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(54) **Inkjet recording head, piezoelectric vibration element unit, and method of manufacturing the piezoelectric vibration element unit**

Tintenstrahlaufzeichnungskopf, piezoelektrische Vibratorelementeinheit und Verfahren zur Herstellung der piezoelektrischen Vibratorelementeinheit

Tête d'enregistrement à jet d'encre, unité d'éléments de vibration piézoélectrique, et méthode de fabrication de l'unité d'éléments de vibration piézoélectrique

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EP-A- 0 550 030 EP-A- 0 761 447
EP-A- 0 787 589 EP-A- 0 860 279
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Description

BACKGROUND OF THE INVENTION

[0001] The present invention generally relates to an inkjet recording head which uses, as a pressure generating source, piezoelectric vibration elements of the longitudinal vibration type, which are each constructed such that a plurality of internal electrodes are alternately layered in a state that piezoelectric material is interposed therebetween.

[0002] The inkjet recording head, which uses the piezoelectric vibration elements each vibrating in the longitudinal vibration mode, includes a plurality of linear arrays each consisting of pressure generating chambers, each chamber communicating with a nozzle orifice and a part of each chamber being sealingly closed with an elastically deformable plate member. Each pressure generating chamber is expanded and contracted by its associated piezoelectric vibration element which axially deflects in accordance with a drive signal applied thereto.

[0003] The piezoelectric vibration elements are constructed as a unit form as shown in Fig. 15. That is, a piezoelectric vibrating plate, which is wide enough to cover a plurality of piezoelectric vibration elements, is fastened to a fixing plate 60, and is cut into a plurality of piezoelectric vibration elements 61 with a wire saw or the like to be arranged at a constant pitch.

[0004] Dummy piezoelectric vibration elements 62 and 63, which are not associated with the ink drop ejecting operation, are provided at both ends of a linear array of piezoelectric vibration elements in order to improve the workability in positioning the piezoelectric vibration elements in the stage of assembling. In assembling the piezoelectric vibration elements, the outer side surfaces 62' and 63' of the dummy piezoelectric vibration elements 62 and 63 are used as a reference in setting the piezoelectric vibration element unit to a case, whereby the piezoelectric vibration elements 61 are positioned with respect to the fluid channel unit within a predetermined tolerance.

[0005] The piezoelectric vibrating plate is formed such that internal electrode material layers including metal and piezoelectric material layers are layered, and the resultant layered structure is sintered. The cutting of the thus formed piezoelectric vibrating plate with a wire saw into a plurality of piezoelectric vibration elements will minutely shift the actual cutting lines from the correct cutting lines since the internal electrodes are hard. The shift of the cutting lines greatly affects an accuracy of the relative positioning of the piezoelectric vibration element unit when the distal ends of the piezoelectric vibration elements are reduced in area for the purpose of increasing a print density.

[0006] EP-A2-0 761 447, EP-A2-0 550 030, and EP-A2-0 787 589 each disclose a piezoelectric element unit according to the preamble of claim 1.

[0007] EP-A2-0 761 447 discloses dummy elements to which no driving signal is applied and which function as guiding members, and discloses piezoelectric vibrating elements and dummy vibrating elements serving as positioning members.

[0008] EP-A2-0 550 030 discloses a piezoelectric element and a fixing plate, with the piezoelectric element being sliced into a plurality of vibrators and including two vibrator positioning members. The fixing plate is formed of ceramics or the like and includes an electrode on its top surface, and the plate-shaped piezoelectric element has an electrode on its lower surface and on its rear face. After the piezoelectric element has been fixed to the fixing plate, it is cut into a plurality of vibrators and two vibrator positioning members.

[0009] EP-A2-0 787 589 discloses an arrangement including piezoelectric vibrators, dummy vibrators, and a connecting bar. One end of a piezoelectric vibrator unit is fixed to a fixing board, and on both ends of the unit are provided dummy piezoelectric vibrators serving as positioning members.

SUMMARY OF THE INVENTION

[0010] Accordingly, an object of the present invention is to provide an inkjet recording head in which piezoelectric vibration elements are positioned at predetermined positions with high accuracy.

[0011] Another object of the invention is to provide a piezoelectric vibration element unit which is configured with high accuracy.

[0012] A third object of the invention is to provide a method of manufacturing the piezoelectric vibration element unit.

[0013] According to the present invention, a piezoelectric vibration element unit is configured as indicated in claim 1, an actuator is configured as indicated in claim 13, and an inkjet recording head is configured as indicated in claim 24. Methods according to the present invention are indicated in claims 27 and 29.

[0014] Preferred embodiments of the invention are indicated in the dependent claims.

[0015] An inkjet recording head according to the present invention includes a piezoelectric vibration element unit in which a plurality of piezoelectric vibration elements, each of which is axially expandable, and is made up of piezoelectric material layers and internal electrodes which are alternately layered, are linearly arrayed on a substrate. The volumes of pressure generating chambers are increased and decreased by said piezoelectric vibration elements associated respectively with said pressure generating chambers. A dummy piezoelectric vibration element is provided at least one end of a linear array of piezoelectric vibration elements, and a region not including the internal electrodes is provided in the vicinity of the outer side surface of said dummy piezoelectric vibration element.

[0016] Thus, in the inkjet recording head of the pref-

erable construction, the internal electrodes are not contained in a region in the vicinity of the outer side surface of said dummy piezoelectric vibration element. Therefore, the cutting of the piezoelectric vibrating plate along the outer side surface of the dummy piezoelectric vibration element does not cause a shift of an actual cutting line from the correct cutting line due to the high hardness of the internal electrodes. Therefore, the piezoelectric vibrating plate can be highly accurately cut.

[0017] The present disclosure relates to the subject matter contained in Japanese patent application Nos. Hei. 11-85788 (filed on March 29, 1999) and 2000-76269 (filed on March 17, 2000).

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

Fig. 1 is a cross sectional view mainly showing a driving piezoelectric vibration element in an inkjet recording head which is an embodiment of the present invention.

Fig. 2 is a cross sectional view mainly showing a dummy piezoelectric vibration element in the inkjet recording head.

Fig. 3 is a view showing a structure of the inkjet recording head when a piezoelectric vibration element unit is assembled into a head holder.

Fig. 4 is a perspective view showing an embodiment of a piezoelectric vibration element unit according to the present invention.

Figs. 5(I) to 5(III) are perspective views showing the first half of a method of manufacturing a piezoelectric vibrating plate in a method of manufacturing the piezoelectric vibrating plate.

Figs. 6(I) to 6(III) are perspective views showing the second half of the method of manufacturing a piezoelectric vibrating plate.

Figs. 7(I) to 7(III) are perspective views showing a process for manufacturing piezoelectric vibration elements by use of a piezoelectric vibrating plate in the method of manufacturing the piezoelectric vibration element unit.

Fig. 8 is a cross sectional view showing a cutting region of a dummy piezoelectric element.

Fig. 9 is a perspective view showing another embodiment of a piezoelectric vibrating plate according to the present invention.

Figs. 10A and 10B perspectively and sectionally show a piezoelectric vibration element unit and a driving piezoelectric vibration element in an inkjet recording head which is another embodiment of the invention.

Fig. 11 is a perspective view showing another embodiment of a piezoelectric vibration element unit of the present invention.

Fig. 12 is a perspective view showing an application of the invention to a recording head in which pres-

sure generating chambers are formed by use of piezoelectric vibration elements.

Figs. 13(I) to 13(III) show perspective views showing a process of manufacturing a piezoelectric vibration element unit which is another embodiment of the invention.

Fig. 14 is an enlarged, perspective view showing a portion E in Fig. 13.

Fig. 15 is a perspective view showing a piezoelectric vibration element unit used in a related inkjet recording head.

Figs. 16 and 17 are plane views showing modified steps of a process of manufacturing a piezoelectric vibration element unit of the present invention.

Figs. 18 and 19 are plane views showing modified steps of a process of manufacturing a piezoelectric vibration element unit of the present invention.

Figs. 20 and 21 are plane views showing modified steps of a process of manufacturing a piezoelectric vibration element unit of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] The present invention will be described in detail with reference to the accompanying drawings.

[0020] Fig. 1 shows an embodiment of the present invention. In a piezoelectric vibration element unit 1, piezoelectric vibration elements 5, as shown in Fig. 4, are disposed at fixed pitches along a fixing plate 6. In each piezoelectric vibration element 5, internal electrodes 3 and 4 having different poles are arranged parallel to one another, and extend in the axial or longitudinal direction of the element 5. Those internal electrodes 3 and 4 are exposed to outside at respective ends, that is, in this embodiment the internal electrodes 3 are exposed at the proximal ends of the piezoelectric vibration elements 5, whereas the other internal electrodes 4 are exposed at the distal ends of the piezoelectric elements 5. Those internal electrodes 3 and 4 are layered one on another in a state that piezoelectric material P is interlayered therebetween in a vibration region of the element 5. That is, each of the piezoelectric vibration element 5 has a layered construction in which electrically conductive layers and piezoelectric material layers are stacked one on another alternately. Dummy piezoelectric elements 7 are located at both ends of an array of the piezoelectric vibration elements 5. The remains 7' of the dummy piezoelectric elements 7, which are produced as a consequence of the formation of the dummy piezoelectric elements 7 are present on the outer side of the dummy piezoelectric elements 7.

[0021] As shown in Fig. 2, the outer side surfaces of the dummy piezoelectric elements 7 are formed of only piezoelectric material P, not including electrodes.

[0022] External electrodes 9 and 10, which form connection parts to a flexible cable 8 for supplying a drive signal are formed, by sputtering or vapor deposition,

over regions ranging from the distal and proximal end faces of each piezoelectric vibration element 5 where the internal electrodes 3 and 4 are exposed, to a surface of the fixing plate (6) side. In this embodiment, the internal electrodes 3 are common (grounded) electrodes, and the internal electrodes 4 are segment electrodes.

[0023] A fluid channel forming unit 11 is formed by liquid-tightly laminating a fluid channel forming substrate 15 defining a reservoir 12, ink supplying ports 13 and pressure generating chambers 14, an elastic plate 16 which is brought into contact with the distal end of piezoelectric vibration elements 5 to increase and reduce the volumes of the associated pressure generating chambers 14, and a nozzle plate 18 which sealingly closes the opposite surface of the fluid channel forming substrate 15 and has nozzle orifices 17 for ejecting ink, which is supplied from the pressure generating chambers 14, in the form of ink drops.

[0024] The fluid channel forming unit 11 is fixed to an opened surface 19a of a head holder 19. The distal ends of the piezoelectric vibration elements 5 are coated with adhesive and brought into contact with islands 16a of the elastic plate 16. The fixing plate 6 is fixed to the head holder 19 by adhesive. In this manner, the inkjet recording head is formed.

[0025] As shown in Fig. 3, the outer side surfaces of the dummy piezoelectric elements 7, which are located at both ends of the array of the piezoelectric vibration elements 5, are brought into contact with the inner surfaces 19b of a piezoelectric-vibration-elements accommodating chamber of the head holder 19, whereby the piezoelectric vibration element unit 1 is positioned in place with respect to the head holder 19 and thus the fluid channel forming unit 11. That is, in this embodiment, each dummy piezoelectric element 7 is used as a positioning member, and the outer side surface of each dummy piezoelectric element 7 is used as a reference surface for positioning the piezoelectric vibration element unit 1 with respect to the head holder 19.

[0026] In the inkjet recording head thus constructed, in operation, a drive signal is applied to a piezoelectric vibration element 5, which is associated with a pressure generating chamber 14 communicating with a nozzle orifice 17 through which ink is to be ejected. In response to the drive signal, the piezoelectric vibration element 5 is shrunk and expanded to increase and decrease the volume of the pressure generating chamber 14. As a result, ink flows into the pressure generating chamber 14 through the ink supplying ports 13, and the ink within the pressure generating chamber 14 is pressurized and forcibly discharged in the form of an ink drop through the nozzle orifice 17.

[0027] Figs. 5 through 7 exemplarily show a method of manufacturing piezoelectric vibration elements 5 thus structured. As shown, a green sheet 21 made of piezoelectric material is placed on a base plate 20 having a flat surface (Fig. 5(I)). The green sheet 21 is preliminarily prepared so as to have the width W2 which is some-

what longer than the width W1 (see Fig. 3) of a portion of the piezoelectric vibration element unit 1 where the piezoelectric vibration elements 5 and dummy piezoelectric elements 7 are formed (the width W1 being defined between the outer side surface of the one dummy piezoelectric element 7 and the outer side surface of the other dummy piezoelectric element 7), and to have a thickness equal to the piezoelectric material layer.

[0028] A conductive layer 22 which serves as the internal electrode 3 which is one of the coupled internal electrodes is formed on a surface of the green sheet 21 by use of a mask with a pattern having such a width W3 that the conductive layer 22 is located on the inner side with respect to the outer side surfaces of the dummy piezoelectric elements 7 but on the outer side with respect to the piezoelectric vibration elements 5 adjacent to the dummy piezoelectric elements 7 (Fig. 5(II)). Then, another green sheet 21, which is made of piezoelectric material and has the same size as of the former green sheet already stated, is layered on the conductive layer thus formed (Fig. 5(III)).

[0029] A conductive layer 23 which serves as the other internal electrode 4 is formed on a surface of the green sheet 21 by use of a mask with a pattern having such a width W3' that the conductive layer is located on the inner side with respect to the outer side surfaces of the dummy piezoelectric elements 7 but on the outer side with respect to the piezoelectric vibration elements 5 adjacent to the piezoelectric elements 7 (Fig. 6(I)). Then, another green sheet 21, which is made of piezoelectric material and has the same size as of the green sheet already stated, is layered on the conductive layer 23 thus formed (Fig. 6(II)).

