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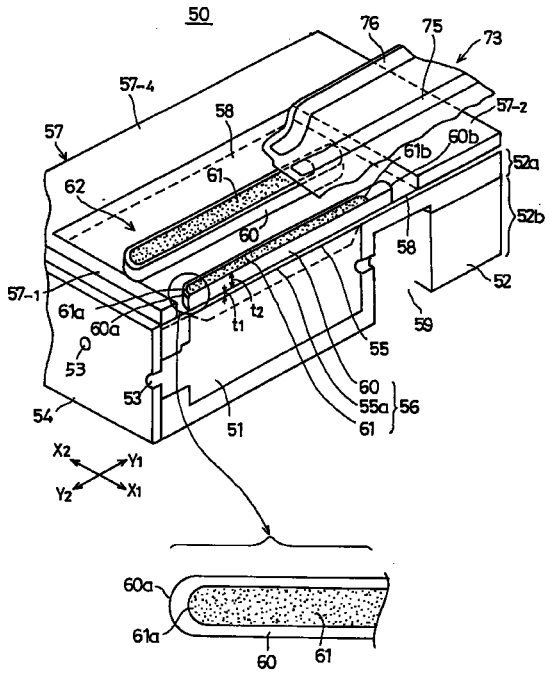
(54) Ink jet printer head and printer apparatus

(57) A piezo-electric reinforcing member surrounding a plurality of pressure generating units is formed in a thin vibrating chromium film membrane. The reinforcing member is not discrete but continuous with respect to a region of the membrane enclosing the pressure generating units. Within the membrane, thermal stress as well as stress caused by differences in the crystal structure of the piezo-electric member and the chromium film arise. The mechanical strength of the reinforcing member itself restrains the shrinkage of the vibrating membrane caused by the internal stress, thereby preventing cracks from occurring in the vibrating membrane. Likewise, the ends of the pressure generating components as well as the individual electrodes are shaped so as to make it difficult for stress to accumulate thereat, thereby also preventing cracks from occurring in the vibrating membrane.

FIG.4



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates generally an ink jet printer head and printer apparatus, and more particularly, to an ink jet printer head and printer apparatus for expelling ink by vibrating a vibrating membrane mounted as one wall of an ink-filled pressure chamber using a bimorph structure pressure generating device.

2. Description of the Related Art

[0002] FIG. 1 shows a conventional ink jet printer device 10. An ink jet printer head 11 is positioned between a feed roller 13 and an extract roller 14 and opposite the platen 15. The carriage 12 has ink tank 16, mounted so as to be movable in a direction perpendicular to the surface of the paper. The paper 17 is squeezed between a pinch roller 18 and the feed roller 13, and between the pinch roller 19 and the extract roller 14, and sent in the direction indicated by the arrow A in the diagram. The ink jet printer head 11 is activated, the carriage 12 is moved in a direction perpendicular to the surface of the paper 17 and the ink jet printer head 11 prints to the paper 17. The printed paper is then collected in a stacker 20.

[0003] With the increasing demand for energy-efficient personal computers in recent years there has been a similar increase in demand for energy-efficient peripheral devices, including energy-efficient ink jet printer apparatuses. In the case of a peripheral device such as an ink jet printer apparatus, such a device may be defined as one in which the semiconductor drive voltage is equal to or less than 20 V. At the same time, however, such an ink jet printer apparatus must also have provide high-resolution print. Accordingly, the diameter of the particles of ink expelled from the ink jet printer head 11 has been rapidly miniaturized. Additionally, the ink jet printer head 11 must not only satisfy the above requirements but must also be of a structure which can be mass-produced with a high degree of reliability.

[0004] FIG. 2 is a partial oblique cross-sectional view of a conventional ink jet printer head. As shown in the diagram, the ink jet printer head 30 comprises a metallic or plastic main unit 36 that has a plurality of pressure generating components 31 for expelling ink 31 (hereinafter pressure generating components), a plurality of nozzles 32 disposed in a nozzle plate 33, a vibrating membrane 34, and a plurality of pressure chambers 35 formed so that one pressure chamber 35 opposes each nozzle 32.

[0005] The pressure generating components 31 are provided on each of the pressure chambers 35 and comprise a long and slender piezo-electric pressure generating component main unit 37, a portion of the vibrating membrane positioned beneath the pressure generating component main unit 37 as well as an individual electrode 38 disposed on the pressure generating component main unit 37. The individual pressure generating components 31 are configured so as to form a bimorph structure consisting of the pressure generating component main unit 37 and that portion of the vibrating membrane 34 that is positioned beneath the pressure generating component main unit 40, so that when a drive signal is applied to the individual electrode from a controller not shown in the diagram the piezo-electric pressure generating component main unit 37 bends so as to shrink, causing the pressure generating component 31 to distort so as to protrude into the interior of the pressure chamber 35 as shown by the dotted line in FIG. 2, thus causing particles of ink within the pressure chamber 35 to be expelled from the nozzle 32. When a drive signal is no longer applied to the pressure generating component 31 the elasticity of the vibrating membrane 35 causes the vibrating membrane 35 to return to its normal flat condition, thus halting the expulsion of ink particles from the pressure chamber 35 via the nozzle 32.

[0006] It should be noted that the use of a combination of a piezo-electric pressure generating component main unit 37 and a thin vibrating membrane 34 as the vibrating member has made it possible to achieve both greater energy efficiency and higher resolution than with the conventional vibrating plate structure even with high electric field intensities generating large amounts of energy within the piezo-electric member.

[0007] The present inventors have previously proposed a method for manufacturing the ink jet printer head 30 described above. That method is shown in FIG. 3, with the ink jet printer head 30A being produced by a process the steps of which are shown in the diagram as A through G. Steps H and I depict the completed ink jet printer head 30A which will be fixedly mounted in place and to which a flexible cable terminal will be attached.

[0008] Initially, a platinum film is formed on a magnesium oxide substrate by spattering. The platinum film is subjected to patterning to form individual electrodes 38 in steps A and B, after which the piezo-electric member is formed by spattering, and the piezo-electric member is then patterned to form the pressure generating component main unit 37 in step C. Next, a polyimide layer 41 is formed on a top surface of the magnesium oxide substrate and the surface flattened as in step D. Chromium is then spattered on the top surface to form the chromium spattering film that constitutes the vibrating membrane 34 in a step E. A dry film 42 is then applied over the surface of the vibrating membrane 33 and pressure chambers 35 are formed on the dry film 42 at a position corresponding to the position of the pressure generating component main units 37 as shown in step F. Finally, the magnesium oxide substrate 40 is etched away in step G, thus forming the ink jet printer head 30A.

[0009] When the magnesium oxide substrate has been removed it may happen that cracks 45 occur in the vibrating membrane 35. When cracks 45 occur in the vibrating membrane 35 the pressure exerted into the pressure chamber 35 is released externally and is not communicated to the interior of the pressure chamber. As a result, not only is ink not expelled from the pressure chamber via the nozzle but ink may also leak from the crack and, since ink is electrically conductive, the electrical circuits may be short-circuited by the leaking ink.

[0010] It is supposed that cracks 45 are generated in the vibrating membrane 35 by the following mechanism.

[0011] Chromium is a metal and the piezo-electric member is a ceramic. Accordingly, the coefficient of thermal expansion of chromium is considerably larger than the coefficient of thermal expansion of the piezo-electric member. Thus the thermal stress caused by the large difference between the thermal expansion coefficient of chromium and the thermal expansion coefficient of the piezo-electric member together with the stress caused by the difference in crystal structure of chromium and the piezo-electric member are generated in the vibrating membrane 35 at step F as shown in FIG. 3, when the pressure chambers are formed in the vibrating membrane 35. The stress within the vibrating membrane 13 is chiefly stress in a lateral direction X identical to the direction of alignment of the pressure generating components disposed side by side. At this stage the magnesium oxide substrate 40 covers and restrains the entire surface of the vibrating membrane 35.

[0012] The dry film 42 is a resist, with a mechanical strength less than that of the chromium film which is a metal. Therefore it is difficult to hold the stress in check in the vibrating membrane by means of the dry film alone. Accordingly, once the magnesium oxide substrate is etched away the vibrating membrane 35 is released from restraint, force is exerted in the direction of the pull caused by the stress described above and this force causes cracks to appear in the vibrating membrane 35.

SUMMARY OF THE INVENTION

[0013] Accordingly, it is an object of the present invention to provide an ink jet printer head and printer apparatus in which the problem described above is solved.

[0014] The above-described object of the present invention is achieved by providing an ink jet printer head comprising:

a plurality of pressure chambers containing ink disposed side by side in a main unit so that each pressure chamber opposes a nozzle for jetting ink;
a vibrating membrane having a size corresponding to the main unit and mounted so as to cover the pressure chambers thereof, a portion of the membrane opposing each of the pressure chambers and forming one wall of each of the pressure chambers;
a plurality of pressure generating components which are disposed side by side on the vibrating membrane, and including a piezo-electric pressure generating component main unit and an individual electrode provided on the pressure generating component main unit; and
a reinforcing member for reinforcing the vibrating membrane composed of a piezo-electric member provided on a region of the vibrating membrane other than a region of the vibrating membrane corresponding to a location of the plurality of pressure generating components disposed side by side.

[0015] Further the above-described object of the present invention is also achieved by providing an ink jet printer head as described above, wherein the reinforcing member is not discrete but continuous within the region corresponding to the location of the plurality of pressure generating components.

[0016] By providing a continuous, uninterrupted piezo-electric reinforcing member as described above within the region of the vibrating membrane corresponding to the location at which the pressure generating components are to be formed, the retraction of the vibrating membrane caused by the stress can be restrained across the entire pressure generating component region, thereby preventing cracks from appearing in the vibrating membrane.

[0017] Further the above-described object of the present invention is also achieved by providing an ink jet printer head comprising:

a plurality of pressure chambers containing ink disposed side by side in a main unit so that each pressure chamber opposes a nozzle for jetting ink;
a vibrating membrane having a size corresponding to the main unit and mounted so as to cover the pressure chambers thereof, a portion of the membrane opposing each of the pressure chambers and forming one wall of each of the pressure chambers; and
a plurality of pressure generating components which are disposed side by side on the vibrating membrane and including a piezo-electric pressure generating component main unit and an individual electrode provided on the pressure generating component main unit; and
wherein end portions of each pressure generating component main unit are shaped in such a way that it is difficult for stress to concentrate thereat.

[0018] By providing an ink jet printer head wherein the pressure generating component main unit is shaped as described above, it is possible to prevent the appearance of cracks extending from the end portions of the

pressure generating components.

