a rectangular shape slightly smaller than an opening shape of the channel 12 in this embodiment, but the liquid chamber 22 can be formed into any specific shape. Moreover, although the liquid chamber 22 is not required in the present invention, providing the liquid chamber 22 is preferable in case of increasing the thickness of the nozzle plate 20 in terms of assuring the depth of the air groove portion 23.

[0047] Usually, a width of the front end face 13a of each partition wall 13 is very narrow, and aligning the plurality of air groove portions 23 is difficult, and hence one air groove portion 23 facing the front end face 13a of one partition wall 13 can suffice. Additionally, as shown in FIG. 4, the air groove portion 23 associated with one partition wall 13 may be constituted of a plurality of air groove portions 23 divided along the height direction of the partition wall 13. However, in view of efficiently buffering the vibration energy, adopting one air groove portion 23 as shown in FIG. 2 is preferable.

[0048] The head chip 10 is bonded to the nozzle plate 20 through the adhesive 30. At this time, as partially shown in FIG. 3, it is preferable to bond these members in a state that the adhesive 30 has partially entered the air groove portion 23. As a result, the excess adhesive 30 can be collected in the air groove portion 23, and the excess adhesive can be prevented from entering each channel 12 or each nozzle 21, and adhesion is also improved.

[0049] The adhesive can enter the air groove portion 23 when the head chip 10 and the nozzle plate 20 are bonded after being heated. When the head chip 10 and the nozzle plate 20 are cooled to a normal temperature, the air in the air groove portion 23 contracts, whereby part of the adhesive 30 can enter the air groove portion 23. When the excess adhesive 30 is accommodated in the air groove portion 23, a bonding area increases, and improvement in adhesion force can be expected.

[0050] It is to be noted that the adhesive 30 only slightly enters from the opening side of the air groove portion 23 as shown in FIG. 3 and the inside of the air groove portion 23 is not entirely filled with the adhesive 30, but an amount of air in the air groove portion 23 is slightly reduced when part of the adhesive 30 enters the air groove portion 23. However, an epoxy-based adhesive generally used as the adhesive 30 has an elastic modulus lower than that of a nozzle plate material (Si, metal, glass) that is preferably used in the present invention, and hence the vibration energy buffering effect of each partition wall 13 is not greatly deteriorated.

[0051] An example of a method for manufacturing the nozzle plate 20 having such air groove portion 23 will now be described with reference to FIG. 5 and FIG. 6.

[0052] An Si substrate 40 (a thickness: 725 μm) that is sufficiently thicker than the nozzle plate 20 as an end product is prepared, one entire surface of this substrate is coated with a resist mask 50 (FIG. 5(a)), and then the resist mask 50 at each region serving as a position for forming each nozzle 21 is removed, thus forming each opening portion 51 (FIG. 5(b)).

[0053] Then, when etching is performed from a surface of the resist mask 50, each concave portion 41 having a predetermined depth is formed in each opening portion 51 (FIG. 5(c)). Here, the concave portions 41 each having a depth of 30 μm was formed. Then, a support substrate 60 formed of a glass substrate having a thickness of 200 μm for reinforcing the Si substrate 40 is attached to the surface where the concave portions 41 are formed from the upper side of the resist mask 50 (FIG. 5(d)).

[0054] The Si substrate 40 having the support substrate 60 attached thereto is polished from the opposite surface side of the support substrate 60 until the Si substrate 40 has a thickness of 200 μm (FIG. 6(a)), and then the polished surface of the Si substrate 40 is coated with a resist mask 70 (FIG. 6(b)).

[0055] Subsequently, the resist mask 70 at regions as positions where liquid chambers 22 and air groove portions 23 are formed is removed to form respective liquid chamber opening portions 71 and air groove portion opening portions 72 (FIG. 6(c)), and then the Si substrate 40 facing the liquid chamber opening portions 71 and the air groove portion opening portions 72 are recessed by performing etching from the surface of the resist mask 70 (FIG. 6(d)).

[0056] When the Si substrate 40 is recessed from the liquid chamber opening portions 71, nozzles 21 and the liquid chambers 22 that communicate with the concave portions 41 and are formed of concave portions 41 are formed. On the other hand, when the Si substrate 40 is recessed from the air groove portion opening portions 72, the air groove portions 23 are formed between the liquid chambers 22. At this time, although etching from the liquid chamber opening portions 71 and etching from the air groove portion opening portions are simultaneously performed, since each air groove portion opening portion 72 has a narrower width and a smaller opening area than each liquid chamber opening portion 71, an etching rate from the air groove portion opening portions 72 is lower, and a depth of each air groove portion 23 is thereby shallower than that of the liquid chamber 22. As a result, each air groove portion 23 shallower than each liquid chamber 22 can be easily formed.