[0030] A sequence of manufacturing steps mentioned above is repeated to form the required number of layers (Fig. 6(III)). The green sheets are dried, and then the resultant structure is sintered. External electrodes 24 and 25, which serve as electrodes used for the connection to a flexible cable 8, are formed on a surface of the structure by sputtering or vapor deposition process. A given dielectric polarization process is carried out by applying voltage to those electrodes 24 and 25. In this way, a piezoelectric vibrating plate 27 is manufactured. A non-vibration region, i.e. an inactive region, of the piezoelectric vibrating plate 27 is positioned to a fixing plate 28 and secured thereto by adhesive (Fig. 7(I)).

[0031] The piezoelectric vibrating plate is cut into a teeth shape or a comb shape with a cutting tool, for example, a wire saw, such that the cutting lines on both ends of the piezoelectric vibrating plate (i.e., the outermost cutting lines C in this embodiment) are located outside the conductive layers 22 and 23, and the width of the dummy piezoelectric elements 7 and the width of the piezoelectric vibration elements 5 are exactly secured. In the cutting process, the outermost cutting lines C are positioned in the regions which are made of only piezoelectric material, not including the conductive layers 22 and 23 (Fig. 8). Therefore, the cutting operation is

smoothly performed while being free from a slip caused by the presence of the metallic material. Thus, the piezoelectric vibrating plate 27 can be cut to have cut surfaces coincident in position with the intended cutting lines.

[0032] Finally, the remains 29 located at the outermost positions are removed, and here the piezoelectric vibration element unit 1 is completed (Fig. 7 (III)). Since the conductive layers 22 and 23 are not present in the remains, those remains are relatively low in strength, and accordingly, may be bent and removed easily.

[0033] In the above-mentioned manufacturing method, the electrodes 24 and 25 for the external connections are formed extending over the full width of the piezoelectric vibrating plate 27. As shown in Fig. 9, in a case where those electrodes 24 and 25 are formed to reach areas where dummy piezoelectric elements are to be formed but not to reach the outermost cutting lines C (i.e. each of those electrodes 24 and 25 are distanced laterally from the respective cutting lines C by width W4), the adverse effect by the hardness of the electrodes 24 and 25 is eliminated in the cutting process of the piezoelectric vibrating plate 27, so that a more smooth cutting operation is ensured. In the illustrated example in Fig. 9, the remains 29 (7') have been completely removed.

[0034] In the embodiment mentioned above, the piezoelectric vibrating plate 27 has such a size as to allow one piezoelectric vibration element unit to be formed. In case where a plurality of piezoelectric vibration element units are formed from a large piezoelectric vibrating plate, the region not including the internal electrodes may be located in each boundary region at which one of the piezoelectric vibration units is separated from another adjacent one of the piezoelectric vibration units.

[0035] Fig. 10 shows another embodiment of a piezoelectric vibration element unit having a (second) piezoelectric constant d33 which is formed with piezoelectric vibration elements 33 each including internal electrodes 30 and 31 layered in the longitudinal direction of the piezoelectric vibration element 33. The internal electrodes 30 and 31 with different poles are arranged such that those electrodes overlap with each other in the vibrating region with the piezoelectric material 32 being interposed therebetween (Fig. 10B), and that the internal electrodes 30 is exposed on the side face of the top and bottom portions of the piezoelectric element 33, whereas the internal electrodes 31 is exposed on the opposite side face of the top and bottom portions thereof. Those piezoelectric vibration elements 33 are fixed onto a fixing plate 34 while being arrayed at fixed pitches along the fixing plate 34. Dummy piezoelectric elements 35 are located at both the ends of the array of the piezoelectric vibration elements 33, respectively. The remains 35' of the dummy piezoelectric elements 35 are present outside the dummy piezoelectric elements 35.

[0036] Also in this embodiment, as shown in Fig. 10A, the electrodes are not present but only piezoelectric material 32 is present in the outside surfaces of the dummy

piezoelectric elements 35. That is, the piezoelectric vibrating plate to be cut into a teeth or comb shape does not have electrodes in regions, each extending by an amount of a width W5 inwardly from the corresponding outer surface of the plate. The slit S to be formed for the purpose of cutting out the dummy piezoelectric element 35 from the plate is located within the region.

[0037] In the above-mentioned embodiments, the internal electrodes are not formed in the remains 7', 35' of the dummy piezoelectric elements 7, 35. In an embodiment shown in Fig. 11, internal electrodes 3' and 4' are not present only in a region D of the dummy piezoelectric element 7 which is bent and cut to form the remain 7'. In this embodiment, a part of the dummy piezoelectric element 7 to be removed as a consequence of bending and cutting the element 7, i.e. a part of the dummy piezoelectric element 7 above the region D, is reinforced by an internal electrode 4'. Therefore, the dummy piezoelectric element 7 can be bent and cut exactly at an intended position to form the remain 7'. Further, a thickness of the piezoelectric vibrating plate can be uniform over its entire area, so that distortion and warp of the piezoelectric vibrating plate are minimized when it is sintered.

[0038] To provide the structure as shown in Fig. 11, the steps explained with reference to Figs. 5(II), 6(I) and 6(III) are modified preferably in the following manner: In each of the steps shown in Figs. 5(I) and 6(III), the conductive layer 22 formed on the green sheet 21 to extend across the cutting line C for defining the positioning reference surface and to have a laterally protruded conductive layer part 22'. The laterally protruded conductive layer part 22' corresponds to the internal electrode 3'. In the step shown in Fig. 6(I), the conductive layer 23 is formed on the green sheet 21 to extend across the cutting line C for defining the positioning reference surface and to have a laterally protruded conductive layer part 23'. The laterally protruded conductive layer part 23' corresponds to the internal electrode 4'.

[0039] In the embodiment shown in Fig. 11, the internal electrodes 3 and 4 appear on the outer side surface (i.e. the positioning reference surface) of the positioning dummy piezoelectric element 7. Of course, the embodiment shown in Fig. 11 may be modified so that no electrode appear on the outer side surface of the positioning dummy piezoelectric element 7 as shown in Fig. 4. To provide such a structure that the dummy piezoelectric element 7 to be bent and cut to form the remain 7' has the internal electrodes 3' and 4' while the internal electrodes 3, 4, 3' and 4' do not appear on the outer side surface of the piezoelectric element 7 used as the positioning member, the steps explained with reference to Figs. 5(II), 6(I) and 6(III) are modified preferably such that: In each of the steps shown in Figs. 5(I) and 6(III), additional conductive layers 22' are formed on the green sheet 21 adjacent to the conductive layer 22 to form the internal electrodes 3' as shown in Fig. 16, and in the step shown in Fig. 6(I), the additional conductive layers 23'

are formed on the green sheet 21 adjacent to the conductive layer 23 to form the internal electrodes 4' as shown in Fig. 17. As shown in Figs. 16 and 17, the cutting line C for defining the positioning reference surface is located between the additional conductive layer 22' and the conductive layer 22 and between the additional conductive layer 23' and the conductive layer 23. The steps explained with reference to Figs. 5(II), 6(I) and 6(III) may be modified such that: In each of the steps shown in Figs. 5(I) and 6(III), additional conductive layers 22' for forming the internal electrodes 3' located below the region D and additional conductive layers 23' for forming the internal electrodes 4' located above the region D are formed on the green sheet 21 adjacent to the conductive layer 22 as shown in Fig. 18, and in the step shown in Fig. 6(I), the additional conductive layers 22' for forming the internal electrodes 3' located below the region D and the additional conductive layers 23' for forming the internal electrodes 4' located above the region D are formed on the green sheet 21 adjacent to the conductive layer 23 as shown in Fig. 19. In Fig. 19, reference numeral R designates another conductive layer formed on the green sheet 21 to make the piezoelectric vibration plate uniform in thickness and reinforce the piezoelectric vibration plate. In addition, the conductive layers 22, 23, 22', 23' and R are the same in thickness.

[0040] In the embodiments mentioned above, the inkjet recording head is of the type in which the fluid channel unit containing ink confined therein is expanded and contracted externally. The present invention may likewise be applied to the inkjet recording head of the zale type in which spaces 41 each between adjacent piezoelectric vibration elements 40 are used as pressure generating chambers as shown in Fig. 12.

[0041] In this case, a region of the width W6, which consists of only piezoelectric material 43 and which does not include the internal electrodes 42, is formed, and a cutting line C is set in the region of the width W6 to form the outermost piezoelectric vibration element 40'. Similarly to the aforementioned embodiments, the outer surface of the outermost piezoelectric vibration element 40' does not have the internal electrodes 42 so that a width of the entire piezoelectric vibrating plate can be secured accurately.

[0042] Fig. 13 is a set of perspective views showing another method of manufacturing a piezoelectric vibration element unit according to the present invention. In this embodiment, dummy piezoelectric elements 7 are each formed by a combination of a piezoelectric vibrating plate and a second member.

[0043] Blocks 50, made of ceramic, e.g., alumina, or metal, e.g., stainless steel, are bonded to both side end surfaces of a piezoelectric vibrating plate 27, by adhesive layers being interlayered therebetween. In this case, external electrodes 24 and 25 serving as electrodes used for connecting to a flexible cable 8 have been formed on the surfaces of the piezoelectric vibrating plate 27. As shown in Fig. 14, each block 50 is slightly

thinner in thickness than the piezoelectric vibrating plate 27 by $\Delta G1$, and the distal end of each block 50 is slightly recessed toward a fixing plate 28 from the distal end of the piezoelectric vibration plate 27 by $\Delta G2$. The surfaces of the blocks 50, which face the fixing plate 28, are also secured thereto by use of adhesive layers (Fig. 13(I)).

[0044] In a case where the blocks 50 are made of conductive material, it is preferable that the internal electrodes are not exposed in the side end surfaces of the piezoelectric vibrating plate 27, as in the previously mentioned embodiments.

[0045] A dielectric polarization process is carried out in a manner that in this state, polarizing voltage applying electrodes having areas large enough to cover at least the piezoelectric vibrating plate 27 are brought into contact with the connection electrodes 24 and 25. It is noted here that the polarizing voltage applying electrodes reliably contact the piezoelectric vibrating plate 27 since the blocks 50 are each thinner than the piezoelectric vibrating plate 27.

[0046] After the polarizing process ends, the piezoelectric vibrating plate is cut into a teeth or comb shape with a cutting tool, e.g., a wire saw, such that both outermost cut lines C are set at the respective blocks 50, and the width of the dummy piezoelectric elements 7 and the width of the piezoelectric vibration elements 5 are exactly secured (Fig. 13(II)). The piezoelectric vibrating plate can be cut smoothly to have cut surfaces exactly along the intended cutting lines C since the blocks 50 are made of homogeneous material.

[0047] After the remains 50' of the blocks 50, which are located at the outermost ends of the array of the piezoelectric vibration elements, are removed, a piezoelectric vibration element unit is completed (Fig. 13(III)). Those remains can be removed relatively easily since those are made of homogeneous material.

[0048] The distal ends of the dummy piezoelectric elements 7 of the piezoelectric vibration element unit thus manufactured are regulated in position with respect to the distal end of the piezoelectric vibrating plate 27 formed highly accurately. Therefore, the dummy piezoelectric elements 7 can be used to position the piezoelectric vibration plate 27 to the fluid channel unit with high accuracy. Further, the dummy piezoelectric elements 7 are reinforced by the blocks 50 having a higher toughness than the piezoelectric material. Therefore, even if the piezoelectric vibration element unit is inserted into a head holder by using the outside surfaces of the blocks 50 as a reference, the piezoelectric element unit can withstand external forces applied during its assembling, whereby it will not be damaged.

[0049] While the blocks are provided on the piezoelectric vibrating plate having a (first) piezoelectric constant d31 in the above-mentioned embodiment, it may likewise be applied to the formation of the dummy piezoelectric elements when a piezoelectric vibrating plate of the piezoelectric constant d33 is cut into piezoelectric

vibration elements. That is, the blocks may be attached to the piezoelectric vibration plate after the piezoelectric vibration plate is subjected to the polarizing process and before the piezoelectric vibration plate is cut into piezoelectric vibration elements.

[0050] As shown in Fig. 4, a proximal end 7p of the dummy piezoelectric element 7 may be separated from a proximal end 5p of an adjacent piezoelectric element 5 and fixed with respect to the proximal end 5p of the adjacent piezoelectric element 5 through the fixing plate 6. Alternatively, as shown in Fig. 3, the proximal end 7p of the positioning dummy piezoelectric element 7 may be integral with the proximal end 5p of the adjacent active piezoelectric element 5 as long as the segment electrodes 4 in the positioning dummy piezoelectric element 7 is electrically insulated from the segment electrodes 4 in the adjacent active piezoelectric element 5. Similarly, the proximal ends 5p of the adjacent piezoelectric elements 5 may be separated one from the other, or integral together.

[0051] Although the embodiments of the present invention have been described with reference to a case that the present invention is applied to an arrangement of an inkjet recording head, the present invention should not be restricted thereto or thereby. For example, the present invention is applicable to various actuators, such as liquid ejection devices, that employ a piezoelectric vibration element or piezoelectric vibration elements.

Claims

1. A piezoelectric vibration element unit (1) including:

a substrate (6); and
a plurality of axially expandable piezoelectric vibration elements (5) arranged on the substrate (6) to form an array, each of the piezoelectric vibration elements (5) being formed of piezoelectric material (P) and having internal electrodes (3, 4) that are alternately layered, wherein a dummy piezoelectric vibration element (7) is provided at least at one end of the array of the piezoelectric vibration elements (5),

characterized in that

a region not including the internal electrodes (3, 4) is provided in the vicinity of a side surface of the dummy piezoelectric vibration element (7).