[0019] Additionally, the above-described object of the present invention is also achieved by providing an ink jet printer head comprising:

a plurality of pressure chambers containing ink disposed side by side in a main unit so that each pressure chamber opposes a nozzle for jetting ink;
a vibrating membrane having a size corresponding to the main unit and mounted so as to cover the pressure chambers thereof, a portion of the membrane opposing each of the pressure chambers and forming one wall of each of the pressure chambers; and
a plurality of pressure generating components which are disposed side by side on the vibrating membrane and including a piezo-electric pressure generating component main unit and an individual electrode provided on the pressure generating component main unit,
wherein end portions of each individual electrode are shaped in such a way that it is difficult for stress to accumulate thereat.

[0020] By providing an ink jet printer head wherein the electrodes are shaped as described above, it is possible to prevent the appearance of cracks extending from the end portions of the electrodes.

[0021] Further, the above-described object of the present invention is also achieved by providing a driving element for an ink jet printer head for expelling ink from an ink-filled pressure chamber by causing a volume of the pressure chamber to change, comprising:

a piezo-electric member and a vibrating membrane, the piezo-electric member and the vibrating membrane being deposited on a target substrate by using thin film forming techniques,
wherein the piezo-electric member comprises:
a pressure generating component for producing pressure with which to cause the volume of the pressure chamber to change; and
a continuous reinforcing member enclosing the region of the pressure generating components.

[0022] By providing a drive element for an ink jet printer head as described above, wherein a continuous reinforcing member encloses the region of the pressure generating components, it is possible to reinforce the entire periphery of the vibrating membrane enclosing the pressure generating components.

[0023] Additionally, the above-described object of the present invention is also achieved by providing a drive element for an ink jet printer head for expelling ink from an ink-filled pressure chamber by causing a volume of the pressure chamber to change, comprising:

a piezo-electric member and a vibrating membrane, the piezo-electric member and the vibrating membrane being deposited on a target substrate by using thin film forming techniques,
wherein the piezo-electric film comprises:
a pressure generating component for producing pressure with which to alter the volume of the pressure chamber, end portions of the pressure generating component being shaped in substantially a square, the corners of the square being shaped in such a way that stress is dissipated thereat.

[0024] By providing end portions of the pressure generating component shaped in substantially a square, the corners of the square being shaped in such a way that stress is dissipated thereat, cracks can be prevented from occurring at and extending from the corners of the square.

[0025] Other objects, features and advantages of the present invention will become more apparent from the following detailed description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026]

FIG. 1 is a schematic diagram of an essential part of a typical conventional ink jet printer device;
FIG. 2 is a partial oblique cross-sectional view of a conventional ink jet printer head;
FIG. 3 is a diagram explaining a method for manufacturing an ink jet printer head previously proposed by the present inventors;
FIG. 4 is a diagram of a first embodiment of an ink jet printer head according to the present invention;
FIG. 5 is a diagram of a printer apparatus mounting the first embodiment of the ink jet printer head according to the present invention;
FIG. 6A is a diagram of a top view of the first embodiment of the ink jet printer head according to the present invention;
FIG. 6B is a cross-sectional view taken along a line B-B shown in FIG. 6A;
FIG. 6C is a cross-sectional view taken along a line C-C shown in FIG. 6A;
FIG. 7 is a diagram showing steps in the manufacture of the first embodiment of the ink jet printer head according to the present invention;
FIG. 8 is a continuation of FIG. 7;
FIG. 9A is a plan view of a completed ink jet printer head;
FIG. 9B is a cross-sectional view taken along a line B-B shown in FIG. 9A;
FIG. 10 shows the point of separation between adjacent ink jet printer heads of an ink jet printer head block produced during manufacture of the ink jet printer head;
FIG. 11A is a diagram of a second embodiment of

an ink jet printer head according to the present invention;

FIG. 11B is a cross-sectional view taken along a line B-B shown in FIG. 11A;

FIG. 11C is a cross-sectional view taken along a line C-C shown in FIG. 11A;

FIG. 12 is a diagram of a third embodiment of an ink jet printer head according to the present invention;

FIG. 13 is a diagram of a fourth embodiment of an ink jet printer head according to the present invention; and

FIG. 14 is a diagram of a fifth embodiment of an ink jet printer head according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0027] A detailed description will now be given of a first embodiment of the present invention, with reference, initially, to FIG. 4 through FIG. 6A.

[0028] FIG. 4 is a diagram of a first embodiment of an ink jet printer head according to the present invention. The ink jet printer head 50 has a plurality of pressure chambers 51 each filled with ink, the pressure chambers being aligned in a lateral X1,X2 direction, the ink let printer head 50 further comprising a main unit 52 made of dry film on which is formed an ink canal 59 extending laterally in the X1,X2 direction, a nozzle plate 54 on which are formed nozzles 53 for expelling ink, a vibrating membrane 55 made of chromium film, a plurality of pressure generating components 56, a reinforcing frame member 57 and a polyimide layer 58.

[0029] The chromium film vibrating membrane 55, as will be explained later, is formed by a process of spattering and is extremely thin, having a thickness t1 of only 2 μm. The chromium film vibrating membrane 55 is fixedly formed on a top surface of the main unit 52 so as to cover each of the pressure chambers 51, that portion of the chromium film vibrating membrane 55 facing the pressure chamber 51 forming one wall of the pressure chamber 51.

[0030] The pressure generating components 56 are individually formed in the vibrating membrane and constitute a piezo-electric member. As will be explained later, the pressure generating components 56 are formed by a process of spattering, and are long and slender in shape and extended longitudinally in a Y1,Y2 direction. The pressure generating components 56 comprise a pressure generating component main unit 60 having an extremely thin thickness of approximately 3 μm, a portion 55a of the vibrating membrane on a bottom surface of the pressure generating component 60 and an individual thin platinum film electrode 61. The pressure generating component main unit 60 and that portion 55a of the vibrating membrane forming the bottom surface of the pressure generating component 60 together form the bimorph structure.

[0031] As is shown in enlarged fashion in FIG. 4, the pressure generating component main unit 60 has arc-shaped end portions 60a and 60b at either end. The individual electrode 61 similarly has arc-shaped end portions 61a and 61b at either end. These arc-shaped end portions 60a, 60b, 61a and 61b function to make it difficult for internal stress arising within the vibrating membrane 55 to concentrate.

[0032] FIG. 6A is a diagram of a top view of a first embodiment of the ink jet printer head according to the present invention, FIG.6B is a cross-sectional view taken along a line B-B shown in FIG.6A, and FIG. 6C is a cross-sectional view taken along a line C-C shown in FIG. 6A. As shown in the diagrams, there is a region 62 of the vibrating membrane within which the pressure generating components are formed, with a plurality of pressure generating components 56 shaped long and slender in the longitudinal Y1,Y2 direction and disposed side by side so as to be aligned in the lateral X1,X2 direction.

[0033] The reinforcing frame member 57 is piezo-electric and, as will be explained later, is formed by a process of spattering. The reinforcing frame member 57 comprises four continuous conjoined belts formed on the top surface of the vibrating membrane 55 so as to enclose the pressure generating component region in substantially a square as shown in FIG. 6A, including a first belt 57-1 extending in a lateral X1-X2 direction along a Y2 edge of the region of the vibrating membrane on which the pressure generating components are formed 62, a second belt 57-2 extending in a lateral X1-X2 direction along a Y1 edge of the region of the vibrating membrane on which the pressure generating components are formed 62, a third belt 57-3 extending in a Y1-Y2 direction along an X1 edge of the region of the vibrating membrane on which the pressure generating components are formed 62, and a fourth belt 57-4 extending in a Y1-Y2 direction along an X2 edge of the region of the vibrating membrane on which the pressure generating components are formed 62. The width a of the space 64 between the periphery of the region of the vibrating membrane on which the pressure generating components are formed 62 and the reinforcing frame member 57 is 200 μm.

[0034] The first and second belts 57-1 and 57-2 of the four belts 57-1 through 57-4 comprising the reinforcing frame member 57 are not interrupted but are instead continuous along the entire length L1 of the region of the vibrating membrane within which the pressure generating components are formed in the lateral X1,X2 direction. Similarly, the third and fourth belts 57-3 and 57-4 of the four belts comprising the reinforcing frame member 57 are not interrupted but are instead continuous along the entire length L2 of the region of the vibrating membrane within which the pressure generating components are formed in the longitudinal Y1,Y2 direction. The first and second belts 57-1 and 57-2, and the second and third belts 57-3 and 57-4, are connected so as to form a continuous reinforcing substantially square

frame member 57.

[0035] The reinforcing frame member 57, due to its mechanical strength, functions to restrain retraction of the vibrating membrane 55 caused by stress within the vibrating membrane 55. The first and second belts 57-1 and 57-2 restrain retraction of the vibrating membrane in the lateral X1,X2 direction and thereby prevent cracks from occurring in the longitudinal Y1,Y2 direction. The third and fourth belts 57-3 and 57-4 restrain retraction of the vibrating membrane in the longitudinal Y1,Y2 direction and thereby prevent cracks from appearing in the lateral X1,X2 direction.

[0036] As noted previously, a platinum film 63 is formed on the top surface of the reinforcing member 57. A polyimide layer 58 is formed on an inner side portion surrounded by the reinforcing member 57. As will be explained later, this polyimide layer 58 was formed in order to provide an undercoating when forming the thin chromium film vibrating membrane 55 by a process of spattering, and remains thereafter.

[0037] In addition to the four belts forming the continuous reinforcing member 57, the arc-shaped end portions 60a, 60b, 61a and 61b also serve to prevent the occurrence of cracks.

[0038] FIG. 5 is a diagram of a printer apparatus mounting the first embodiment of the ink jet printer head 50 according to the present invention. The ink jet printer head apparatus 70 comprises the above-described ink jet printer head 50, mounted on a forward portion of a top surface of a base 71 and a drive circuit board 72 having a semiconductor package 72a mounted on a rear portion of the base 71, a flexible cable 73 joining the ink jet printer head 50 and the drive circuit board 72.

[0039] The flexible cable 73, as shown in FIGS. 6A, 6B and 6C, comprises a plurality of individual electrode lines 75 and common electrode lines 76 formed on a bottom surface of a base film 74, the individual electrode lines 75 and common electrode lines 76 being covered by a cover film 77 except for both side edge portions. The common electrode lines 76 are disposed at both side edges in the lateral X1,X2 direction, with the Y1 ends of the common electrode lines 76 connected to a ground terminal. The Y1 end of the flexible cable is connected to the drive circuit board 72. As shown in FIG. 6A, the remaining Y2 end of the flexible cable 73 is connected so that the individual terminal lines 75 are connected to the edge of the individual electrode 61 and the common electrode lines 76 are connected to the vibrating membrane 55 via an opening 58a in the polyimide layer 58.