[0057] Thereafter, the Si substrate 40 is diced into a size of the nozzle plate 20, a plurality of nozzle plates 20 are sliced out, and the support substrate 60 and the respective resist masks 50 and 70 are removed, thereby fabricating the nozzle plate 20 having the air groove portions 23 (FIG. 6(e)).

[0058] The above-described inkjet head 1 has a conformation that all channels 12 are ink channels from which an ink is discharged and the nozzle 21 and the liquid chamber 22 are provided in accordance with each channel 12, but this inkjet head 1 may be of a so-called independent drive type that ink channels 121 from which the ink is discharged and dummy channels 122 from which the ink is not discharged are alternately arranged. In this conformation, likewise, since each partition wall 13 deforms in order to discharge the ink from each ink channel 121, each air groove portion 23 is formed on the joint surface of the nozzle plate 20 at a position associated with a front end face 13a of each partition wall 13.

[0059] It is to be noted that, in this conformation, the nozzle 21 and the liquid chamber 22 are not formed at a region associated with each dummy channel 122 in the nozzle plate 20.

[0060] Further, the above-described inkjet head 1 has one channel string, but it may have a plurality of channel strings which are two or more strings as shown in FIG. 8. In this case, like FIG. 7, the inkjet head 1 can be of an independent drive type that the ink channels 121 and the dummy channels 122 are alternately arranged.

[0061] Furthermore, although each above-described air groove portion 23 is formed independently from the other air groove portions 23, the air groove portions 23 may be connected to each other as shown in FIG. 9 as long as each air

groove portion 23 is formed at a position in the head chip 10 facing the front end face 13a of each partition wall 13. FIG. 9(a) shows a conformation that the air groove portions 23 are connected to each other when one channel string is provided, and FIG. 9(b) shows a conformation that the air groove portions 23 are connected to each other when two channel strings are provided. When the air groove portions 23 are connected to each other, an amount of air included inside is increased by joining to the head chip 10, and hence the vibration energy buffering effect provided by air can be further improved.

EXAMPLES

[0062] The effect of the present invention will now be verified hereinafter based on examples.

(Example 1)

[0063] There was used an inkjet head that adopts polarized PZT as a partition wall material and has one channel string with partition walls each having an upper wall portion and a lower wall portion so that polarization directions are opposed along a partition wall height direction. A head chip structure and a nozzle plate structure are as follows.

Head Chip Structure

[0064]

Number of channels: 256
Channel height: 200 μm
Channel width: 82 μm
Partition wall width: 62 μm

Nozzle Plate Structure

[0065]

Material: Si
Thickness: 200 μm
Depth of the liquid chamber: 170 μm
Nozzle diameter: 30 μm

[0066] Like FIG. 2 and FIG. 3, each air groove portion extending along a height direction of the partition wall was formed in this nozzle plate at a position facing a front end face of each partition wall of the head chip.

Depth of the air groove portion: 160 μm
Width of the air groove portion: 20 μm
Length L of the air groove portion: 300 μm

[0067] The above-described nozzle plate was bonded to the front end face of the head chip using an epoxy-based adhesive, thereby fabricating the inkjet head. In regard to the obtained inkjet head, an ink was continuously discharged with a drive voltage of 16.6 V and a drive frequency of each of 24.7 kHz and 12.3 kHz, attention was paid to one of nozzles, and a drop speed was obtained from this nozzle, and evaluation was carried out based on the following criteria. The drop speed was measured by imaging each discharged ink drop and performing image processing to an ink drop image. Table 1 shows this result.

◎: 10 m/s or more
○: 9 m/s or more and less than 10 m/s
△: 8 m/s or more and less than 9 m/s
▲: 6 m/s or more and less than 8 m/s

(Example 2)

[0068] An ink was discharged in completely the same manner as Example 1 except a length L of each air groove portion 2 was set to 180 μm which is shorter than a height H of each channel, and a drop speed was evaluated. Table

1 shows this result.

(Comparative Example 1)

- 5 **[0069]** An ink was discharged in completely the same manner as Example 1 except that air groove portions were not formed in a nozzle plate at all, and a drop speed was evaluated. Table 1 shows this result.

(Comparative Example 2)

- 10 **[0070]** Air groove portions of a nozzle plate were formed in regions that are parallel to a nozzle string direction and associated with outer sides of respective channels as shown in FIG. 10. A depth and width of each air groove portion are the same as those in Example 1, and a length along the nozzle string direction was set to 50 μm . An ink was discharged from this inkjet head under completely the same drive conditions as those of Example 1, and a drop speed was evaluated. Table 1 shows this result.