2. A piezoelectric vibration element unit in accordance with claim 1, wherein the side surface of the dummy piezoelectric vibration element (7) is formed of only the piezoelectric material (P).

3. A piezoelectric vibration element unit in accordance

with claim 1, wherein each of said piezoelectric vibration elements (40) has a first piezoelectric constant (d31) and is arranged so that the internal electrodes (42) extend parallel to an axial direction, the internal electrodes (42) of a first set are exposed only on a first axial end face of the piezoelectric vibration element (40), the internal electrodes of a second set different in polarity from the first set are exposed only on a second, opposite axial end face thereof, and the internal electrodes of the first and second sets overlap in a vibrating region of the piezoelectric vibration element (40) with the piezoelectric material (43) interposed therebetween.

4. A piezoelectric vibration element unit in accordance with claim 1, wherein each of said piezoelectric vibration elements (33) has a second piezoelectric constant (d33) and is arranged so that the internal electrodes (30, 31) extend perpendicular to an axial direction, the internal electrodes (30) of the first set are exposed only on a first side face of the piezoelectric vibration element (33), the internal electrodes (31) of a second set different in polarity from the first set are exposed only on a second, opposite side face thereof, and the internal electrodes (30, 31) of the first and second sets overlap in a vibrating region of the piezoelectric vibration element (33) with the piezoelectric material (32) interposed therebetween.

5. A piezoelectric vibration element unit in accordance with claim 1, wherein a remaining piece (7') is present outside the dummy piezoelectric element (7).

6. A piezoelectric vibration element unit in accordance with claim 1, wherein external electrodes (9, 10) are formed which connect the internal electrodes (3, 4) to signal supplying means (8).

7. A piezoelectric vibration element unit in accordance with claim 6, wherein the external electrodes (24, 25) formed on the dummy piezoelectric element are narrower in width than said dummy piezoelectric element.

8. A piezoelectric vibration element unit in accordance with claim 1, wherein a block (50) is disposed on the outer side surface of the dummy piezoelectric element (7).

9. A piezoelectric vibration element unit in accordance with claim 8, wherein a thickness of the block (50) is less ($\Delta G1$) than a thickness of the piezoelectric vibration element (5), and a distal end of the block (50) is recessed ($\Delta G2$) toward a fixing plate (28) from a distal end of the piezoelectric vibration element (5).

10. A piezoelectric vibration element unit in accordance with claim 8, wherein the block (50) is made of a material having a higher toughness than that of the piezoelectric material.
11. A piezoelectric vibration element unit in accordance with claim 8, wherein the block (50) is made of ceramic or metal.
12. A piezoelectric vibration element unit in accordance with claim 8, wherein a remaining piece (50') of the block (50) is present outside the dummy piezoelectric element (7).
13. An actuator comprising a piezoelectric vibration element unit in accordance with claim 1, wherein an outer side surface of the dummy piezoelectric element (7) forms a reference surface of homogeneous material for positioning the piezoelectric vibration element unit (1), thus forming a positioning member (7).
14. An actuator in accordance with claim 13, wherein the plurality of piezoelectric vibration elements (5) are fixed to a fixing plate (6) in a row, and the positioning member (7) is fixed to the fixing plate (6).
15. An actuator according to claim 14, wherein a positioning member (7) is disposed on each of opposite ends of the row of vibration elements (5) outside the outermost ones of the vibration elements in the direction of the row.
16. An actuator according to claim 14, wherein a proximal end (7p) of the positioning member (7) is integral with a proximal end (5p) of the outermost one of the vibration elements (5).
17. An actuator according to claim 14, wherein a proximal end (7p) of the positioning member (7) is separated from a proximal end (5p) of the outermost one of the vibration elements (5), but fixed with respect to the proximal end of the outermost one of the vibration elements (5) through the fixing plate (6).
18. An actuator according to claim 14, wherein the homogeneous material is lower in hardness than internal electrodes embedded in the piezoelectric vibration elements.
19. An actuator according to claim 14, wherein the homogeneous material includes one of piezoelectric material, ceramic, and metal.
20. An actuator according to claim 14, wherein internal electrodes (3', 4') are embedded in the positioning member (7) so as not to be exposed on the reference surface.
21. An actuator according to claim 14, wherein the reference surface is disposed to have a predetermined positional relationship to distal ends of the vibration elements (27, 5).
22. An actuator according to claim 14, wherein the positioning member has a piezoelectric inactive region extending over the entire length of the positioning member.
23. An actuator according to claim 14, wherein the reference surface is continuous with and perpendicular to a distal end face of the positioning member.
24. An inkjet recording head comprising a piezoelectric vibration element unit according to one of claims 1 - 12, further comprising pressure generating chambers (16), wherein each of the piezoelectric vibration elements (5) increases and decreases the volume of an associated one of the pressure generating chambers (16).
25. An inkjet recording head in accordance with claim 24, wherein the dummy piezoelectric element (7) is a positioning reference, the piezoelectric vibration element unit (1) is in contact with a fluid channel forming unit (11) through a head unit, the fluid channel forming unit (11) is a laminate including a fluid channel forming substrate (15) defining a reservoir (12), ink supplying ports (13) and pressure generating chambers (14), an elastic plate (16) which is in contact with a distal (5p) end of each piezoelectric vibration element (5) to increase and reduce the volumes of said pressure generating chambers (14), and a nozzle plate (18) which closes a surface of said fluid channel forming substrate (15) and has nozzle orifices (17) for ejecting ink droplets.
26. An inkjet recording head in accordance with claim 24, wherein the side surface of the dummy piezoelectric element (7) functions as a positioning reference between the piezoelectric vibration element unit (1) and a head holder (19).
27. A method of manufacturing a piezoelectric vibration element unit used for an inkjet recording head, comprising the steps of:
- alternately laminating conductive layers (22; 23) and piezoelectric material layers (21) so that each of said conductive layers is located inside of a cut line (C) along which a dummy piezoelectric element (7) is to be cut out, each of the piezoelectric material layers (21) having a predetermined size and a predetermined thickness;

sintering a laminated structure after the conductive layers (22; 23) and the piezoelectric layers (21) are laminated to a predetermined thickness;

forming external connection electrodes (24, 25) on surfaces of a sintered structure; and
fixing a non-vibration region of the sintered structure onto a fixing plate (28), and cutting a region of the structure where the conductive layers (22, 23) are formed therein into drive piezoelectric vibration elements (5), and cutting a region of the structure where the conductive layers (22, 23) are not formed into the dummy piezoelectric element (7).

28. A method in accordance with claim 27, further comprising a step of:

bending and removing a piezoelectric vibration element located outside the dummy piezoelectric vibration element.

29. A method of manufacturing a piezoelectric vibration element unit used for an inkjet recording head, comprising the steps of:

alternately laminating conductive layers and piezoelectric material layers, each of the piezoelectric layers having a predetermined size and a predetermined thickness;
sintering a laminated structure after the conductive layers and the piezoelectric layers are laminated to a predetermined thickness;
forming external connection electrodes (24, 25) on surfaces of a sintered structure to form a piezoelectric vibrating plate (27);
locating blocks (50) on respective side ends of the piezoelectric vibrating plate (27) and fixing a non-vibrating region of the piezoelectric vibrating plate (27) onto a fixing plate (28); and
cutting said piezoelectric vibrating plate (27) into piezoelectric vibration elements (5), and cutting the blocks (50) into dummy piezoelectric elements (7).

30. A method in accordance with claim 29, wherein the side portions of the piezoelectric vibration elements include electrically non-conductive layers.

31. A method in accordance with claim 29, further comprising a step of:

bending and removing blocks (50') located outside the dummy piezoelectric elements (7).

Patentansprüche

1. Piezoelektrische Schwingungselementeinheit (1), welche aufweist:

ein Substrat (6); und

mehrere in Axialrichtung expandierbare piezoelektrische Schwingungselemente (5), die auf dem Substrat (6) zur Ausbildung einer regelmäßigen Anordnung angeordnet sind, wobei jedes der piezoelektrischen Schwingungselemente (5) aus piezoelektrischem Material (P) besteht und interne Elektroden (3,4) aufweist, die abwechselnd geschichtet sind, und ein piezoelektrisches Attrappenschwingungselement (7) zumindest an einem Ende der regelmäßigen Anordnung der piezoelektrischen Schwingungselemente (5) vorgesehen ist,

dadurch gekennzeichnet, dass

ein Bereich, der nicht die internen Elektroden (3,4) enthält, in der Nähe einer Seitenoberfläche des piezoelektrischen Attrappenschwingungselements (7) vorgesehen ist.

2. Piezoelektrische Schwingungselementeinheit nach Anspruch 1, bei welcher die Seitenoberfläche des piezoelektrischen Attrappenschwingungselements (7) nur aus dem piezoelektrischen Material (P) besteht.

3. Piezoelektrische Schwingungselementeinheit nach Anspruch 1, bei welcher jedes der piezoelektrischen Schwingungselemente (40) eine erste piezoelektrische Konstante (d31) aufweist, und so angeordnet ist, dass die internen Elektroden (42) parallel zu einer Axialrichtung verlaufen, die internen Elektroden (42) einer ersten Gruppe nur auf einer ersten axialen Endoberfläche des piezoelektrischen Schwingungselements (40) frei liegen, die internen Elektroden einer zweiten Gruppe, deren Polarität von jener der ersten Gruppe verschieden ist, nur auf einer zweiten, entgegengesetzten axialen Endoberfläche des piezoelektrischen Schwingungselements frei liegen, und sich die internen Elektroden der ersten und der zweiten Gruppe in einem Schwingungsbereich des piezoelektrischen Schwingungselements (40) überlappen, wobei das piezoelektrische Material (43) dazwischen angeordnet ist.

4. Piezoelektrische Schwingungselementeinheit nach Anspruch 1, bei welcher jedes der piezoelektrischen Schwingungselemente (33) eine zweite piezoelektrische Konstante (d33) aufweist, und so angeordnet ist, dass die internen Elektroden (30,31) senkrecht zu einer Axialrichtung verlaufen, die in-

ternen Elektroden (30) der ersten Gruppe nur auf einer ersten Seitenoberfläche des piezoelektrischen Schwingungselements (33) frei liegen, die internen Elektroden (31) einer zweiten Gruppe, deren Polarität von jener der ersten Gruppe verschieden ist, nur auf einer zweiten, entgegengesetzten Seitenoberfläche des piezoelektrischen Schwingungselements frei liegen, und sich die internen Elektroden (30,31) der ersten und der zweiten Gruppe in einem Schwingungsbereich des piezoelektrischen Schwingungselements (33) überlappen, wobei das piezoelektrische Material (32) dazwischen angeordnet ist.

5. Piezoelektrische Schwingungselementeinheit nach Anspruch 1, bei welcher ein übrig bleibendes Stück (7') außerhalb des piezoelektrischen Attrappenelements (7) vorhanden ist. 15
6. Piezoelektrische Schwingungselementeinheit nach Anspruch 1, bei welcher externe Elektroden (9,10) vorgesehen sind, welche die internen Elektroden (3,4) mit einer Signalversorgungsvorrichtung (8) verbinden. 20
7. Piezoelektrische Schwingungselementeinheit nach Anspruch 6, bei welcher die externen Elektroden (24,25), die auf dem piezoelektrischen Attrappenelement vorgesehen sind, eine geringere Breite aufweisen als das piezoelektrische Attrappenelement. 25
8. Piezoelektrische Schwingungselementeinheit nach Anspruch 1, bei welcher ein Block (50) auf der Oberfläche an der Außenseite des piezoelektrischen Attrappenelements (7) angeordnet ist. 30
9. Piezoelektrische Schwingungselementeinheit nach Anspruch 8, bei welcher eine Dicke des Blocks (50) geringer ($\Delta G1$) als eine Dicke des piezoelektrischen Schwingungselements (5) ist, und ein distales Ende des Blocks (50) zu einer Befestigungsplatte (28) hin ausgenommen ($\Delta G2$) ist, von einem distalen Ende des piezoelektrischen Schwingungselements (5) aus. 35
10. Piezoelektrische Schwingungselementeinheit nach Anspruch 8, bei welcher der Block (50) aus einem Material besteht, das eine höhere Festigkeit aufweist als das piezoelektrische Material. 40
11. Piezoelektrische Schwingungselementeinheit nach Anspruch 8, bei welcher der Block (50) aus Keramik oder Metall besteht. 45
12. Piezoelektrische Schwingungselementeinheit nach Anspruch 8, bei welcher ein übrigbleibendes Stück (50') des Blocks (50) außerhalb des piezoelektri-

schen Attrappenelements (7) vorhanden ist.