[0040] In the ink jet printer head 70, that is, the ink jet printer head 50 the structure of which has been described in detail above, when a drive signal from the drive circuit board 72 is applied to the individual electrodes 61 the piezo-electric pressure generating component main unit 60 retracts in the longitudinal Y1,Y2 direction so as to distort the bimorph structure pressure generating component 56 in such a way that the pressure generating component 56 projects into the interior of the pressure chamber 51 along the dotted line shown in FIG. 4, causing particles of ink to be expelled from the pressure chamber 51 via the nozzle 53. When a drive signal stops being supplied the elasticity of the vibrating membrane 55 causes the pressure generating component 56 to return to its normal flat condition.

[0041] It should be noted that both the vibrating membrane 55 and the pressure generating component main unit 60 are extremely thin, thus making it possible to achieve reductions in energy consumption during printing and also making it possible to achieve a high degree of print resolution by reducing the size of the particles of ink expelled from the nozzle 53 to approximately 2 pl, as compared to the typical 8 pl achieved by the conventional art.

[0042] As shown in FIG. 6A the common electrode line 76 is electrically connected to the platinum film 63 on the top surface of the reinforcing frame member 57 at location 78. Accordingly, the vibrating membrane 55 and the platinum film 63 between which the dielectric reinforcing frame member 57 is disposed have the same electric potential and the accumulation of a charge at the reinforcing frame member 57 can be avoided. Accordingly, the ink jet printer head 70, that is, the above-described ink jet printer head 50, does not experience electrical trouble due to charge accumulation at the reinforcing frame member 57.

[0043] A detailed description will now be given of a method for manufacturing the ink jet printer head 50 of FIG. 4, with reference to FIG. 7 and FIG. 8.

[0044] As shown in steps A and B in FIG. 7, a platinum film having a thickness of 0.2 μm is formed by a process of spattering on a clear, colorless magnesium oxide substrate 80, that is, a target substrate 80. This platinum film is then masked and a pattern etched thereon by a process of photo-etching to form the individual electrode 61 as well as the substantially rectangular platinum film 63. By adjusting the mask pattern as appropriate both ends of the individual electrode 61 can be shaped into arc-shaped portions 61a, 61b as shown in an enlarged version in step B of FIG 7.

[0045] Next, as shown in step C in FIG. 7, the piezo-electric member is formed as a piezo-electric film by a process of spattering so as to form a film having a thickness of 3 μm. The film is then masked and a pattern etched thereon by a process of photo-etching to form the pressure generating component main unit 60 and the reinforcing frame member 57. By adjusting the mask pattern as appropriate both ends of the pressure generating component main unit 60 can be shaped into arc-shaped portions 60a, 60b as shown in an expanded version in step C of FIG 7.

[0046] It should be noted that in the above-described process the reinforcing frame member 57 and the pressure generating component main unit 60 are formed together, eliminating the need for a separate step solely to form the reinforcing member. Therefore

the number of steps needed for the manufacturing method of the ink jet printer head 50 does not increase but remains the same as with the conventional method.

[0047] Next, as shown in step D in FIG. 7, the mask pattern is left in place and a flat polyimide layer 58 is formed by filling with a photosensitive polyimide resin, to a depth identical to the thickness of the pressure generating component main unit 60 and reinforcing frame member 57, the portion from which the photosensitive polyimide resin from which the piezo-electric member film has been removed, that is, the portion between adjacent pressure generating component main units 60 and the portion between the pressure generating component main units 60 and the inner periphery of the reinforcing member 60.

[0048] The mask pattern is then removed and, as shown in step E in FIG. 7, chromium is spattered on the surface in order to form the vibrating membrane 55, which is a chromium membrane having a thickness of 3 μm. Since the undercoating laid down previously as described above is flat the vibrating membrane 55 is also flat. It should be noted that, in step E of FIG. 7, a resinous portion except for the magnesium oxide substrate 80, that is, the target substrate, comprises a drive element 100.

[0049] Next, as shown in step A of FIG. 8, a dry film resist is laminated onto the vibrating membrane 55 at 35°C, 1m/min., 2.5 kgf/cm^2. Thereafter the laminated dry film resist is masked and exposed to light, and then developed in order to form the pressure chambers 51 at a position corresponding to the position of the pressure generating component main units 60, and then baked at 150°C for 14 hours to form the upper main unit 52a.

[0050] At this stage, the vibrating membrane 55 is subjected to thermal stress caused by the difference between the coefficient of thermal expansion of the chromium and the coefficient of thermal expansion of the piezo-electric member as well as to stress caused by the difference between the crystal structure of the chromium and the crystal structure of the piezo-electric member. This stress acts chiefly in the lateral X-axis direction, identical to the direction of alignment of the pressure generating component main units 60 disposed side by side.

[0051] Then the magnesium oxide substrate 80 is removed by using an acidic etching fluid as shown in FIG. 8 to obtain the completed ink jet printer head 81 depicted in FIGS. 9A and 9B.

[0052] The magnesium oxide substrate 80 functions as a substrate from step B in FIG. 7 through step A in FIG. 8, acting to restrain movement across the entire surface of the vibrating membrane 55. By removing this magnesium oxide substrate 80 the vibrating membrane 55 is released from this restraint and subjected to a force exerted in a pulling direction.

[0053] However, the effect of this force exerted on the vibrating membrane 55 in the pulling direction as described above is minimized by the restraint exerted by the reinforcing frame member 57 on the periphery of the vibrating membrane 55. Moreover, with the pressure generating component main units 60 having arc-shaped end portions 60a, 60b it is difficult for stress to accumulate at end portions of the pressure generating components 56. Further, with the individual electrodes 61 having arc-shaped end portions 61a, 61b it is difficult for stress to accumulate at end portions of the pressure generating components 56. Accordingly, cracks do not appear in the vibrating membrane 55.

[0054] Finally, as shown in step C of FIG. 8, the lower main unit 52b is attached to the upper main unit 52a of the partially completed ink jet printer head 81 so as to complete the ink jet printer head 50.

[0055] It should be noted that, during mass production, the ink jet printer head 50 is produced by first producing an ink jet printer head block 90 on which a plurality of ink jet printer heads 50 are disposed on a single substrate and then cutting the substrate into pieces so as to separate a number of individual ink jet printer heads. As shown in FIG. 10, the reinforcing frame members 57 are formed so as to leave a belt-like zone of separation 91 between adjacent reinforcing frame members 57. The cutting takes place at the belt-like zone of separation 91, at the location of the broken line 92. That is, the separation between printer heads takes place beyond the outer perimeter of any reinforcing frame member 57.

[0056] If the separation were to take place at the reinforcing member itself the shock of the separation would crack the reinforcing frame member 57, possibly causing a crack to appear in the vibrating membrane 55 as well. However, by carrying out the separation at a position removed from the reinforcing frame member 57 itself any cracking of the reinforcing frame member 57 can be avoided, thus avoiding the possibility of causing cracks in the vibrating member 55 as well.

[0057] It should be noted that the present invention is not limited to the embodiment described above. That is, the present invention is not limited to that which has a reinforcing frame member 57 and pressure generating component main units 60 and individual electrodes 61 with rounded ends.

[0058] In order to prevent the appearance of cracks in the vibrating membrane 55 it is effective to mount the reinforcing frame member 57 alone. Similarly, in order to prevent the appearance of cracks in the vibrating membrane 55 it is effective to alone have pressure generating component main units 60 having rounded end portions 60a, 60b, just as it is effective to have individual electrodes 61 having rounded end portions 61a, 61b.

[0059] Moreover, with respect to the reinforcing frame member 57, in order to prevent the occurrence of cracks in the vibrating membrane the use of only the first and second belts 57-1 and 57-2 is effective, as is the use of only the third and fourth belts 57-3 and 57-4, as is the use of only the first, third and fourth belts 57-1, 57-3 and 57-4.

[0060] A description will now be given of a second embodiment of the present invention, involving a variation of the reinforcing frame member.

[0061] FIG. 11A is a diagram of a second embodiment of an ink jet printer head according to the present invention, FIG. 11B is a cross-sectional view taken along a line B-B shown in FIG. 11A and FIG. 11C is a cross-sectional view taken along a line C-C shown in FIG. 11A. This ink jet printer head 50A differs from the ink let printer head 50 depicted in FIG. 4 and FIG. 6A only with respect to the reinforcing member 57A.

[0062] That is, the reinforcing member 57A depicted in FIGS. 11A, 11B and 11C is a reinforcing member from which the second belt 57-2 has been removed. Accordingly, the reinforcing member 57A comprises the first, third and fourth belts 57-1, 57-3 and 57-4. The lack of a second belt 57-2 eliminates the possibility of a short-circuiting of the flexible cable 73 by the platinum film 63 on the top surface of the reinforcing member 57.

[0063] The connection of the flexible cable 73 is carried out by using a jig to apply pressure. The pressure thus applied is exerted on a location at which the reinforcing member does not exist, and, accordingly, no crack occurs in the piezo-electric reinforcing member. As a result, the possibility of a crack in the reinforcing member 57 causing a crack in the vibrating membrane 55 can be avoided.

[0064] A description will now be given of a third embodiment of the present invention, involving a variation of the arc-shaped end portion of the pressure generating component main unit 60 as well as individual electrodes 61.

[0065] FIG. 12 is a diagram of a third embodiment of an ink jet printer head 50B according to the present invention. As shown in the diagram, this ink jet printer head 50B has a pressure generating component 56B. This pressure generating component 56B comprises a pressure generating component main unit 60B and individual electrode 61B. The end portions of the pressure generating component main unit 60B are shaped into multi-angular portions 60Ba, 60Bb, as are the end portions of the individual electrode 61Ba and 61Bb. As a result of the end portions 60Ba, 60Bb of the pressure generating component main unit 60B and the end portions 61Ba, 61Bb of the individual electrode 61B having a multi-angular shape, it is difficult for stress to accumulate at the end portions of the pressure generating component 56B and, accordingly, cracks do not appear in the vibrating membrane 55.

[0066] A description will now be given of a fourth embodiment of the present invention, involving a variation of the arc-shaped portion of the pressure generating component main unit 60 as well as individual electrode 61.