[Table 1]

	MATERIAL OF NOZZLE PLATE	DRIVE VOLTAGE (V)	EMISSION STABILITY	
			24.7kHz	12.3kHz
20	EXAMPLE 1	Si	16.6	○ ◎
	EXAMPLE 2	Si	16.6	○ ○
	COMPARATIVE EXAMPLE 1	Si	16.6	▲ △
25	COMPARATIVE EXAMPLE 2	Si	16.6	△ △

- 30 **[0071]** As described above, when the air groove portions are formed at positions facing the front end faces of the partition walls like the present invention, the drop speed was improved, and the ink was stably discharged even at the time of high-frequency drive. In particular, when the air groove portions longer than the channel height were formed like Example 1, the higher effects than those of Example 2 were obtained.

EXPLANATIONS OF LETTERS OR NUMERALS

[0072]

35

1: inkjet head

10: head chip

10a: front end face

40

11: channel substrate

12: channel

121: ink channel

122: dummy channel

45

13: partition wall

13a: front end face

131: upper wall portion

132: lower wall portion

50

14: cover substrate

15: common flow path

16: plate

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17: ink supply opening

18: ink supply tube

20: nozzle plate

20a: joint surface

21: nozzle
 22: liquid chamber
 23: groove portion
 30: adhesive
 40: Si substrate
 41: concave portion
 50: resist mask
 51: opening portion
 60: support substrate
 70: resist mask
 71: liquid chamber opening portion
 72: air groove portion opening portion

Claims

1. An inkjet head comprising: a head chip in which a plurality of channels and a plurality of partition walls at least partially containing piezoelectric material are alternately aligned and which exerts a pressure for discharging an ink in the channels by a deforming operation of the partition walls based on a drive voltage; and a nozzle plate joined to a front end face of the head chip through an adhesive, front end faces of the partition walls facing the nozzle plate through the adhesive,
 wherein the nozzle plate has air groove portions concaved from a joint surface of the head chip at positions on the joint surface facing front end faces of the partition walls.
2. The inkjet head according to claim 1,
 wherein the air groove portions are provided along a height direction of the partition walls.
3. The inkjet head according to claim 2,
 wherein each of the air groove portions is longer than a height dimension of the channels on the front end face of the head chip.
4. The inkjet head according to claim 1, 2, or 3,
 wherein liquid chambers communicating with nozzles and having a larger diameter than the nozzles are concaved on the joint surface of the nozzle plate relative to the head chip, and
 a depth of each air groove portion is equal to or shallower than a depth of each liquid chamber.
5. The inkjet head according to any one of claims 1 to 4,
 wherein the nozzle plate is bonded to the head chip in a state that the adhesive has partially entered the air groove portions.
6. The inkjet head according to any one of claims 1 to 5, wherein the nozzle plate is made of Si, metal, or glass.