13. Betätigungsglied mit einer piezoelektrischen Schwingungselementeinheit nach Anspruch 1, bei welchem eine Oberfläche an der Außenseite des piezoelektrischen Attrappenelements (7) eine Bezugsoberfläche aus homogenem Material zum Positionieren der piezoelektrischen Schwingungselementeinheit (1) bildet, wodurch ein Positionierungsteil (7) ausgebildet wird. 5
14. Betätigungsglied nach Anspruch 13, bei welchem die mehreren piezoelektrischen Schwingungselemente (5) an einer Befestigungsplatte (6) in einer Zeile befestigt sind, und das Positionierungsteil (7) an der Befestigungsplatte (6) befestigt ist. 10
15. Betätigungsglied nach Anspruch 14, bei welchem ein Positionierungsteil (7) an jedem von entgegengesetzten Enden der Zeile der Schwingungselemente (5) außerhalb der äußersten Schwingungselemente in Richtung der Zeile angeordnet ist. 15
16. Betätigungsglied nach Anspruch 14, bei welchem ein proximales Ende (7p) des Positionierungsteils (7) einstückig mit einem proximalen Ende (5p) des äußersten der Schwingungselemente (5) ausgebildet ist. 20
17. Betätigungsglied nach Anspruch 14, bei welchem ein proximales Ende (7p) des Positionierungsteils (7) von einem proximalen Ende (5p) des äußersten der Schwingungselemente (5) getrennt ist, jedoch in Bezug auf das proximale Ende des äußersten Schwingungselements (5) über die Befestigungsplatte (6) befestigt ist. 25
18. Betätigungsglied nach Anspruch 14, bei welchem das homogene Material eine niedrigere Härte aufweist als interne Elektroden, die in die piezoelektrischen Schwingungselemente eingebettet sind. 30
19. Betätigungsglied nach Anspruch 14, bei welchem das homogene Material entweder piezoelektrisches Material, Keramik, oder Metall ist. 35
20. Betätigungsglied nach Anspruch 14, bei welchem interne Elektroden (3',4') so in das Positionierungsteil (7) eingebettet sind, dass sie nicht auf der Bezugsoberfläche frei liegen. 40
21. Betätigungsglied nach Anspruch 14, bei welchem die Bezugsoberfläche so angeordnet ist, dass sie eine vorbestimmte Positionsbeziehung zu distalen Enden der Schwingungselemente (27,5) aufweist. 45
22. Betätigungsglied nach Anspruch 14, bei welchem das Positionierungsteil einen piezoelektrisch inak-

tiven Bereich aufweist, der sich über die gesamte Länge des Positionierungsteils erstreckt.

23. Betätigungsglied nach Anspruch 14, bei welchem die Bezugs-
oberfläche kontinuierlich mit und senkrecht zu einer distalen End-
oberfläche des Positionierungsteils verläuft. 5
24. Tintenstrahlaufzeichnungskopf mit einer piezoelektrischen Schwingungselementeinheit nach einem der Ansprüche 1 bis 12, welcher weiterhin Druckerzeugungskammern (16) aufweist, wobei jedes der piezoelektrischen Schwingungselemente (5) das Volumen einer zugehörigen Druckerzeugungskammer (16) erhöht und verringert. 10
25. Tintenstrahlaufzeichnungskopf nach Anspruch 24, bei welchem das piezoelektrische Attrappenelement (7) eine Positionierungsbezugsgröße ist, die piezoelektrische Schwingungselementeinheit (1) in Kontakt mit einer Fluidkanalaus-
bildungseinheit (11) über eine Kopfeinheit steht, die Fluidkanalaus-
bildungseinheit (11) ein Laminat ist, welches ein Fluidkanalaus-
bildungssubstrat (15) aufweist, das einen Vorratsbehälter (12) aus-
bildet, Tintenzufuhröffnungen (13) und Druckerzeugungskammern (14), eine elastische Platte (16), die in Kontakt mit einem distalen Ende (5p) jedes piezoelektrischen Schwingungselements (5) steht, um die Volumina der Druckerzeugungskammer (14) zu vergrößern und zu verkleinern, und eine Düsenplatte (18), welche eine Oberfläche des Fluidkanalaus-
bildungssubstrats (15) verschließt, und Düsenöffnungen (17) zum Ausspritzen von Tintentröpfchen aufweist. 15
26. Tintenstrahlaufzeichnungskopf nach Anspruch 24, bei welchem die Seitenoberfläche des piezoelektrischen Attrappenelements (7) als Positionierungsbezugsgröße zwischen der piezoelektrischen Schwingungselementeinheit (1) und einem Kopfhalter (19) dient. 20
27. Verfahren zur Herstellung einer piezoelektrischen Schwingungselementeinheit, die bei einem Tintenstrahlaufzeichnungskopf eingesetzt wird, mit folgenden Schritten: 25

abwechselndes Laminieren leitfähiger Schichten (22;23) und Schichten (21) aus piezoelektrischem Material auf solche Weise, dass jede der leitfähigen Schichten innerhalb einer Abschnidelinie (C) angeordnet ist, entlang welcher ein piezoelektrisches Attrappenelement (7) ausgeschnitten werden soll, wobei jede der Schichten (21) aus piezoelektrischem Material eine vorbestimmte Größe und eine vorbestimmte Dicke aufweist; 30

Sintern einer Laminatanordnung, nach dem die leitfähigen Schichten (22;23) und die piezoelektrischen Schichten (21) zu einer vorbestimmten Dicke zusammenlaminiert wurden;

Ausbildung externer Verbindungselektroden (24,25) auf Oberflächen einer gesinterten Anordnung; und

Befestigung eines nicht schwingenden Bereichs der gesinterten Anordnung auf einer Befestigungsplatte (28), und Schneiden eines Bereichs der Anordnung, in welcher die leitfähigen Schichten (22,23) vorgesehen sind, in piezoelektrische Schwingungsantriebs-
elemente (5), und Schneiden eines Bereichs der Anordnung, in welchem die leitfähigen Schichten (22,23) nicht vorgesehen sind, in das piezoelektrische Attrappenelement (7). 35

28. Verfahren nach Anspruch 27, mit dem weiteren Schritt, ein piezoelektrisches Schwingungselement zu biegen und zu entfernen, das außerhalb des piezoelektrischen Attrappenschwingungselements angeordnet ist. 40

29. Verfahren zur Herstellung einer piezoelektrischen Schwingungselementeinheit, die bei einem Tintenstrahlaufzeichnungskopf eingesetzt wird, mit folgenden Schritten: 45

abwechselndes Laminieren leitfähiger Schichten und Schichten aus piezoelektrischem Material, wobei jede der piezoelektrischen Schichten eine vorbestimmte Größe und eine vorbestimmte Dicke aufweist;

Sintern einer Laminatanordnung, nach dem die leitfähigen Schichten und die piezoelektrischen Schichten zu einer vorbestimmten Dicke zusammenlaminiert wurden;

Ausbildung externer Verbindungselektroden (24,25) auf Oberflächen einer gesinterten Anordnung zur Ausbildung einer piezoelektrischen Schwingungsplatte (27);

Anordnen von Blöcken (50) an jeweiligen Seitenenden der piezoelektrischen Schwingungsplatte (27), und Befestigen eines nicht schwingenden Bereichs der piezoelektrischen Schwingungsplatte (27) auf einer Befestigungsplatte (28); und

Schneiden der piezoelektrischen Schwingungsplatte (27) in piezoelektrische Schwingungselemente (5), und Schneiden der Blöcke (50) in piezoelektrische Attrappenelemente (7). 55

30. Verfahren nach Anspruch 29, bei welchem die Seitenabschnitte der piezoelektrischen Schwingungselemente elektrisch nicht leitende Schichten enthalten.
31. Verfahren nach Anspruch 29, mit dem weiteren Schritt, Blöcke (50'), die außerhalb der piezoelektrischen Attrappenelemente (7) angeordnet sind, zu biegen und zu entfernen.

Revendications

1. Unité d'élément de vibration piézoélectrique (1) comprenant :

un substrat (6); et
une multiplicité d'éléments de vibration piézoélectriques axialement expansibles (5) disposés sur le substrat (6) afin de former une rangée, chacun des éléments de vibration piézoélectriques (5) étant formé dans une matière piézoélectrique (P) et ayant des électrodes internes (3, 4) qui sont en couches alternées, un élément de vibration piézoélectrique factice (7) étant prévu au moins à une extrémité de la rangée des éléments de vibration piézoélectriques (5), **caractérisée en ce que** une zone ne comprenant pas les électrodes internes (3, 4) est prévue au voisinage d'une surface latérale de l'élément de vibration piézoélectrique factice (7).

2. Unité d'élément de vibration piézoélectrique selon la revendication 1, dans laquelle la surface latérale de l'élément de vibration piézoélectrique factice (7) est formée seulement dans la matière piézoélectrique (P).

3. Unité d'élément de vibration piézoélectrique selon la revendication 1, dans laquelle chacun desdits éléments de vibration piézoélectriques (40) a une première constante piézoélectrique (d31) et est disposé de telle sorte que les électrodes internes (42) s'étendent parallèlement à une direction axiale, les électrodes internes (42) d'un premier ensemble sont exposées seulement sur une première face d'extrémité axiale de l'élément de vibration piézoélectrique (40), les électrodes internes d'un deuxième ensemble d'une polarité différente du premier ensemble sont exposées seulement sur une deuxième face d'extrémité axiale opposée, et les électrodes internes des premier et deuxième ensembles se chevauchent dans une zone de vibration de l'élément de vibration piézoélectrique (40) avec la matière piézoélectrique (43) interposée entre elles.

4. Unité d'élément de vibration piézoélectrique selon la revendication 1, dans laquelle chacun desdits éléments de vibration piézoélectriques (33) a une deuxième constante piézoélectrique (d33) et est disposé de telle sorte que les électrodes internes (30, 31) s'étendent perpendiculairement à une direction axiale, les électrodes internes (30) du premier ensemble sont exposées seulement sur une première face latérale de l'élément de vibration piézoélectrique (33), les électrodes internes (31) d'un deuxième ensemble d'une polarité différente du premier ensemble sont exposées seulement sur une deuxième face latérale opposée, et les électrodes internes (30, 31) des premier et deuxième ensembles se chevauchent dans une zone de vibration de l'élément de vibration piézoélectrique (33) avec la matière piézoélectrique (32) interposée entre elles.

5. Unité d'élément de vibration piézoélectrique selon la revendication 1, dans laquelle une pièce restante (7') est présente à l'extérieur de l'élément piézoélectrique factice (7).

6. Unité d'élément de vibration piézoélectrique selon la revendication 1, dans laquelle sont formées des électrodes externes (9, 10) qui relient les électrodes internes (3, 4) à des moyens d'alimentation en signal (8).

7. Unité d'élément de vibration piézoélectrique selon la revendication 6, dans laquelle les électrodes externes (24, 25) formées sur l'élément piézoélectrique factice sont plus étroites en largeur que ledit élément piézoélectrique factice.

8. Unité d'élément de vibration piézoélectrique selon la revendication 1, dans laquelle un bloc (50) est disposé sur la surface latérale extérieure de l'élément piézoélectrique factice (7).

9. Unité d'élément de vibration piézoélectrique selon la revendication 8, dans laquelle une épaisseur du bloc (50) est inférieure ($\Delta G1$) à une épaisseur de l'élément de vibration piézoélectrique (5), et une extrémité distale du bloc (50) est renfoncée ($\Delta G2$) vers une plaque de fixation (28) par rapport à une extrémité distale de l'élément de vibration piézoélectrique (5).

10. Unité d'élément de vibration piézoélectrique selon la revendication 8, dans laquelle le bloc (50) est fabriqué dans une matière ayant une dureté plus grande que celle de la matière piézoélectrique.

11. Unité d'élément de vibration piézoélectrique selon la revendication 8, dans laquelle le bloc (50) est fabriqué en céramique ou en métal.

12. Unité d'élément de vibration piézoélectrique selon la revendication 8, dans laquelle une pièce restante (50') du bloc (50) est présente à l'extérieur de l'élément piézoélectrique factice (7).
13. Dispositif d'actionnement comportant une selon la revendication 1, dans lequel une surface latérale extérieure de l'élément piézoélectrique factice (7) forme une surface de référence de matière homogène pour le positionnement de l'unité d'élément de vibration piézoélectrique (1), en formant ainsi un élément de positionnement (7).
14. Dispositif d'actionnement selon la revendication 13, dans lequel la multiplicité d'éléments de vibration piézoélectriques (5) est fixée sur une plaque de fixation (6) en une rangée, et l'élément de positionnement (7) est fixé sur la plaque de fixation (6).
15. Dispositif d'actionnement selon la revendication 14, dans lequel un élément de positionnement (7) est disposé sur chacune des extrémités opposées de la rangée d'éléments de vibration (5) à l'extérieur de ceux les plus à l'extérieur des éléments de vibration dans la direction de la rangée.
16. Dispositif d'actionnement selon la revendication 14, dans lequel une extrémité proximale (7p) de l'élément de positionnement (7) fait partie intégrante d'une extrémité proximale (5p) de celui le plus à l'extérieur des éléments de vibration (5).
17. Dispositif d'actionnement selon la revendication 14, dans lequel une extrémité proximale (7p) de l'élément de positionnement (7) est séparée d'une extrémité proximale (5p) de celui le plus à l'extérieur des éléments de vibration (5), mais fixe par rapport à l'extrémité proximale de celui le plus à l'extérieur des éléments de vibration (5) par l'intermédiaire de la plaque de fixation (6).
18. Dispositif d'actionnement selon la revendication 14, dans lequel la matière homogène est d'une dureté plus faible que les électrodes internes noyées dans les éléments de vibration piézoélectriques.
19. Dispositif d'actionnement selon la revendication 14, dans lequel la matière homogène comprend une matière piézoélectrique, une céramique ou un métal.
20. Dispositif d'actionnement selon la revendication 14, dans lequel des électrodes internes (3', 4') sont noyées dans l'élément de positionnement (7) de façon à ne pas être exposées sur la surface de référence.
21. Dispositif d'actionnement selon la revendication 14, dans lequel la surface de référence est disposée de façon à avoir une relation de position prédéterminée par rapport aux extrémités distales des éléments de vibration (27, 5).
22. Dispositif d'actionnement selon la revendication 14, dans lequel l'élément de positionnement a une zone inactive piézoélectrique sur toute la longueur de l'élément de positionnement.
23. Dispositif d'actionnement selon la revendication 14, dans lequel la surface de référence est continue avec et perpendiculaire à une face d'extrémité distale de l'élément de positionnement.
24. Tête d'enregistrement à jet d'encre comportant une unité d'élément de vibration piézoélectrique selon une des revendications 1 à 12, comportant en outre des chambres de génération de pression (16), chacun des éléments de vibration piézoélectriques (5) augmentant et diminuant le volume d'une chambre associée des chambres de génération de pression (16).
25. Tête d'enregistrement à jet d'encre selon la revendication 24, dans laquelle l'élément piézoélectrique factice (7) est une référence de positionnement, l'unité d'élément de vibration piézoélectrique (1) est en contact avec une unité de formation de canal de fluide (11) par l'intermédiaire d'une unité de tête, l'unité de formation de canal de fluide (11) est un stratifié comprenant un substrat de formation de canal de fluide (15) définissant un réservoir (12), des orifices d'alimentation en encre (13) et des chambres de génération de pression (14), une plaque élastique (16) qui est en contact avec une extrémité distale (5p) de chaque élément de vibration piézoélectrique (5) afin d'augmenter et réduire les volumes desdites chambres de génération de pression (14), et une plaque de buse (18) qui ferme une surface dudit substrat de formation de canal de fluide (15) et a des orifices de buse (17) destinés à éjecter des gouttelettes d'encre.
26. Tête d'enregistrement à jet d'encre selon la revendication 24, dans laquelle la surface latérale de l'élément piézoélectrique factice (7) fonctionne comme une référence de positionnement entre l'unité d'élément de vibration piézoélectrique (1) et un support de tête (19).
27. Procédé de fabrication d'une unité d'élément de vibration piézoélectrique utilisée pour une tête d'enregistrement à jet d'encre, comportant les étapes consistant à :
- stratifier de manière alternée des couches conductrices (22; 23) et des couches de matière