[0067] FIG. 13 is a diagram of a fourth embodiment of an ink jet printer head 50C according to the present invention. As shown in the diagram, this ink jet printer head 50C has a pressure generating component 56C. This pressure generating component 56C comprises a pressure generating component main unit 60C and an individual electrode 61C. The end portions 60Ca, 60Cb of the pressure generating component main unit 60C have a multi-step shape, as do the end portions 61Ca, 61Cb of the individual electrode 61C. As a result of the end portions 60Ca, 60Cb of the pressure generating component main unit 60C and the end portions 61Ca and 61Cb of the individual electrode 61C having a multi-step shape, it is difficult for stress to accumulate at the end portions of the pressure generating component 56C and, accordingly, cracks do not appear in the vibrating membrane 55.

[0068] A description will now be given of a fifth embodiment of the present invention, involving a variation of the arc-shaped end portions of the pressure generating component main unit 60 as well as the individual electrode 61.

[0069] FIG. 14 is a diagram of a fifth embodiment of an ink jet printer head according to the present invention. As shown in the diagram, the ink jet printer head 50D has a pressure generating component 56D. This pressure generating component 56D comprises a pressure generating component main unit 60D and an individual electrode 61D. The pressure generating component main unit 60D has squared end portions whereas the individual electrode 61D has arc-shaped end portions 61Da, 61Db. As a result of the end portions 61Da and 61Db of the individual electrode 61D having an arc shape, it is difficult for stress to accumulate at the end portions of the pressure generating component 56C and, accordingly, cracks do not appear in the vibrating membrane 55.

[0070] The above description is provided in order to enable any person skilled in the art to make and use the invention and sets forth the best mode contemplated by the inventors of carrying out their invention.

[0071] The present invention is not limited to the specifically disclosed embodiments and variations, and modifications may be made without departing from the scope of the present invention.

[0072] The present application is based on Japanese priority application No. 10-371033 filed on December 25, 1998, the entire contents of which are hereby incorporated by reference.

Claims

1. An ink jet printer head comprising:

a plurality of pressure chambers containing ink disposed side by side in a main unit so that each pressure chamber opposes a nozzle for jetting ink;

a vibrating membrane having a size corresponding to the main unit and mounted so as to cover the pressure chambers thereof, a portion

of the membrane opposing each of the pressure chambers and forming one wall of each of the pressure chambers;

a plurality of pressure generating components which are disposed side by side on the vibrating membrane, and including a piezo-electric pressure generating component main unit and an individual electrode provided on the pressure generating component main unit; and

a reinforcing member for reinforcing the vibrating membrane composed of a piezo-electric member provided on a region of the vibrating membrane other than a region of the vibrating membrane corresponding to a location of the plurality of pressure generating components disposed side by side.

2. The ink jet printer head as claimed in claim 1, wherein the region of the piezo-electric reinforcing member has an area formed simultaneously with the pressure generating components disposed side by side.

3. The ink jet printer head as claimed in claim 1, wherein the reinforcing member comprises a belt extending continuously in a direction identical to a direction in which the pressure generating components are disposed side by side within the region of the vibrating membrane corresponding to the location of the pressure generating components.

4. The ink jet printer head as claimed in claim 1, wherein the reinforcing member comprises two belts extending continuously, in a direction identical to a direction in which the pressure generating components are disposed side by side, along each of two opposite sides of the region of the vibrating membrane corresponding to the location of the pressure generating components.

5. The ink jet printer head as claimed in claim 1, wherein the reinforcing member comprises a belt extending continuously in a longitudinal direction of the pressure generating components within the region of the vibrating membrane corresponding to the location of the pressure generating components.

6. The ink jet printer head as claimed in claim 1, wherein the reinforcing member comprises:

two belts extending continuously, in a direction identical to a direction of alignment of the pressure generating components disposed side by side, along each of two opposite sides of the region of the vibrating membrane corresponding to the location of the pressure generating components; and

two belts extending continuously, in a direction identical to the direction in which each of the pressure generating components is aligned, along each of two opposite ends of the region of the vibrating membrane corresponding to the location of the pressure generating components,

the two belts disposed in the direction of alignment of the pressure generating components disposed side by side and the two belts disposed in the direction of the individual pressure generating components being joined so as to enclose a substantially rectangular area, including therein a region of the vibrating membrane corresponding to the location of the pressure generating components.

7. The ink jet printer head as claimed in claim 1, wherein the reinforcing member is not discrete but continuous within the region corresponding to the location of the plurality of pressure generating components.

8. An ink jet printer head comprising:

a plurality of pressure chambers containing ink disposed side by side in a main unit so that each pressure chamber opposes a nozzle for jetting ink;

a vibrating membrane having a size corresponding to the main unit and mounted so as to cover the pressure chambers thereof, a portion of the membrane opposing each of the pressure chambers and forming one wall of each of the pressure chambers; and

a plurality of pressure generating components which are disposed side by side on the vibrating membrane and including a piezo-electric pressure generating component main unit and an individual electrode provided on the pressure generating component main unit; and

wherein end portions of each pressure generating component main unit are shaped in such a way that it is difficult for stress to concentrate thereat.

9. An ink jet printer head comprising:

a plurality of pressure chambers containing ink disposed side by side in a main unit so that each pressure chamber opposes a nozzle for jetting ink;

a vibrating membrane having a size corresponding to the main unit and mounted so as to cover the pressure chambers thereof, a portion of the membrane opposing each of the pressure chambers and forming one wall of each of the pressure chambers; and

a plurality of pressure generating components which are disposed side by side on the vibrating membrane and including a piezo-electric pressure generating component main unit and an individual electrode provided on the pressure generating component main unit,
wherein end portions of each individual electrode are shaped in such a way that it is difficult for stress to accumulate thereat.

10. A printer apparatus comprising:

a recording medium transporting mechanism; and
an image forming unit having an ink jet printer head, the ink jet printer head comprising:
a plurality of pressure chambers containing ink disposed side by side in a main unit so that each pressure chamber opposes a nozzle for jetting ink;
a vibrating membrane having a size corresponding to the main unit and mounted so as to cover the pressure chambers thereof, a portion of the membrane opposing each of the pressure chambers and forming one wall of each of the pressure chambers;
a plurality of pressure generating components which are disposed side by side on the vibrating membrane, and including a piezo-electric pressure generating component main unit and an individual electrode provided on the pressure generating component main unit; and
a reinforcing member for reinforcing the vibrating membrane composed of a piezo-electric member provided on a region of the vibrating membrane other than a region of the vibrating membrane corresponding to a location of the plurality of pressure generating components disposed side by side.

11. A printer apparatus comprising:

a recording medium transporting mechanism; and
an image forming unit having an ink jet printer head, the ink jet printer head comprising:
a plurality of pressure chambers containing ink disposed side by side in a main unit so that each pressure chamber opposes a nozzle for jetting ink;
a vibrating membrane having a size corresponding to the main unit and mounted so as to cover the pressure chambers thereof, a portion of the membrane opposing each of the pressure chambers and forming one wall of each of the pressure chambers; and
a plurality of pressure generating components which are disposed side by side on the vibrating membrane and including a piezo-electric pressure generating component main unit and an individual electrode provided on the pressure generating component main unit; and
wherein end portions of each pressure generating component main unit are shaped in such a way that it is difficult for stress to concentrate thereat.

12. A printer apparatus comprising:

a recording medium transporting mechanism; and
an image forming unit having an ink jet printer head, the ink jet printer head comprising:
a plurality of pressure chambers containing ink disposed side by side in a main unit so that each pressure chamber opposes a nozzle for jetting ink;
a vibrating membrane having a size corresponding to the main unit and mounted so as to cover the pressure chambers thereof, a portion of the membrane opposing each of the pressure chambers and forming one wall of each of the pressure chambers; and
a plurality of pressure generating components which are disposed side by side on the vibrating membrane and including a piezo-electric pressure generating component main unit and an individual electrode provided on the pressure generating component main unit,
wherein end portions of each individual electrode are shaped in such a way that it is difficult for stress to accumulate thereat.

13. A driving element for an ink jet printer head for expelling ink from an ink-filled pressure chamber by causing a volume of the pressure chamber to change, comprising:

a piezo-electric member and a vibrating membrane, the piezo-electric member and the vibrating membrane being deposited on a target substrate by using thin film forming techniques,
wherein the piezo-electric member comprises:
a pressure generating component for producing pressure with which to cause the volume of the pressure chamber to change; and
a continuous reinforcing member enclosing the region of the pressure generating components.

14. A drive element for an ink jet printer head for expelling ink from an ink-filled pressure chamber by causing a volume of the pressure chamber to change, comprising:

a piezo-electric member and a vibrating mem-

brane, the piezo-electric member and the vibrating membrane being deposited on a target substrate by using thin film forming techniques,
wherein the piezo-electric film comprises:

a pressure generating component for producing pressure with which to alter the volume of the pressure chamber, end portions of the pressure generating component being formed in substantially a square, the corners of the square being shaped in such a way that stress is dissipated thereat.

15. The ink jet printer head drive element as claimed in claim 14, wherein the shape for dispersing stress is either a taper, an arc or a step, or any combination thereof.