FIG. 1

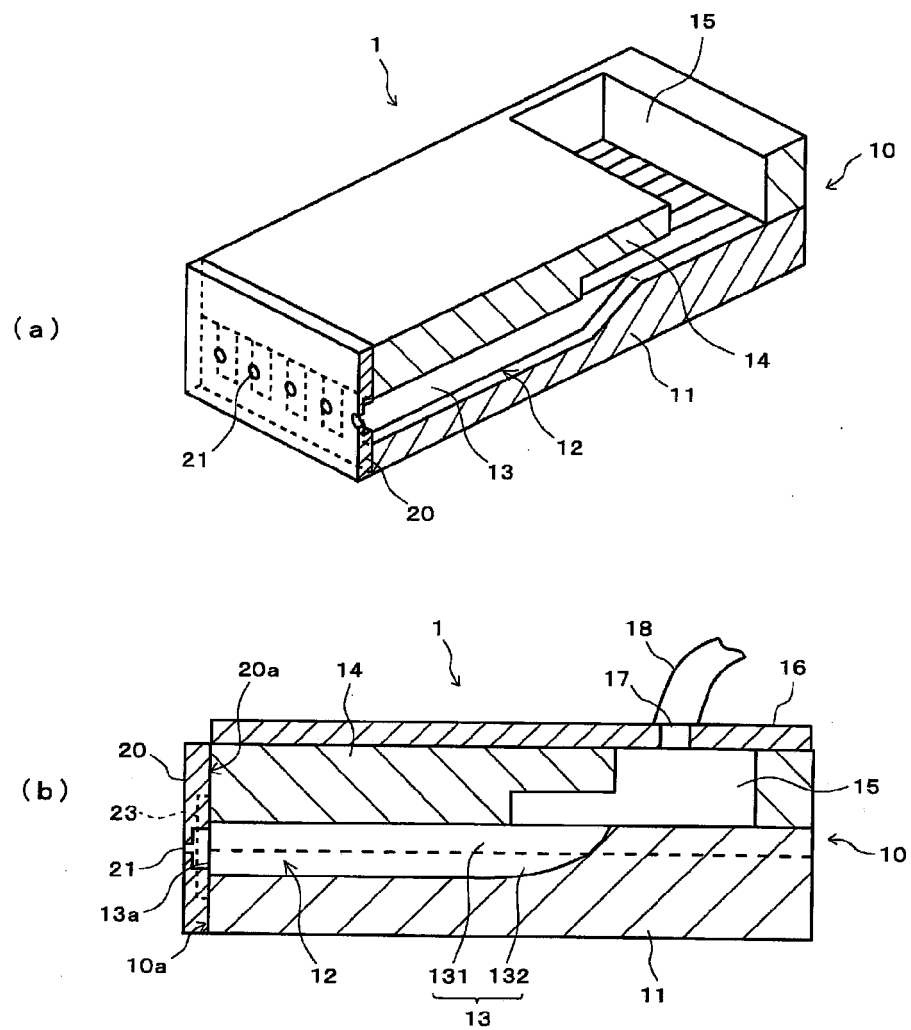


FIG. 2

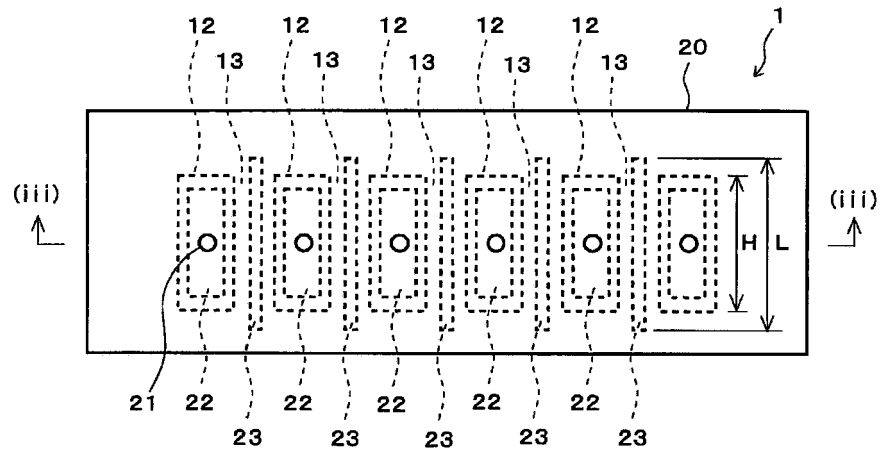


FIG. 3

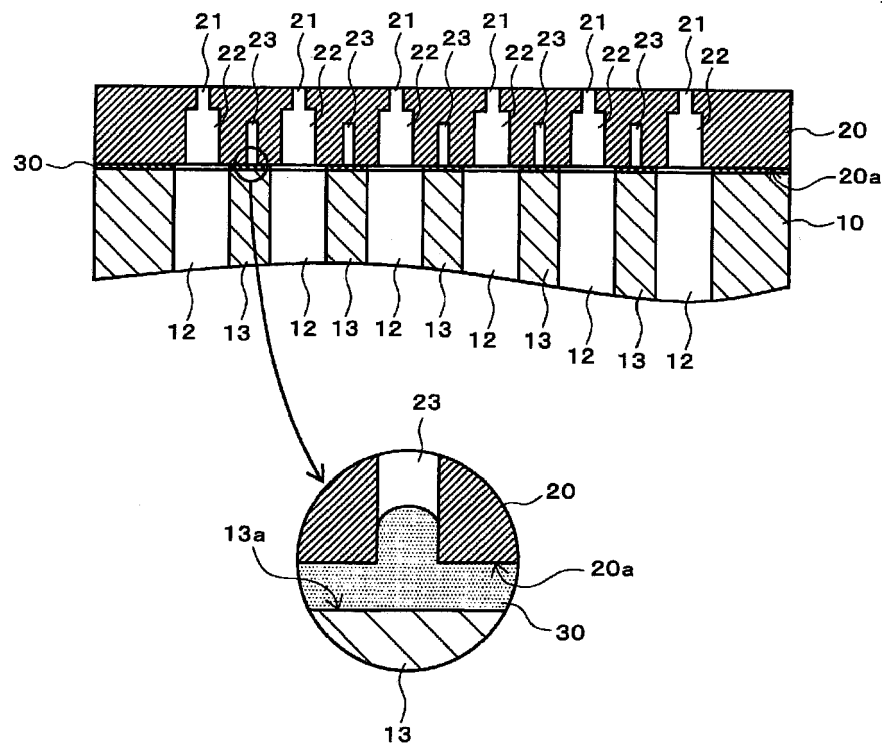