piézoélectrique (21) de telle sorte que chacune desdites couches conductrices est disposée à l'intérieur d'une ligne de coupe (C) le long de laquelle un élément piézoélectrique factice (7) doit être découpé, chacune des couches de matière piézoélectrique (21) ayant une taille prédéterminée et une épaisseur prédéterminée;

fritter une structure stratifiée une fois que les couches conductrices (22; 23) et les couches piézoélectriques (21) sont stratifiées à une épaisseur prédéterminée;

former des électrodes de connexion externes (24, 25) sur des surfaces d'une structure frittée; et

fixer une zone sans vibration de la structure frittée sur une plaque de fixation (28), et découper une zone de la structure où les couches conductrices (22; 23) sont formées en éléments de vibration piézoélectriques d'entraînement (5), et découper une zone de la structure où les couches conductrices (22; 23) ne sont pas formées en élément piézoélectrique factice (7).

- 28.** Procédé selon la revendication 27, comportant en outre une étape consistant à :

plier et enlever un élément de vibration piézoélectrique disposé à l'extérieur de l'élément de vibration piézoélectrique factice.

- 29.** Procédé de fabrication d'une unité d'élément de vibration piézoélectrique utilisée pour une tête d'enregistrement à jet d'encre, comportant les étapes consistant à :

stratifier de manière alternée des couches conductrices et des couches de matière piézoélectrique, chacune des couches piézoélectriques ayant une taille prédéterminée et une épaisseur prédéterminée;

fritter une structure stratifiée une fois que les couches conductrices et les couches piézoélectriques sont stratifiées à une épaisseur prédéterminée;

former des électrodes de connexion externes (24, 25) sur des surfaces d'une structure frittée afin de former une plaque de vibration piézoélectrique (27);

disposer des blocs (50) sur des extrémités latérales respectives de la plaque de vibration piézoélectrique (27) et fixer une zone sans vibration de la plaque de vibration piézoélectrique (27) sur une plaque de fixation (28); et

découper ladite plaque de vibration piézoélectrique (27) en éléments de vibration piézoélectriques d'entraînement (5), et découper les blocs (50) en éléments piézoélectrique factices

(7).

- 30.** Procédé selon la revendication 29, selon lequel les parties latérales des éléments de vibration piézoélectriques comprennent des couches électriquement non conductrices.

- 31.** Procédé selon la revendication 29, comportant en outre l'étape consistant à :

plier et enlever des blocs (50') disposés à l'extérieur des éléments piézoélectriques factices (7).