FIG.1

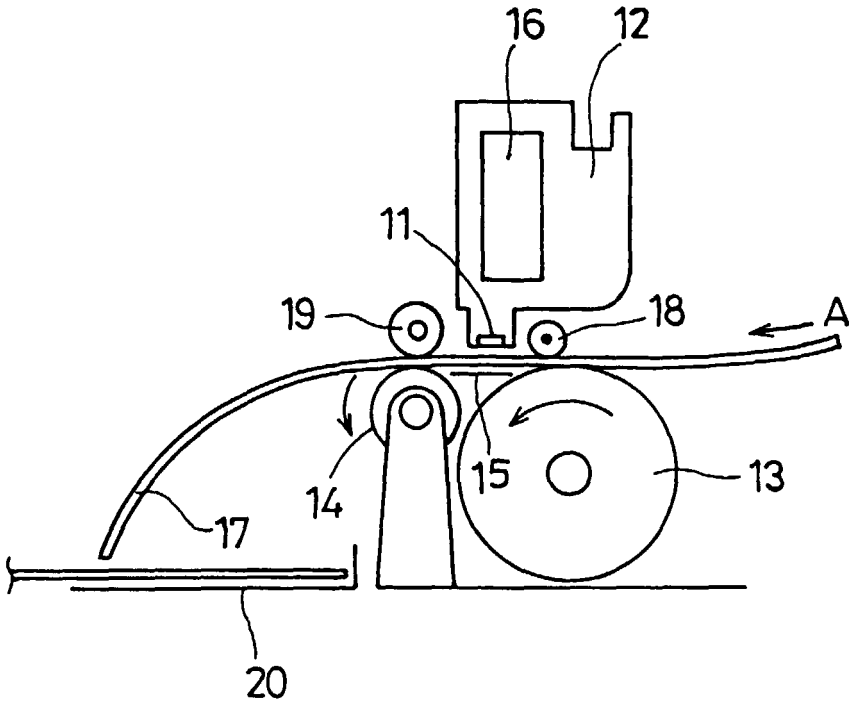


FIG.2

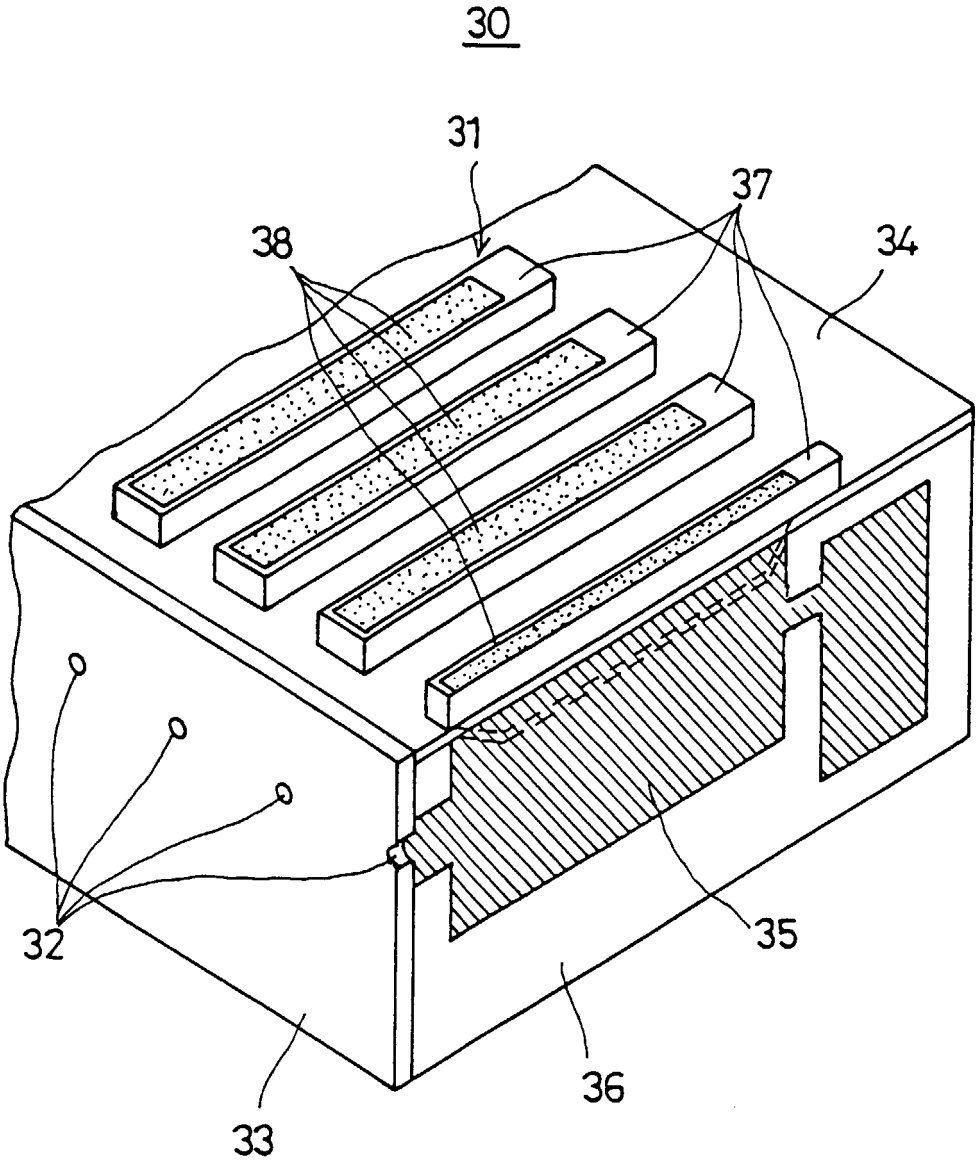


FIG.3

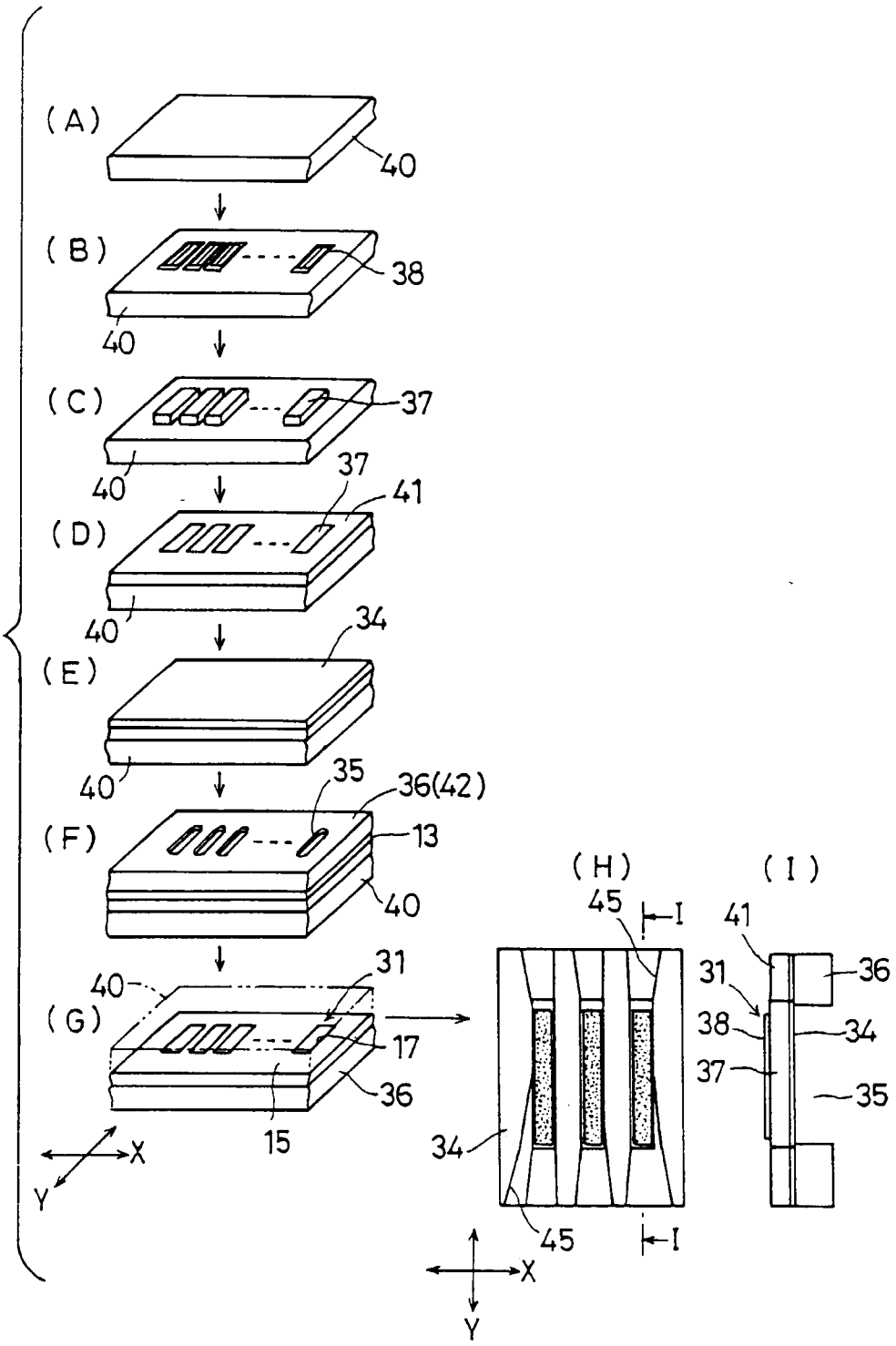

(A)
40
(B)
38
40
(C)
37
40
37
41
(D)
40
34
(E)
40
35
36(42)
(F)
13
40
40
31
(G)
17
36
15
X
Y
(H)
45
I
34
45
I
X
Y
(I)
41
31
36
38
34
37
35

FIG.4

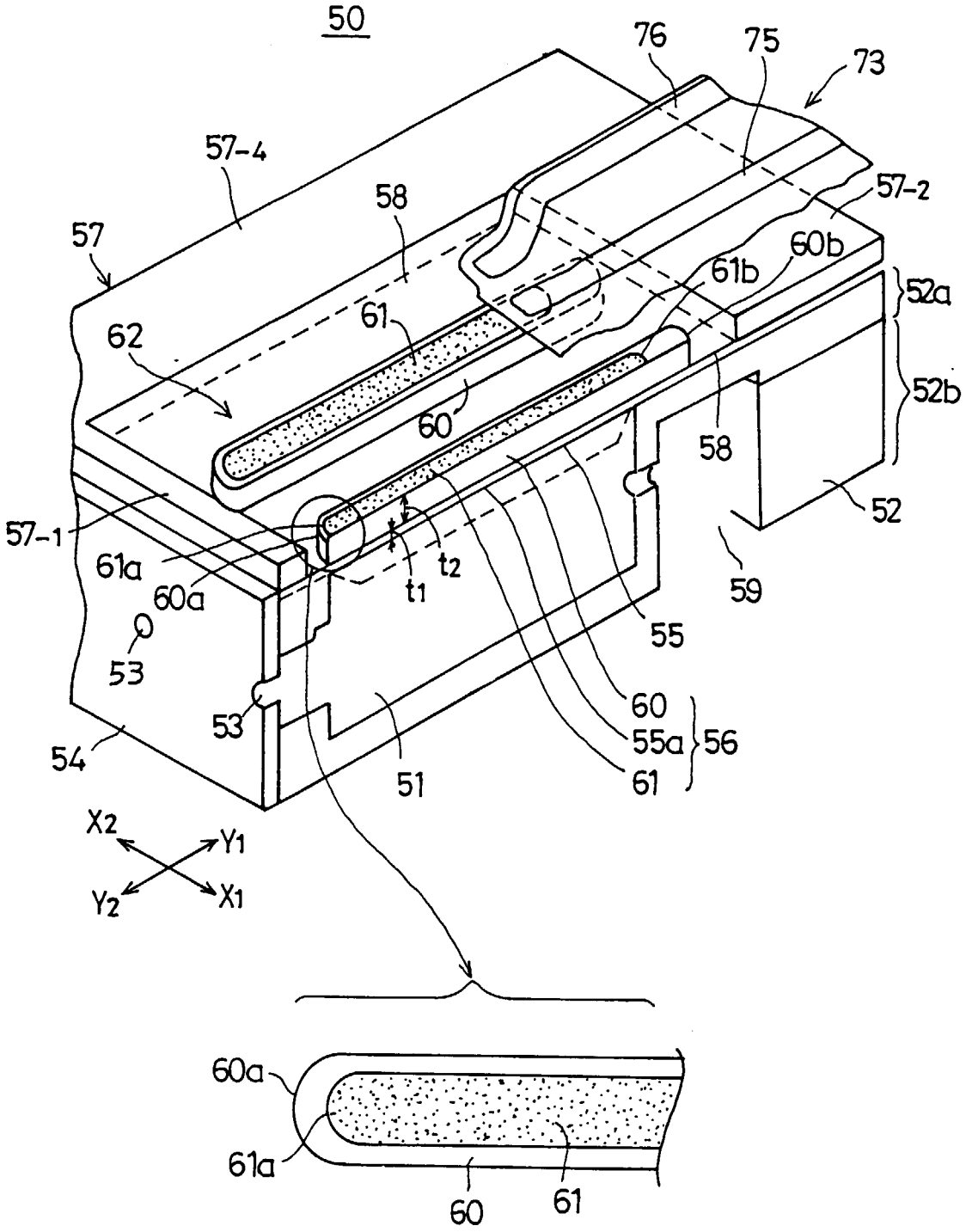

50
76
75
73
57-4
58
57-2
57
60b
61b
52a
62
61
52b
60
58
57-1
52
61a
60a
t1
t2
59
53
55
53
60
55a
56
54
51
61
X2
Y1
Y2
X1
60a
61a
60
61