FIG. 4

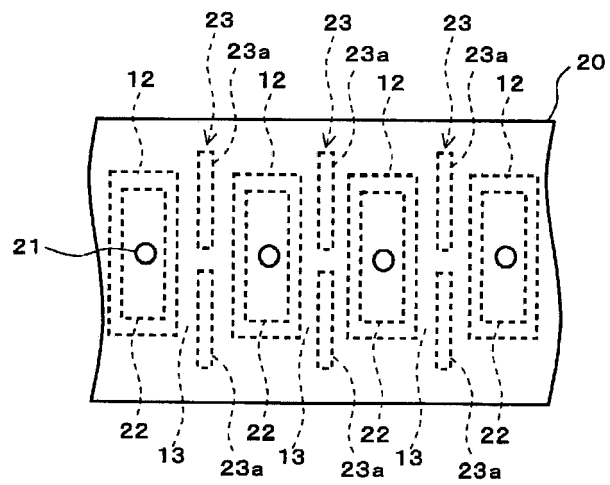


FIG. 5

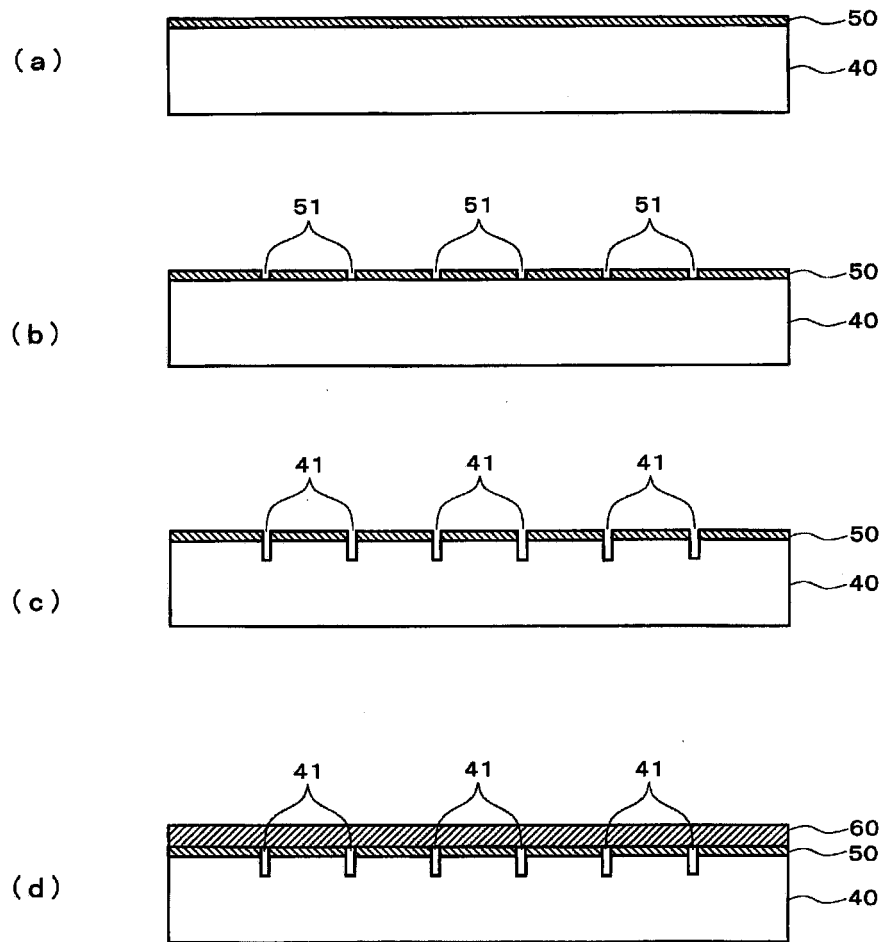


FIG. 6