FIG. 1

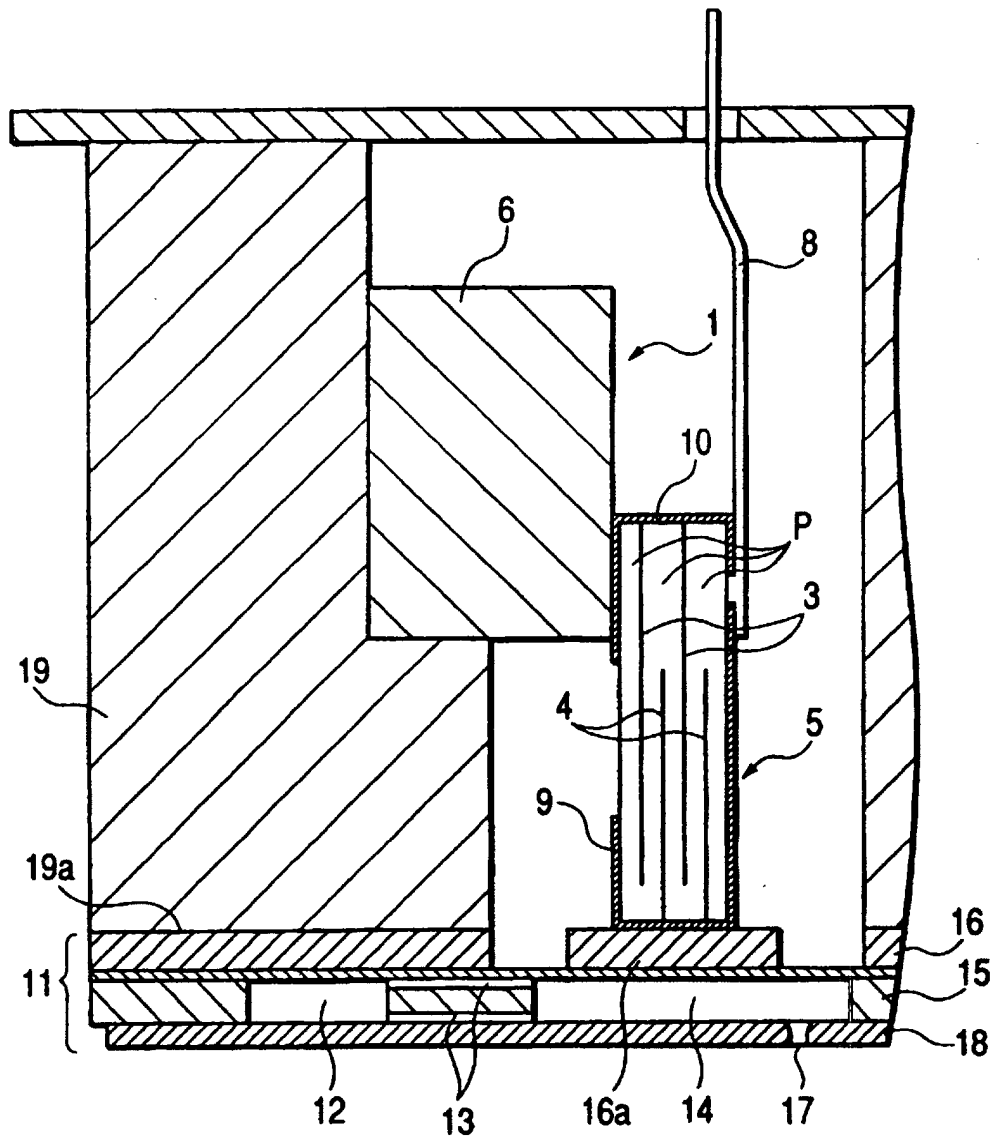


FIG. 2

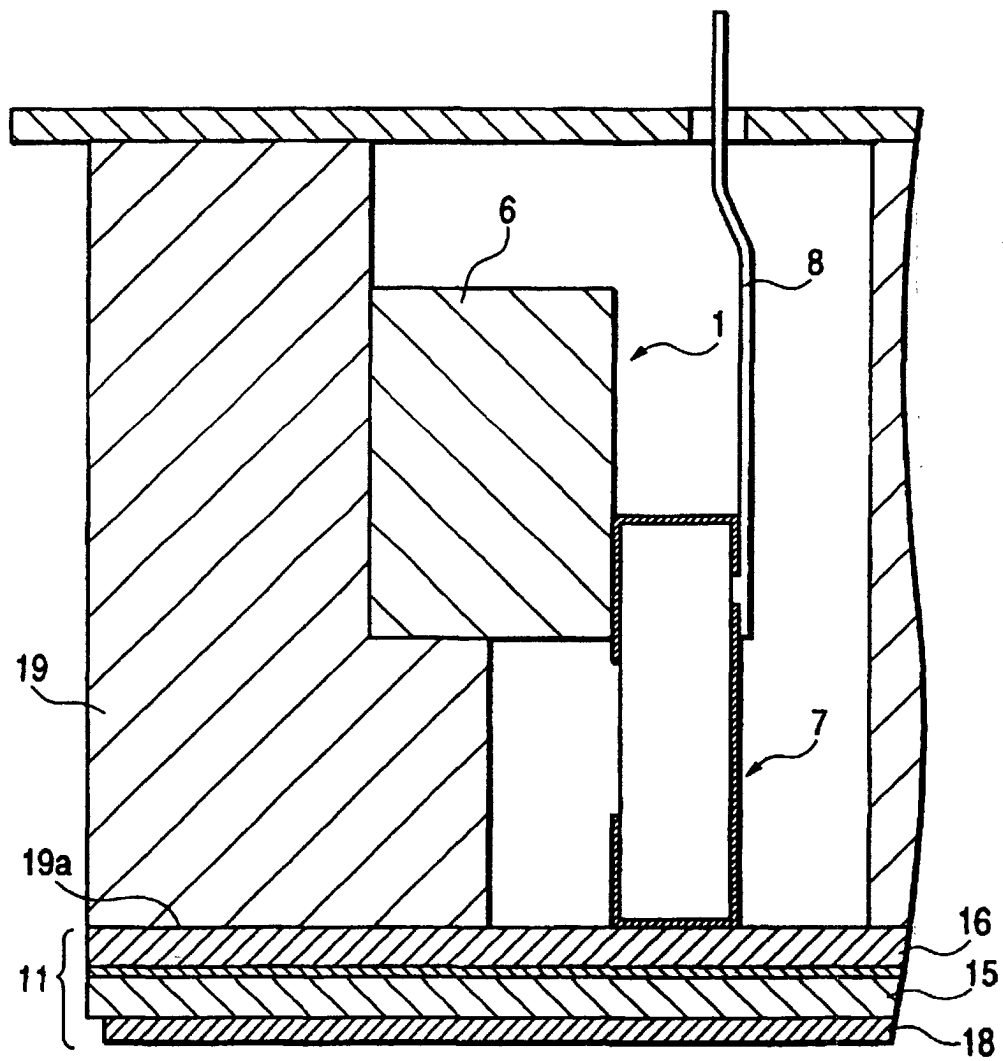


FIG. 3

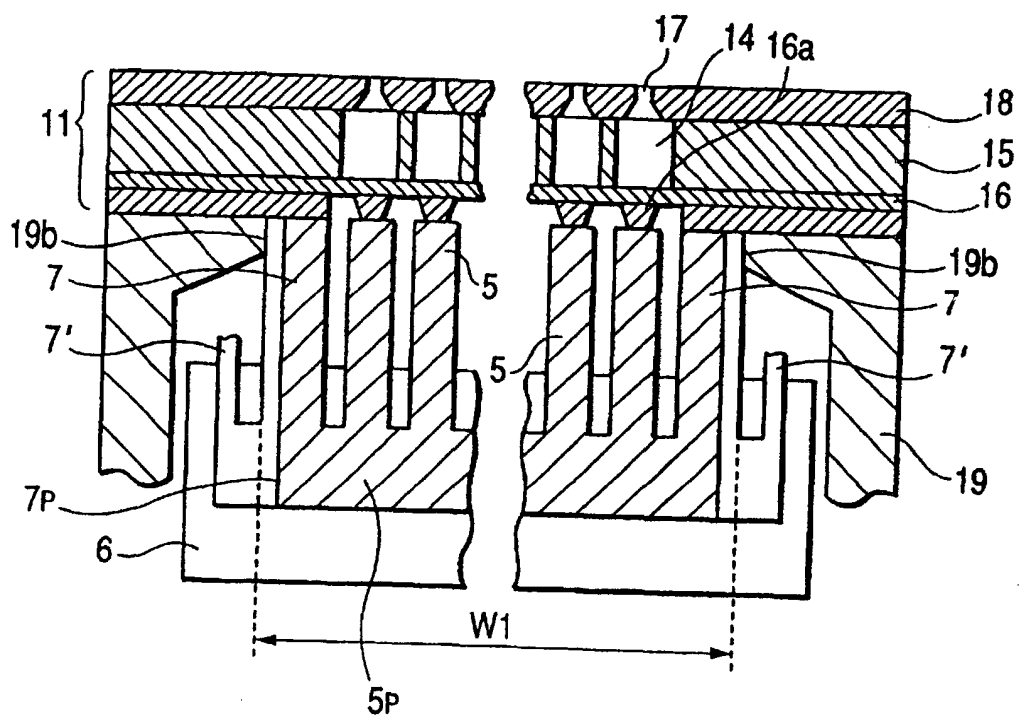


FIG. 4

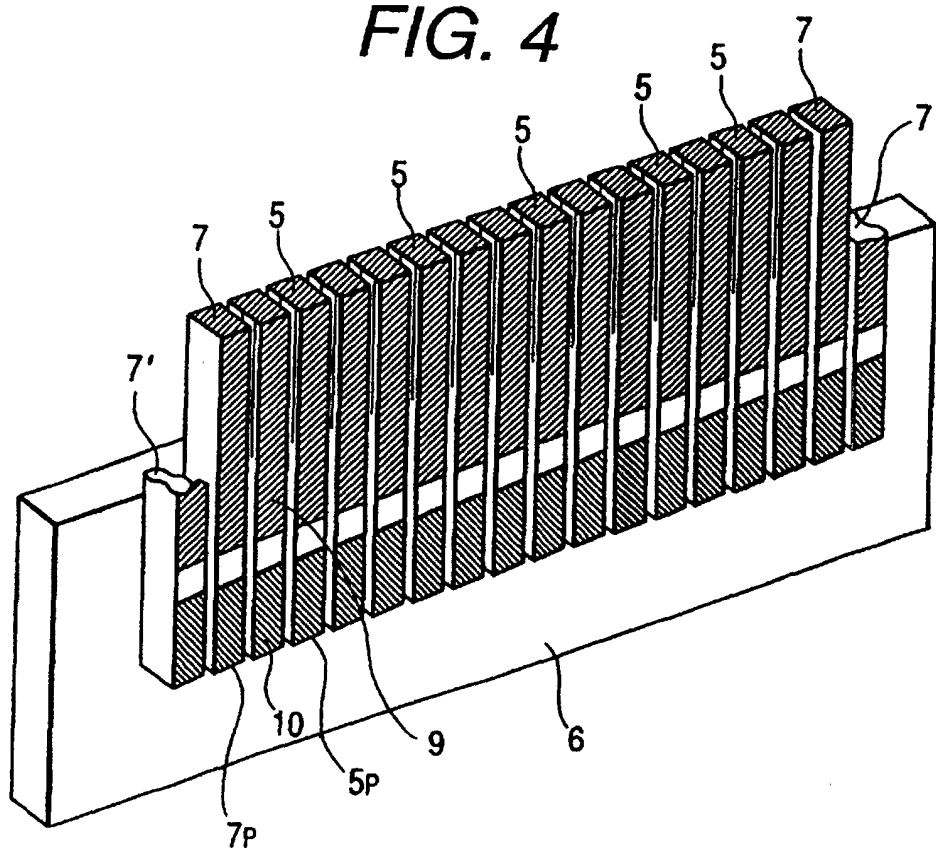


FIG. 5

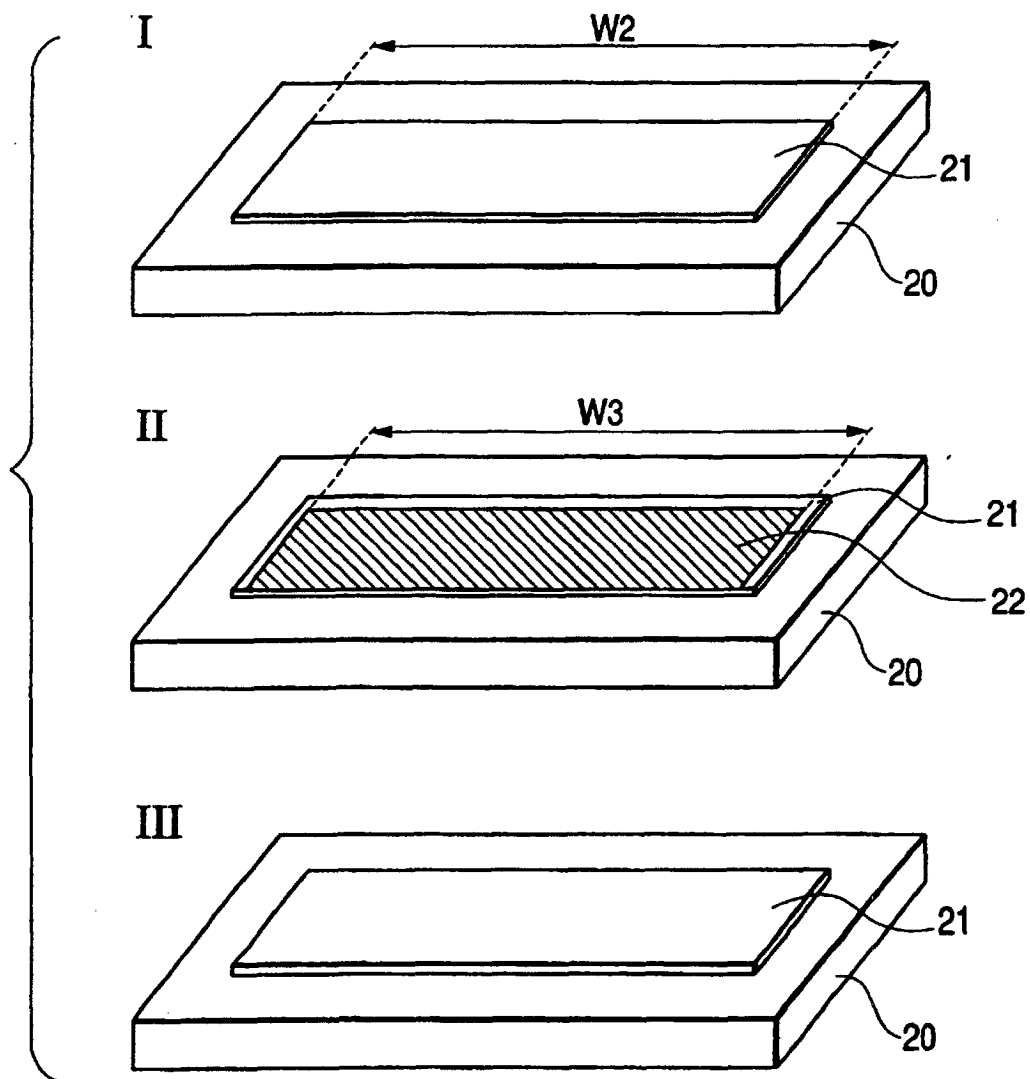


FIG. 6