FIG.5

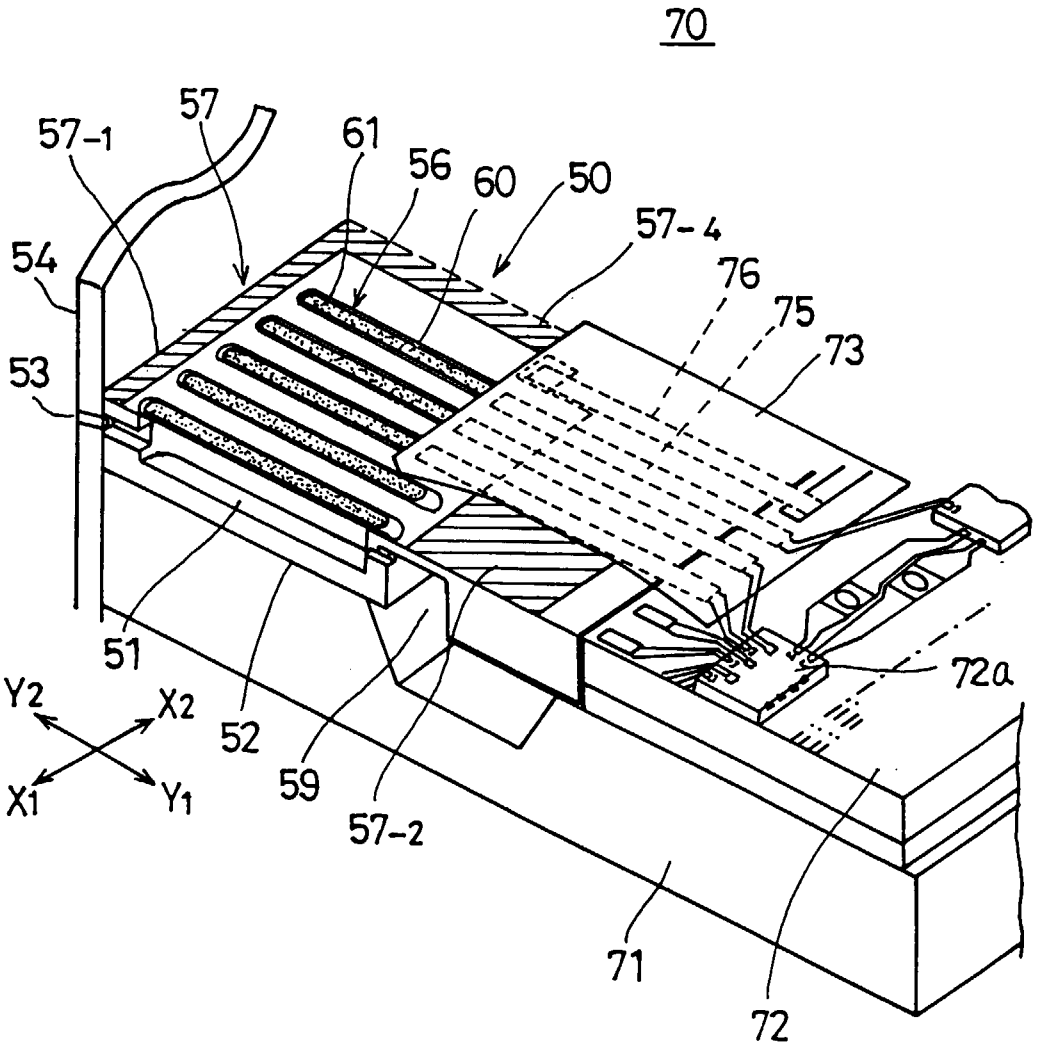

70
57
57-1
61
56
60
50
57-4
54
76
75
73
53
51
72a
Y2
X2
52
59
57-2
X1
Y1
71
72

FIG.6A

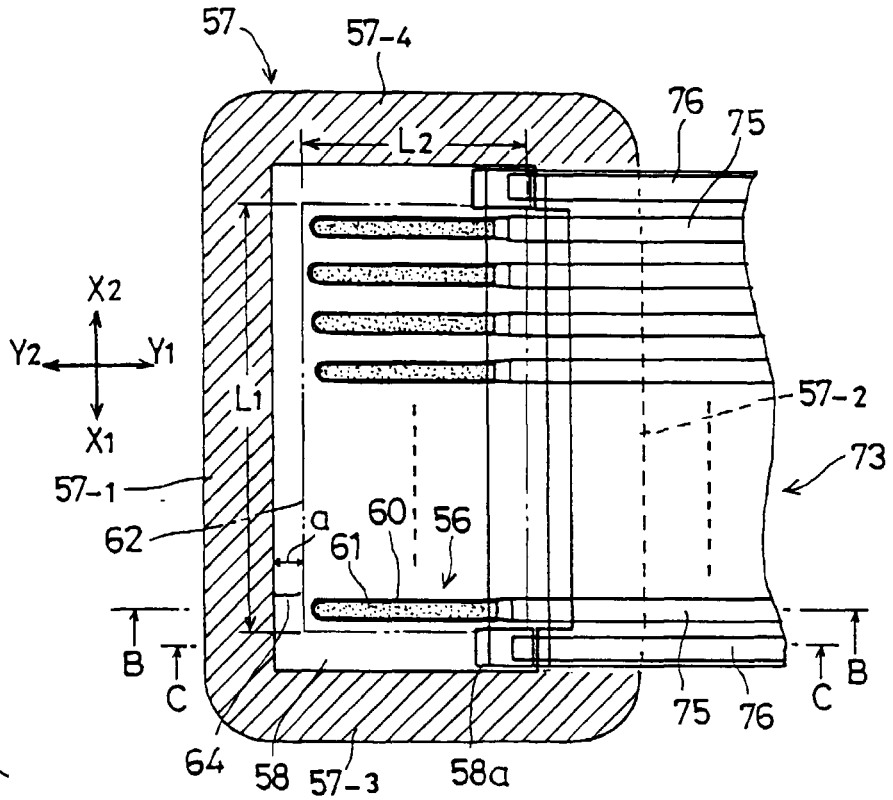


FIG.6B

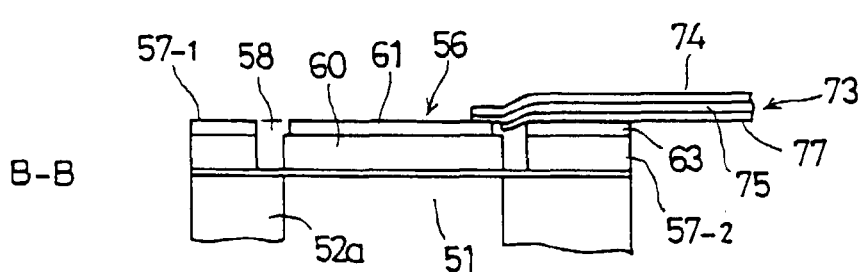


FIG.6C

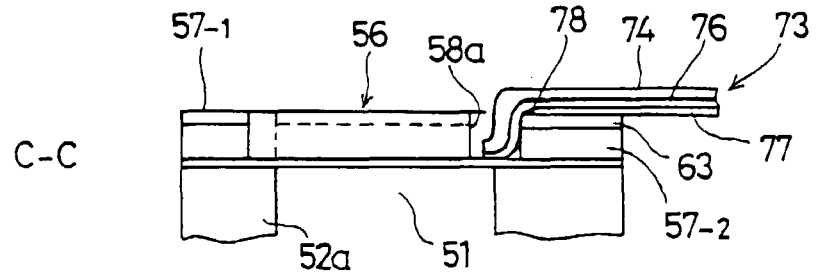
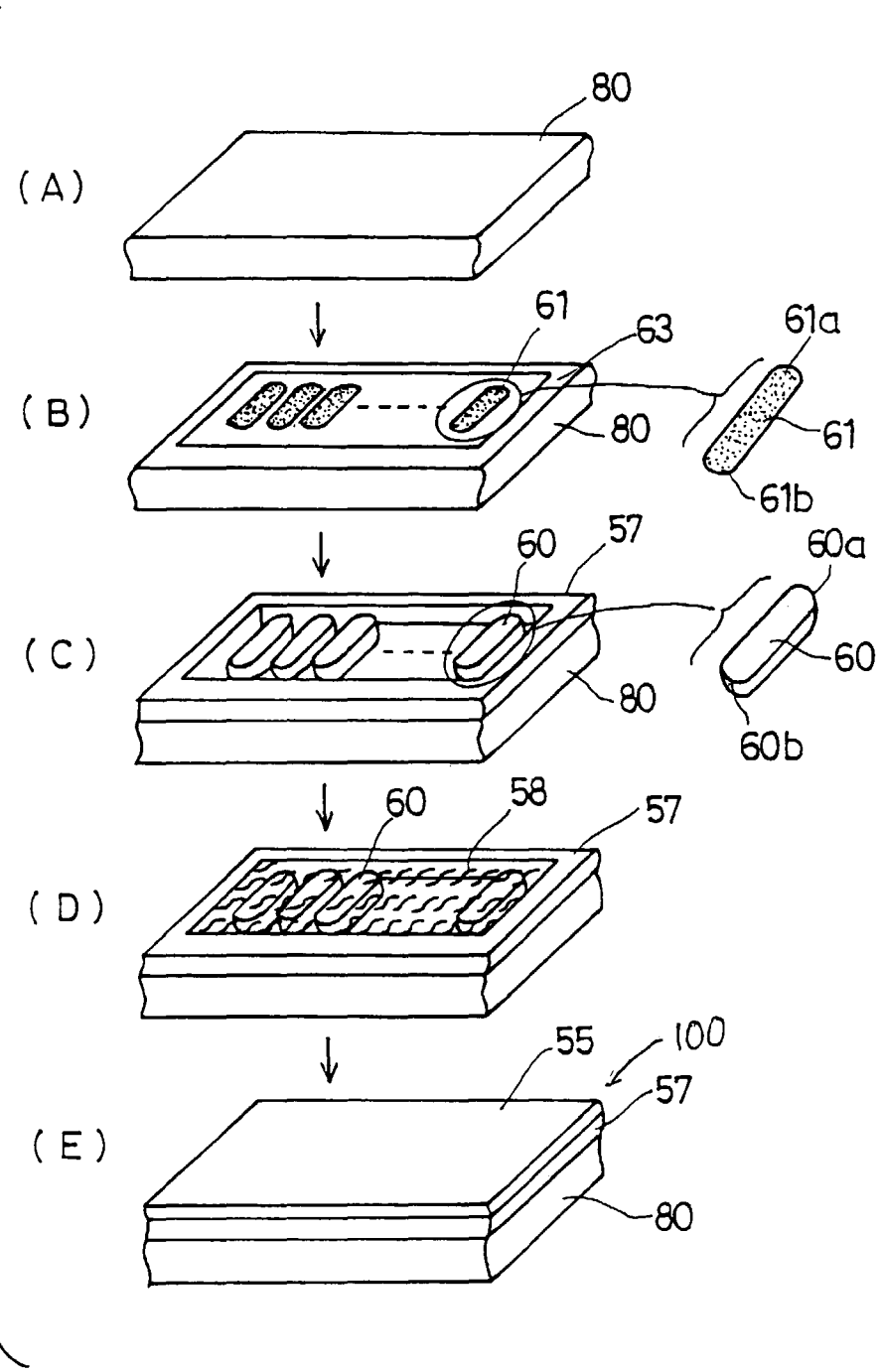


FIG.7


(A)
80
(B)
61
63
61a
80