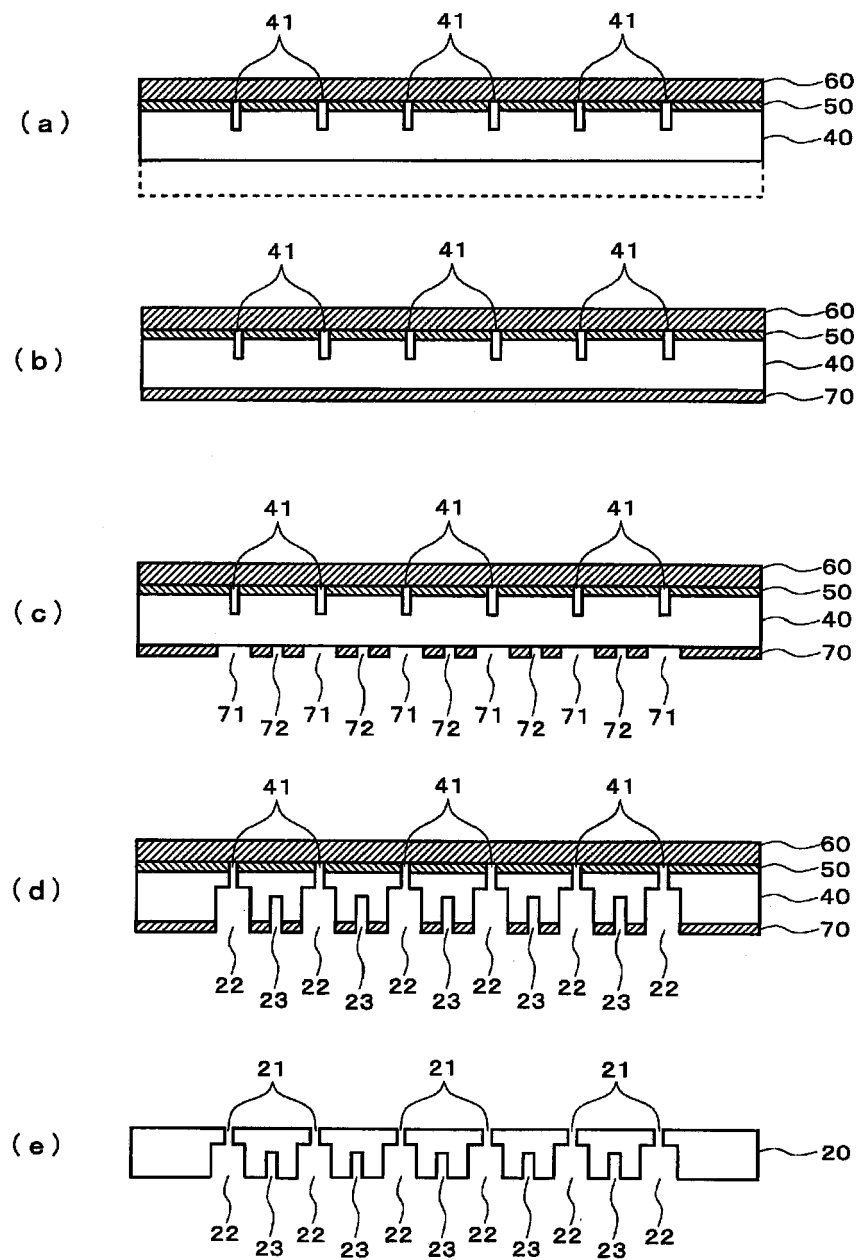


FIG. 7

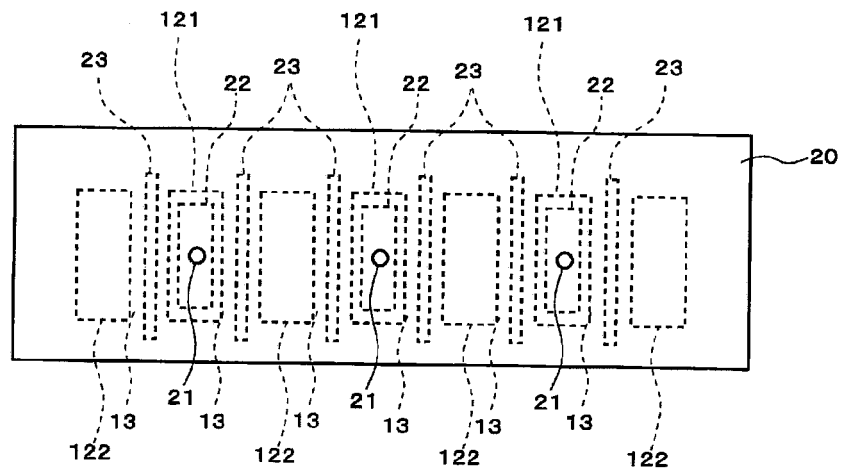


FIG. 8

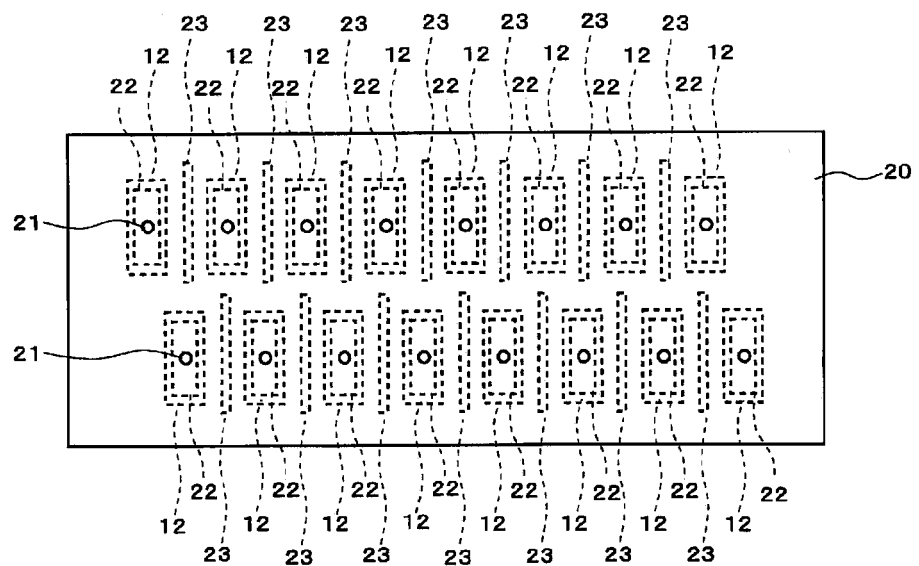


FIG. 9