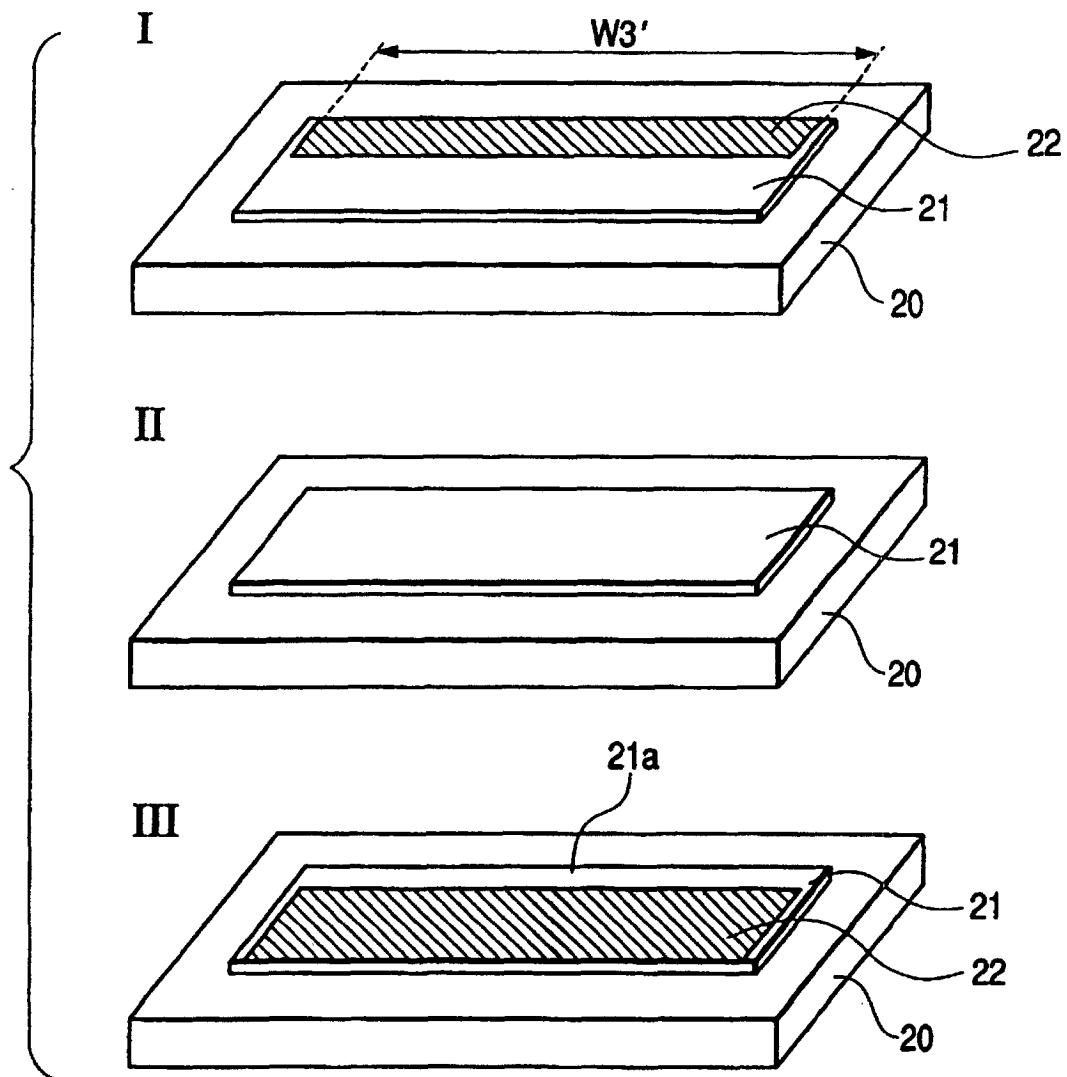


FIG. 7

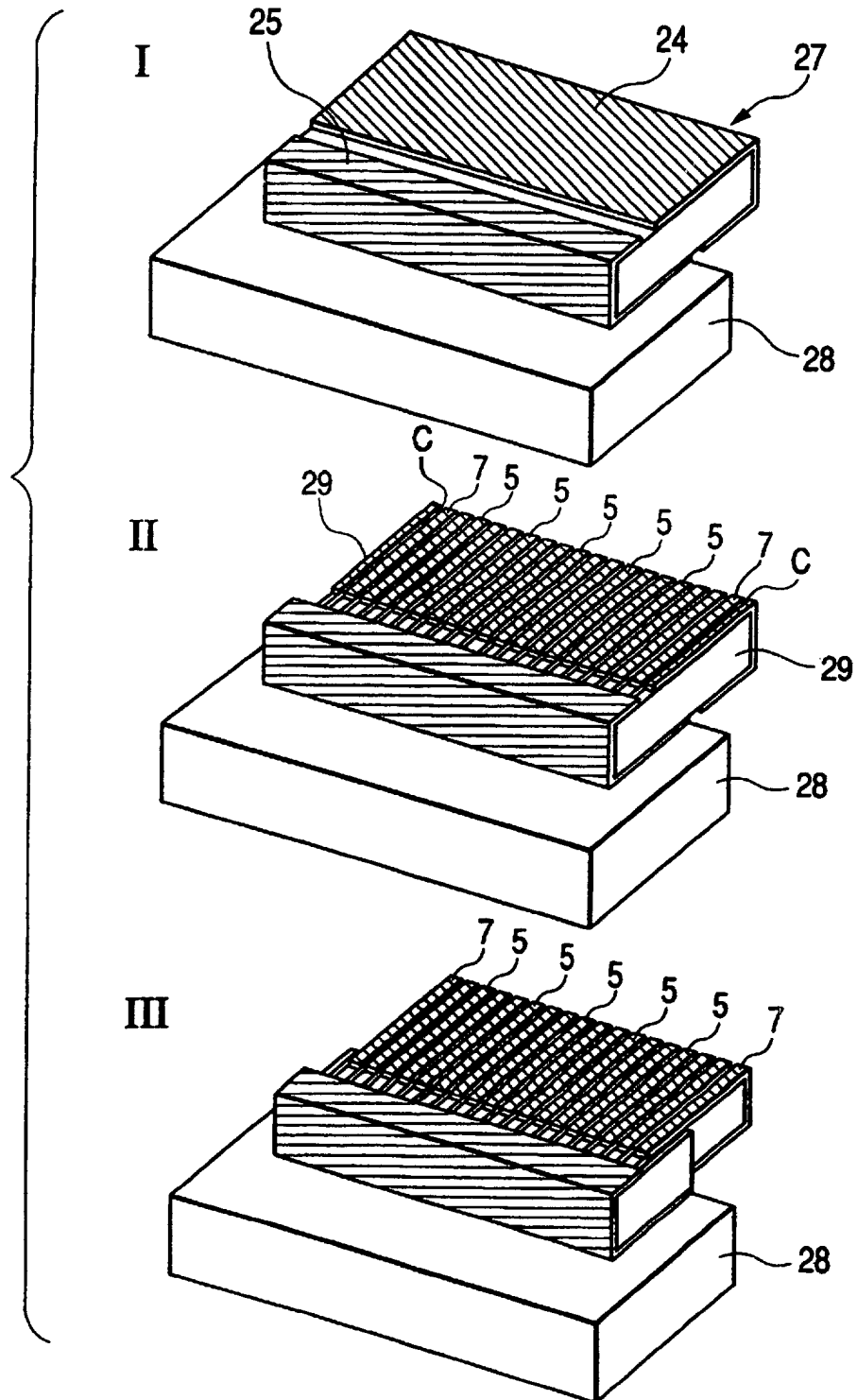


FIG. 8

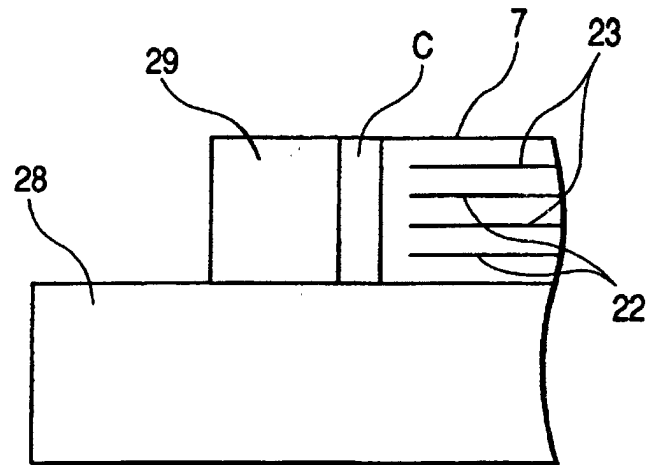


FIG. 9

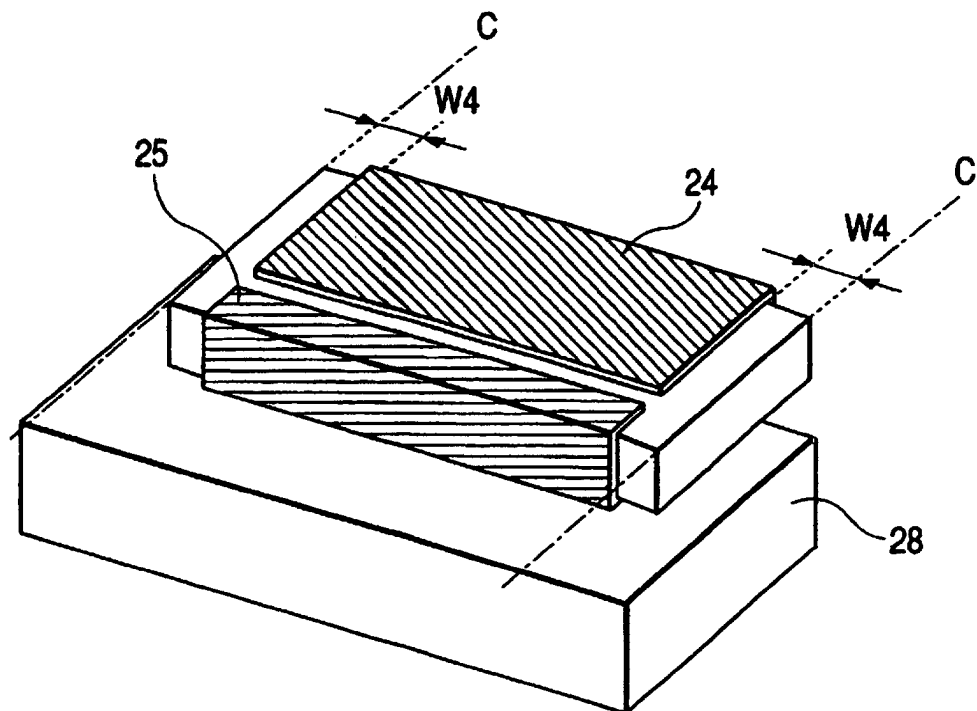


FIG. 10(A)

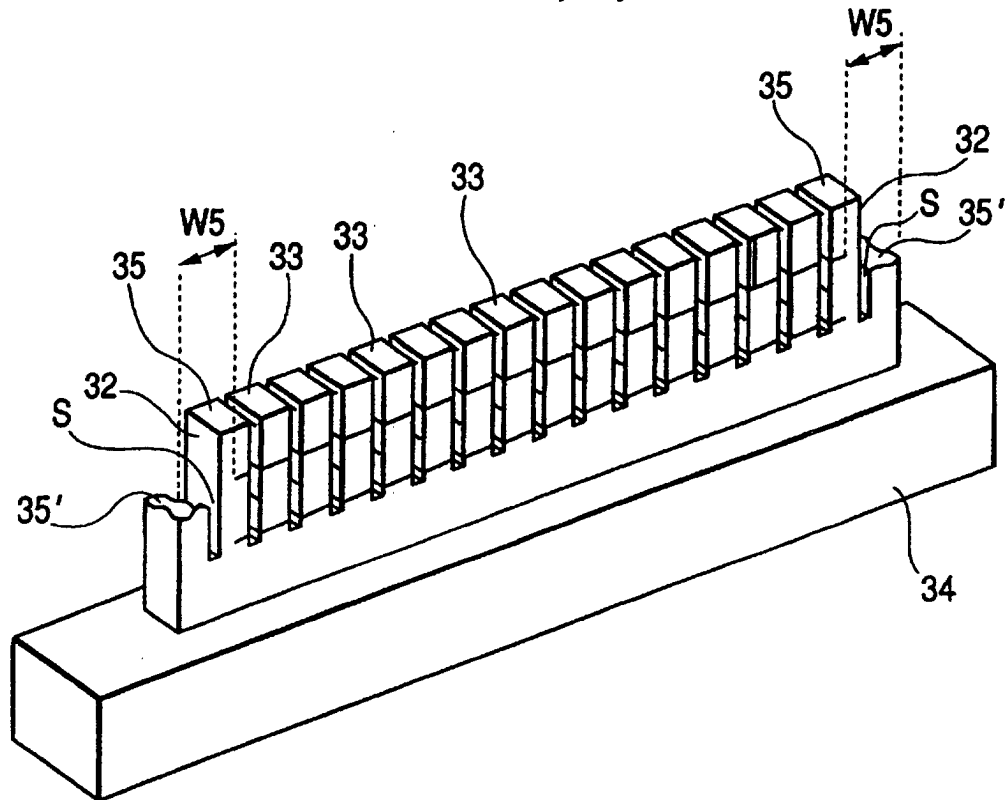


FIG. 10(B)