61
61b
(C)
60
57
60a
80
60
60b
(D)
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58
57
(E)
55
100
57
80

FIG.8

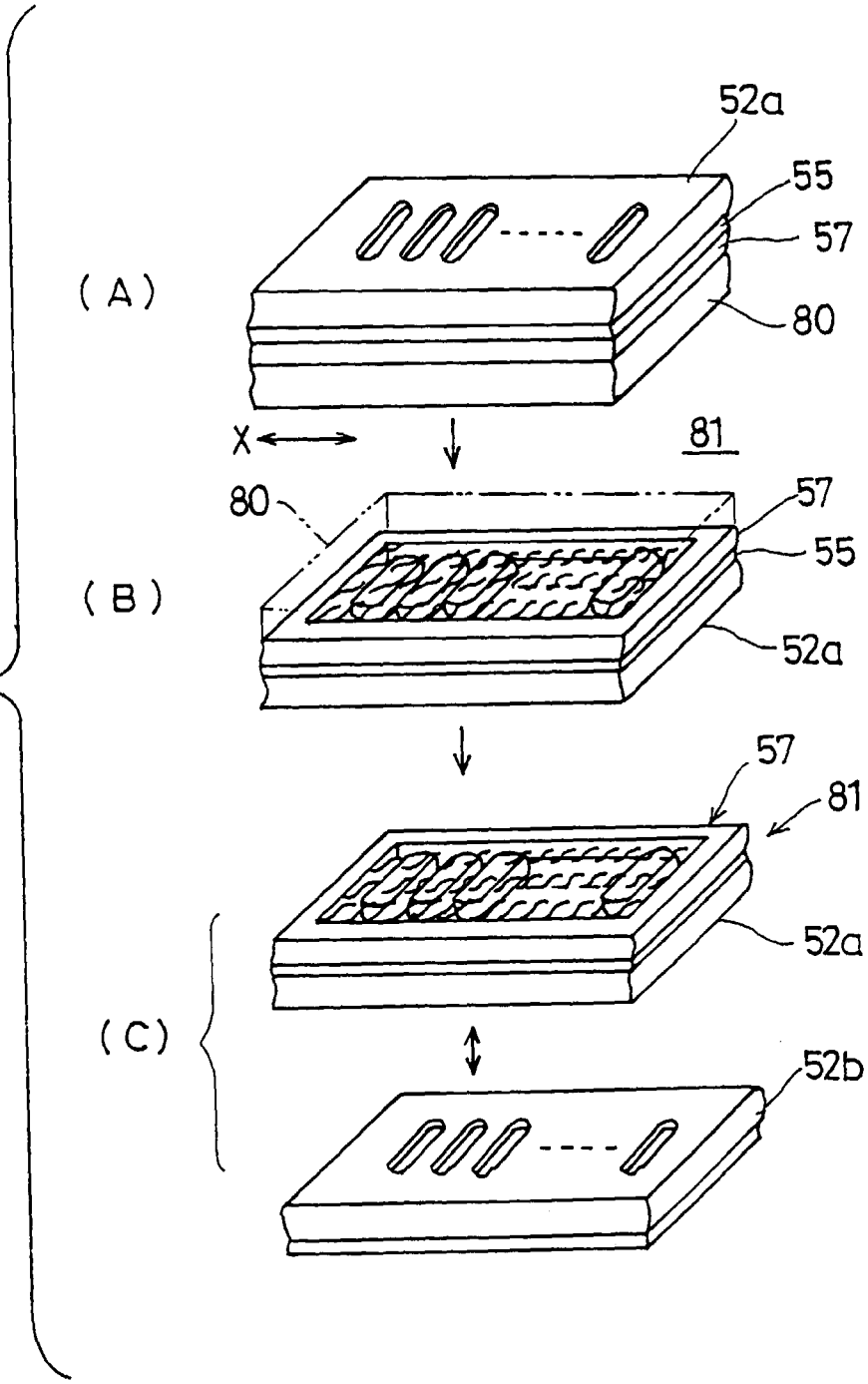

FIG.9B

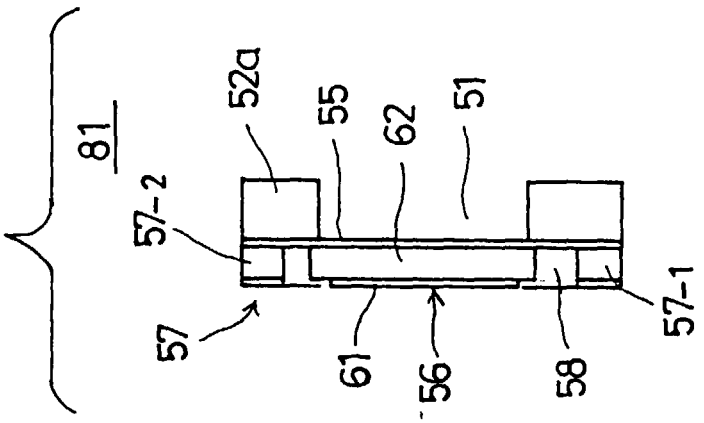
81
52a
55
62
51
57-2
57
61
56
58
57-1

FIG.9A

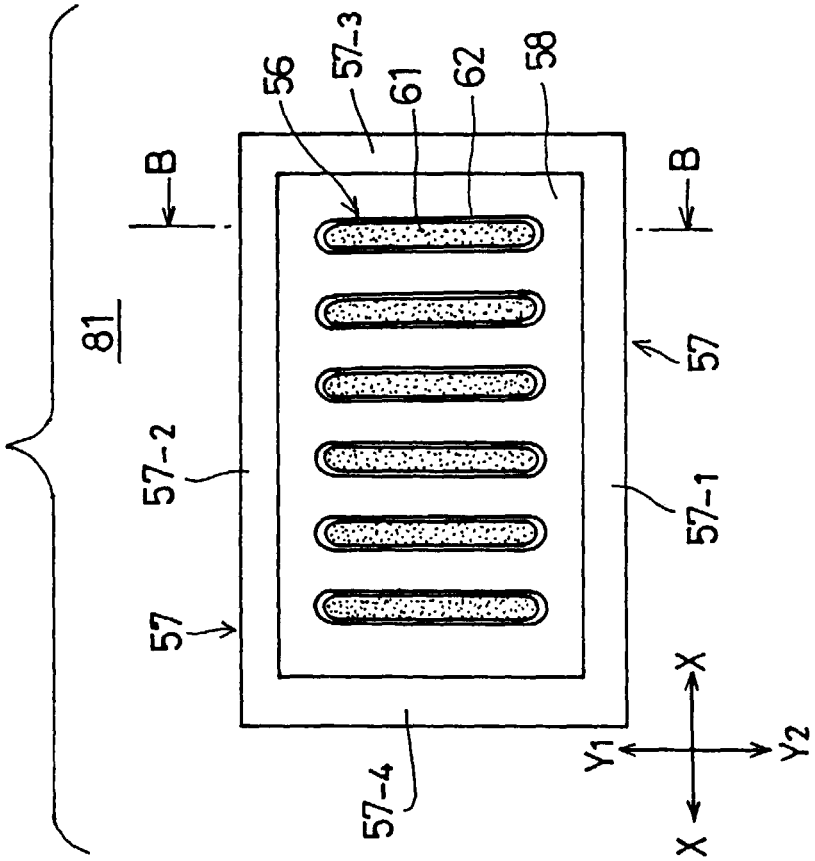
81
56
57-3
61
62
58
B
B
57
57-2
57-1
57
57-4
X
Y1
Y2
X