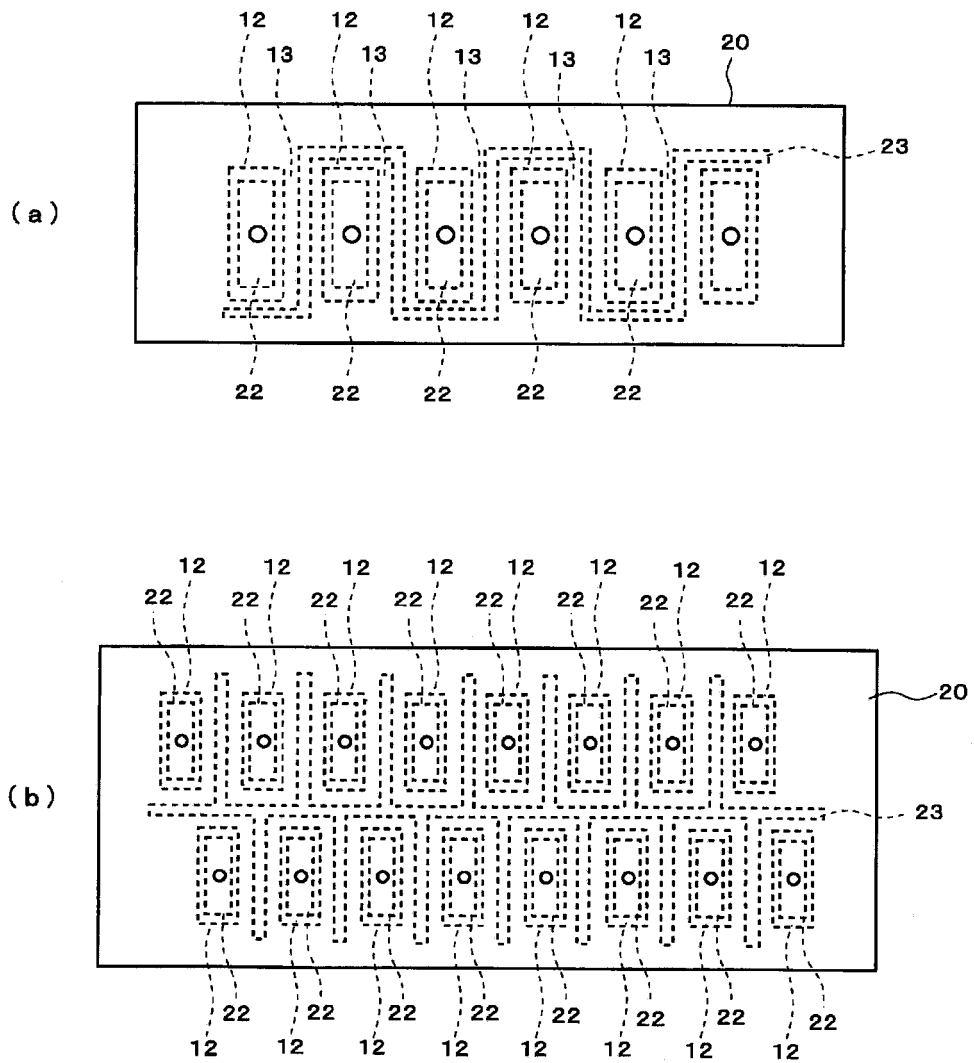


FIG. 10

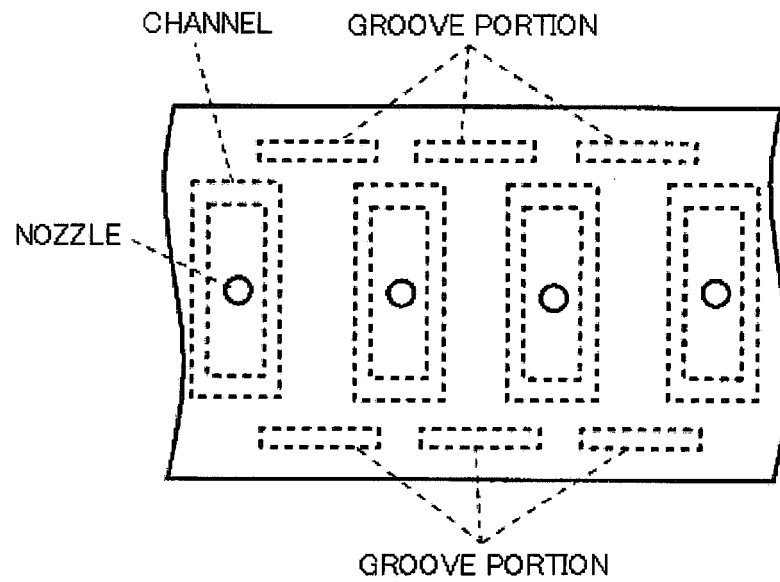


FIG. 11

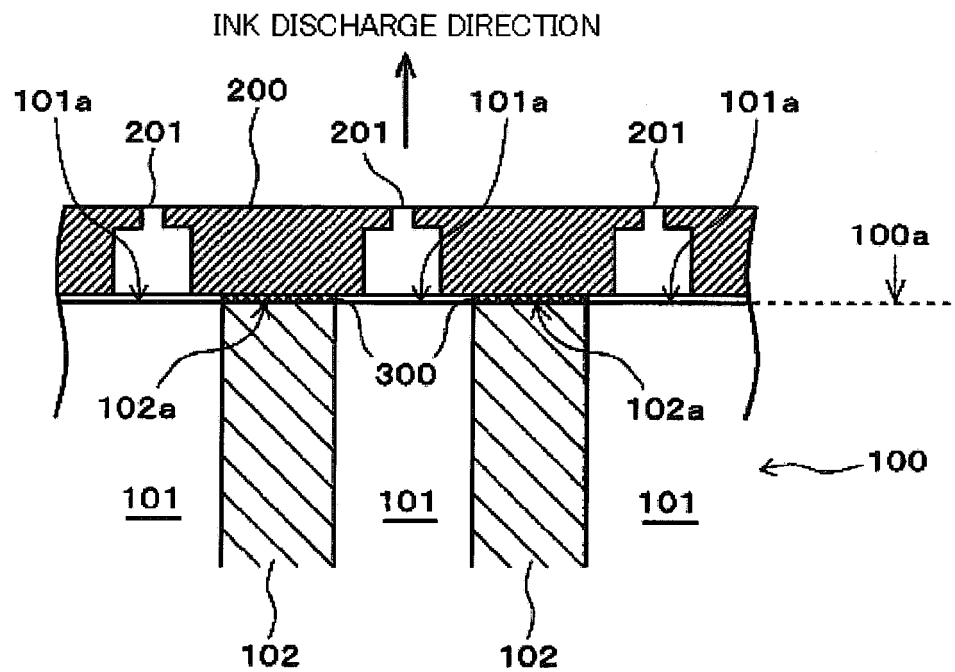