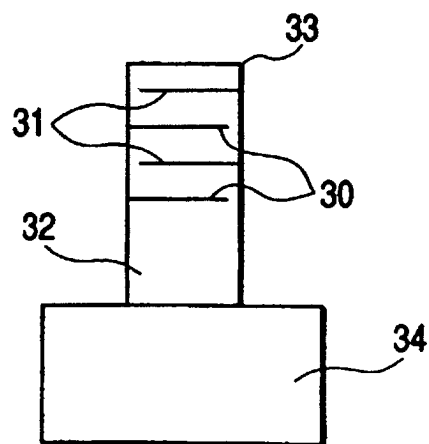


FIG. 11

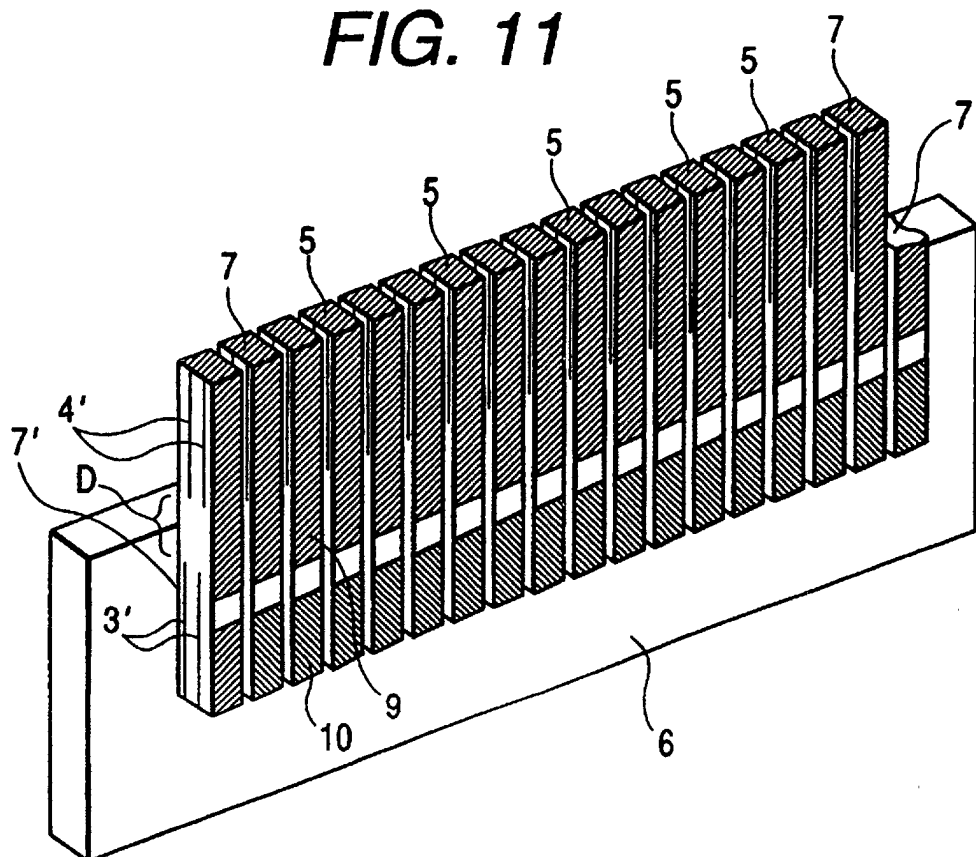


FIG. 12

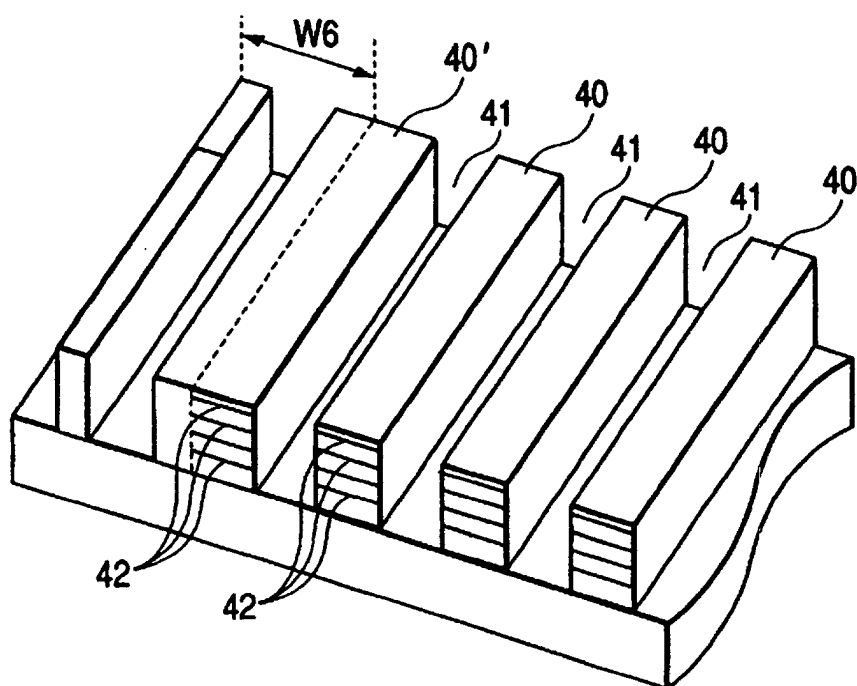


FIG. 13

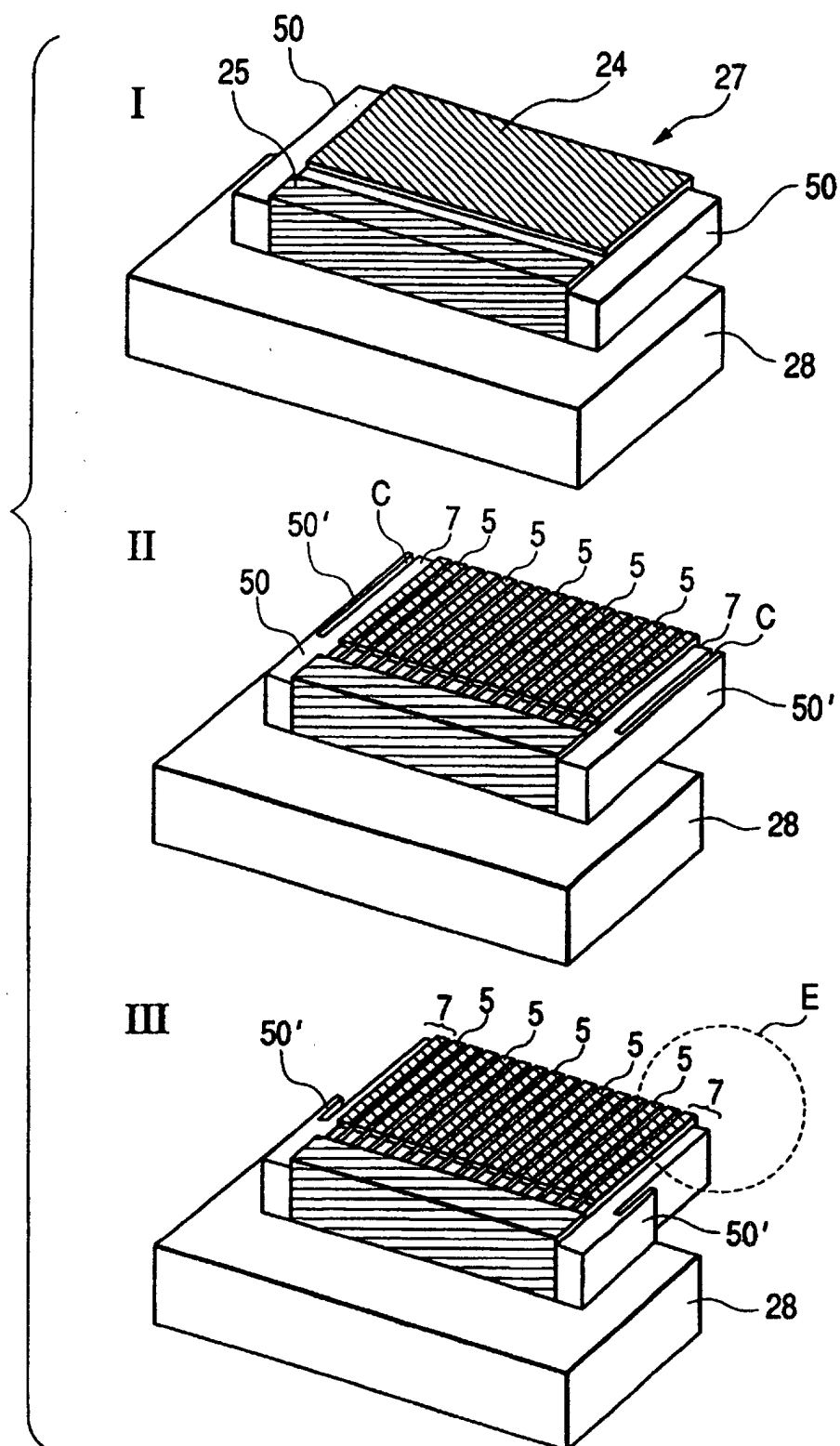


FIG. 14

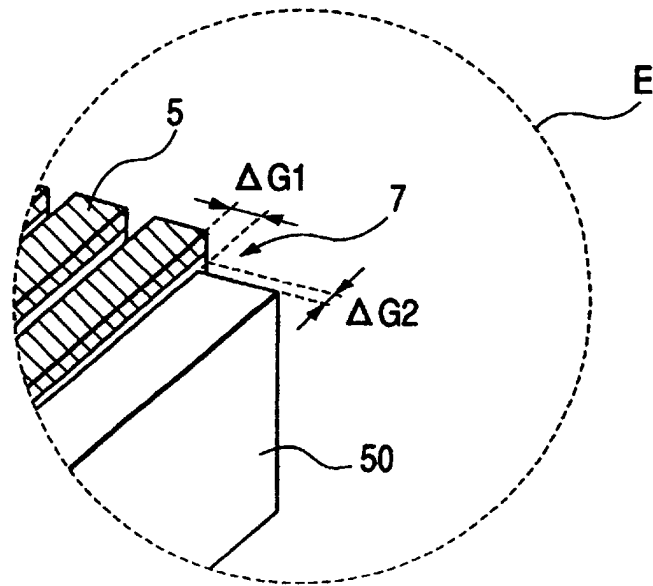


FIG. 15

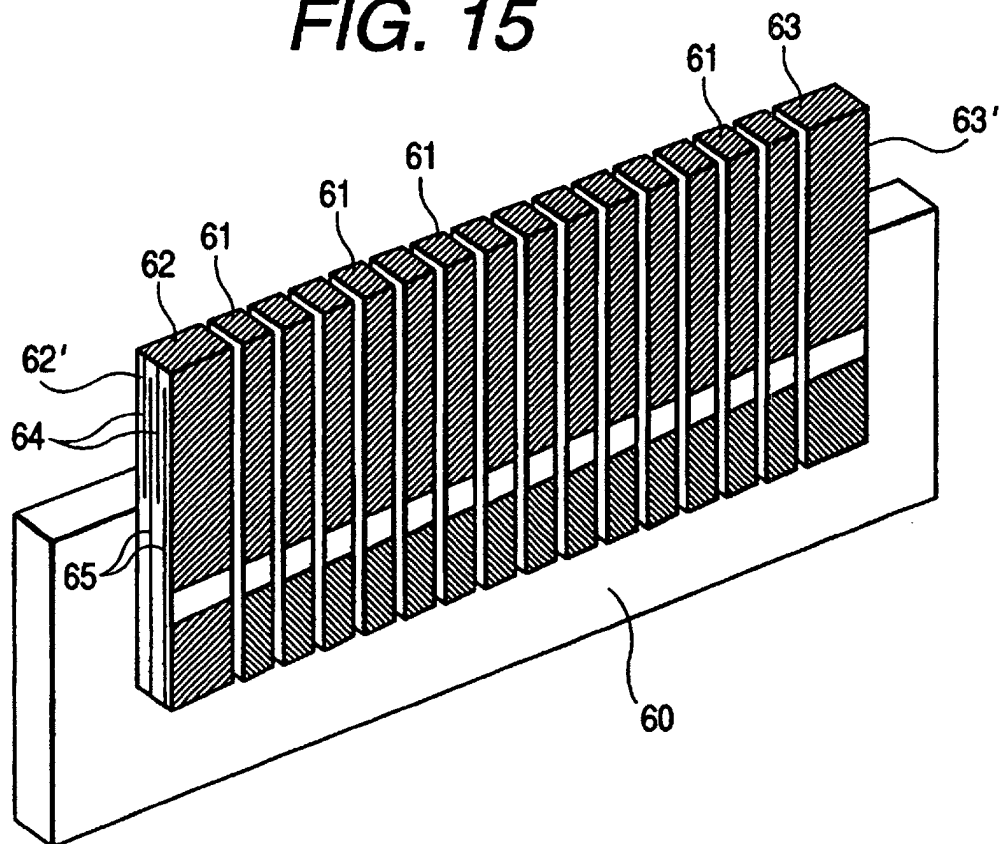


FIG. 17

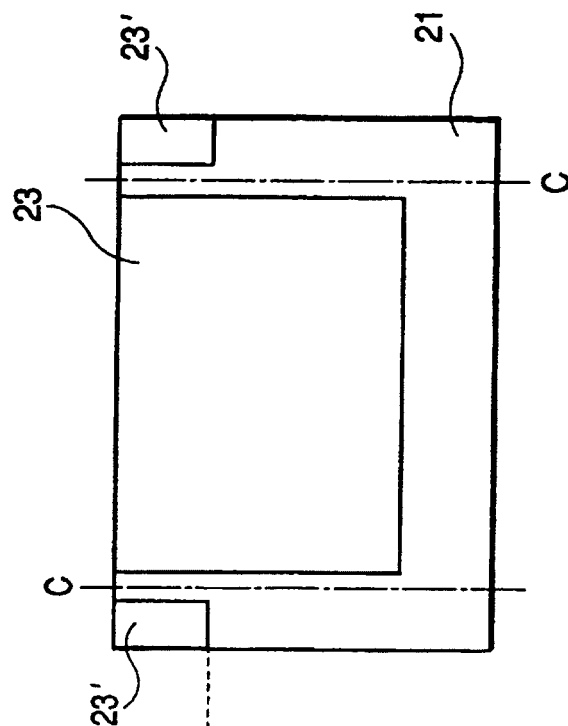


FIG. 16

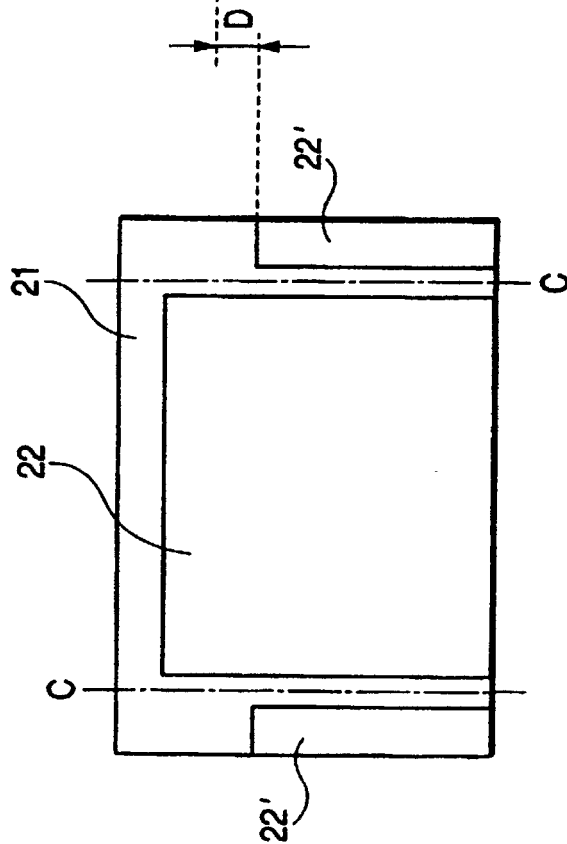


FIG. 18

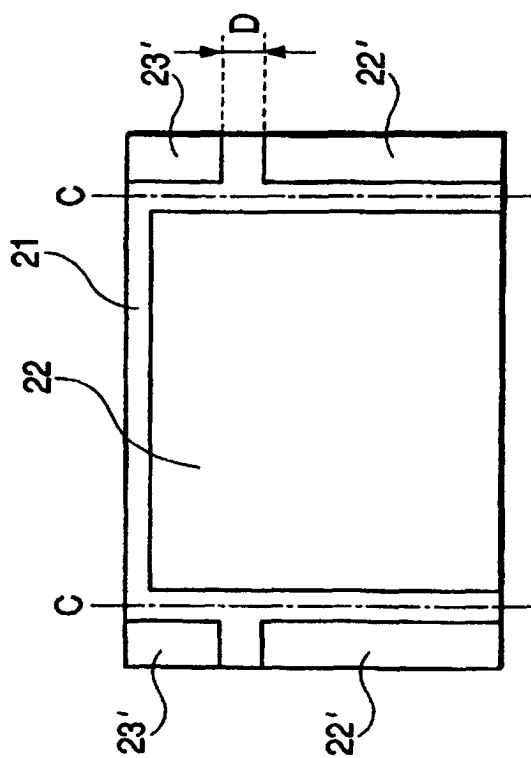


FIG. 19

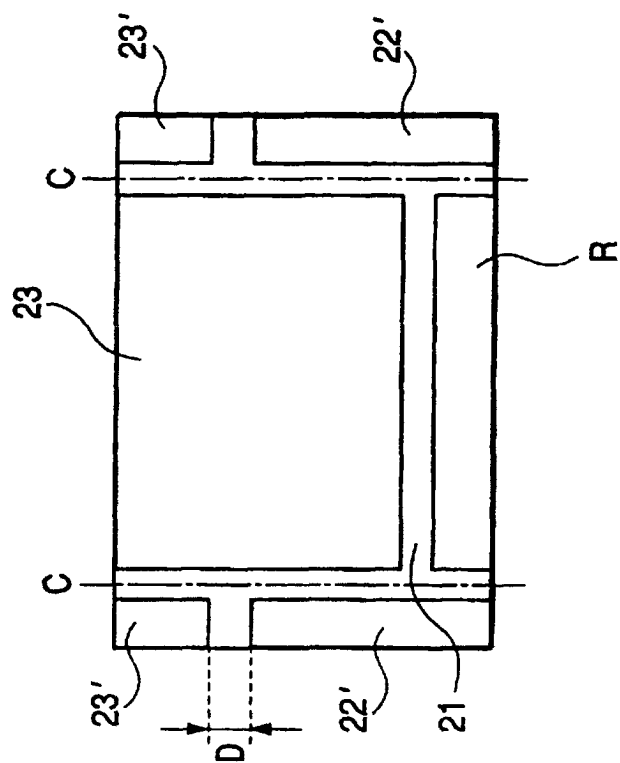


FIG. 21

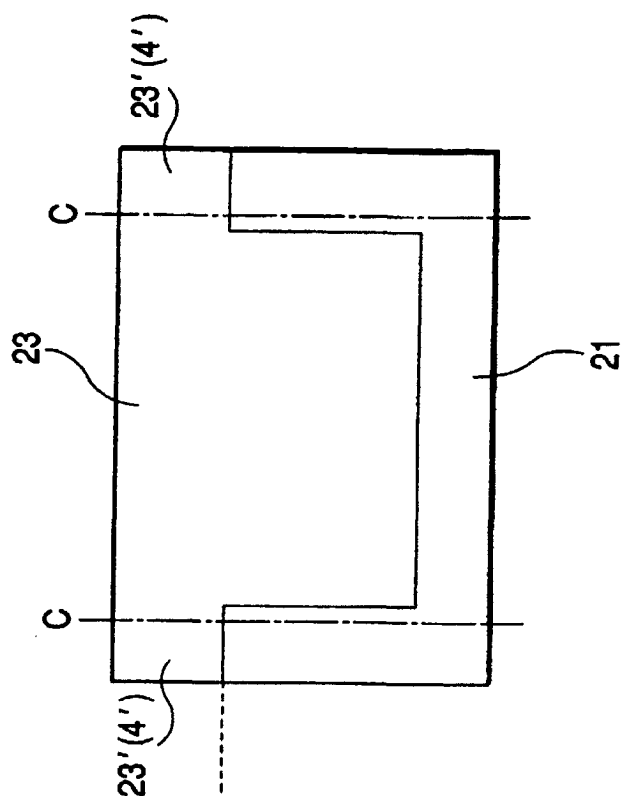


FIG. 20