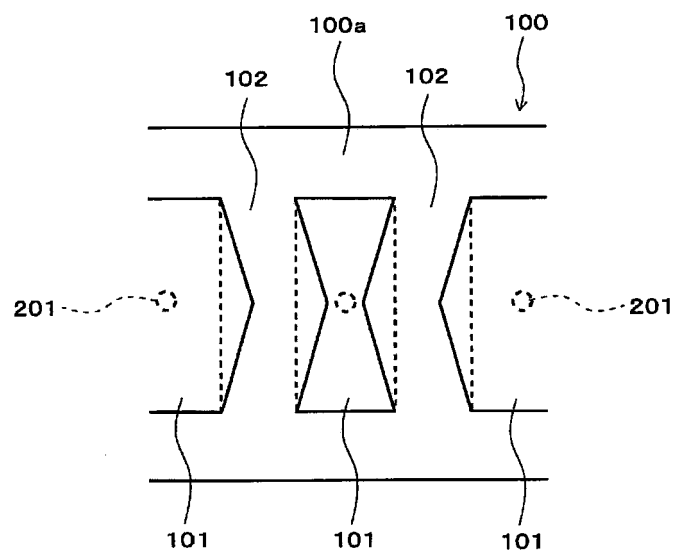


FIG. 12



REFERENCES CITED IN THE DESCRIPTION

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