FIG.10

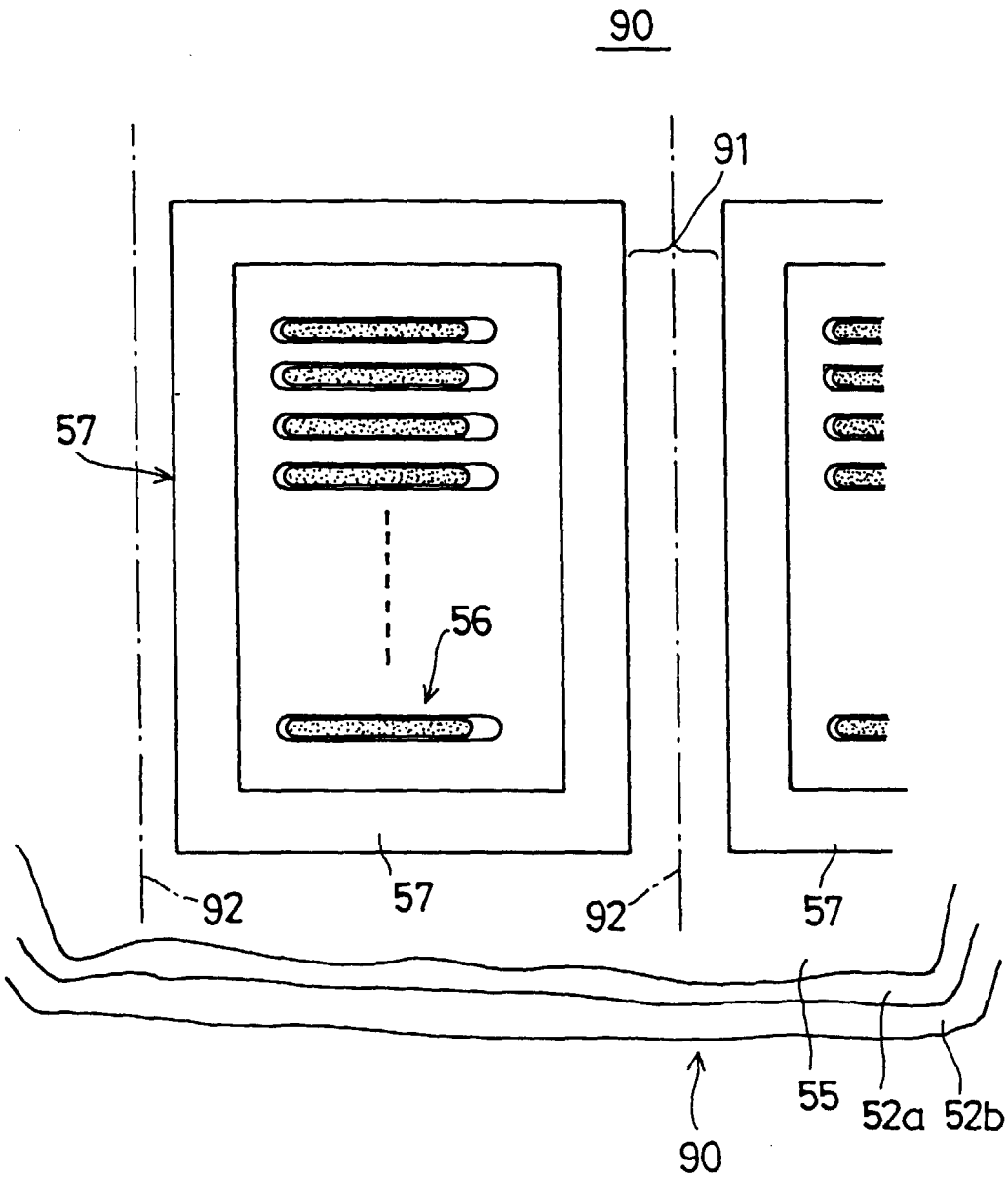

FIG.11A

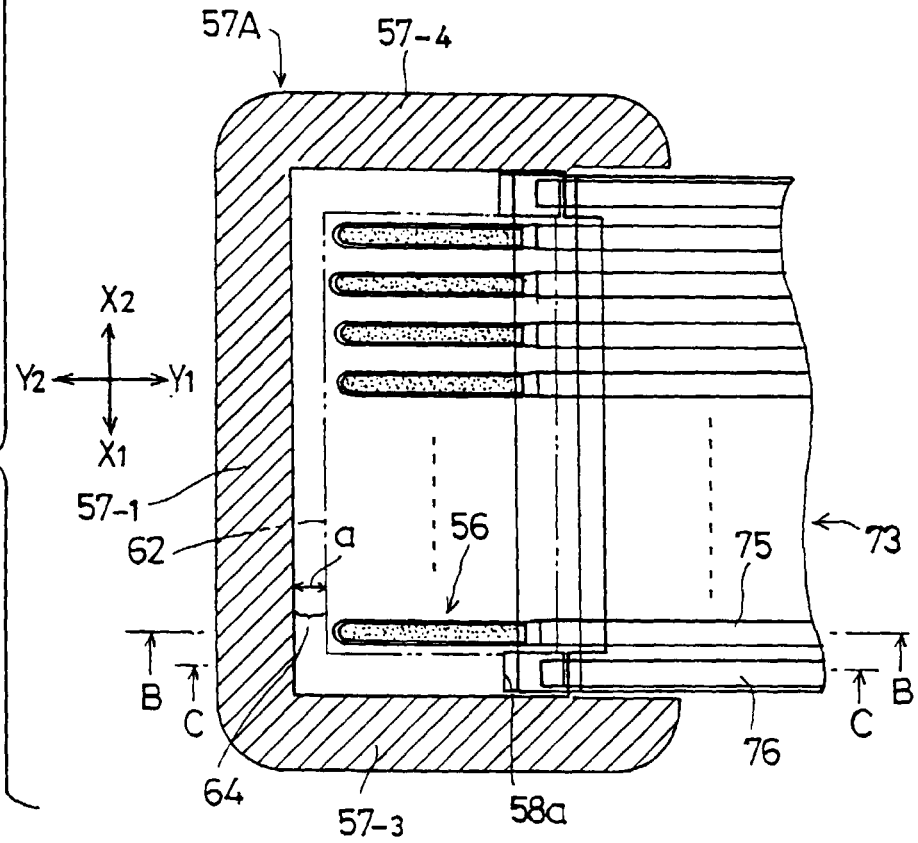

FIG.11B

B - B

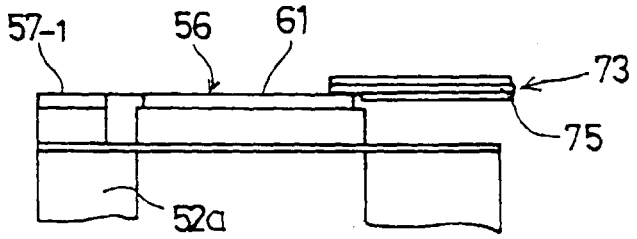

FIG.11C

C - C

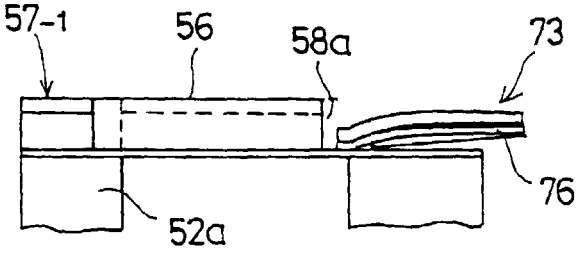

FIG.12

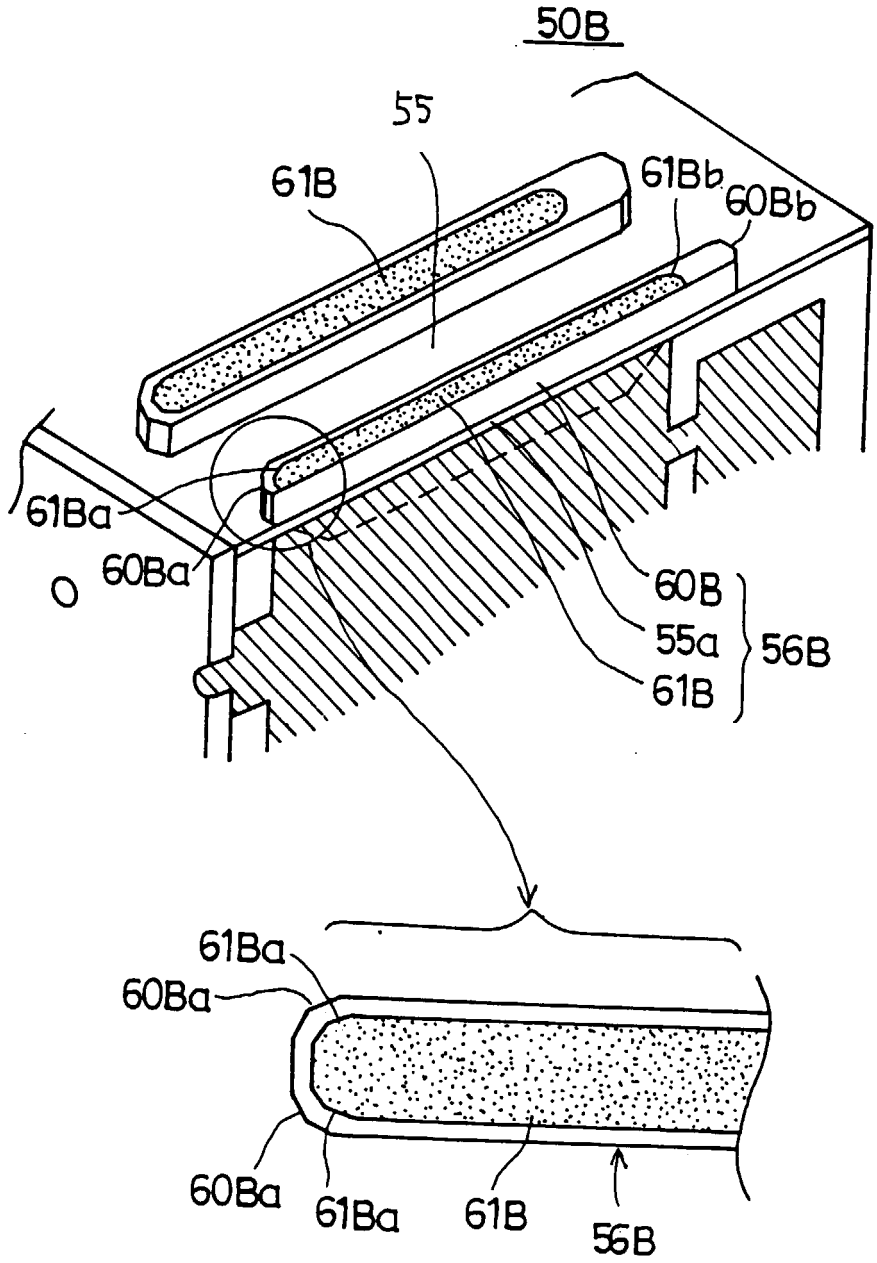
50B
55
61B
61Bb
60Bb
61Ba
60Ba
60B
55a
61B
56B
61Ba
60Ba
60Ba
61Ba
61B
56B

FIG.13

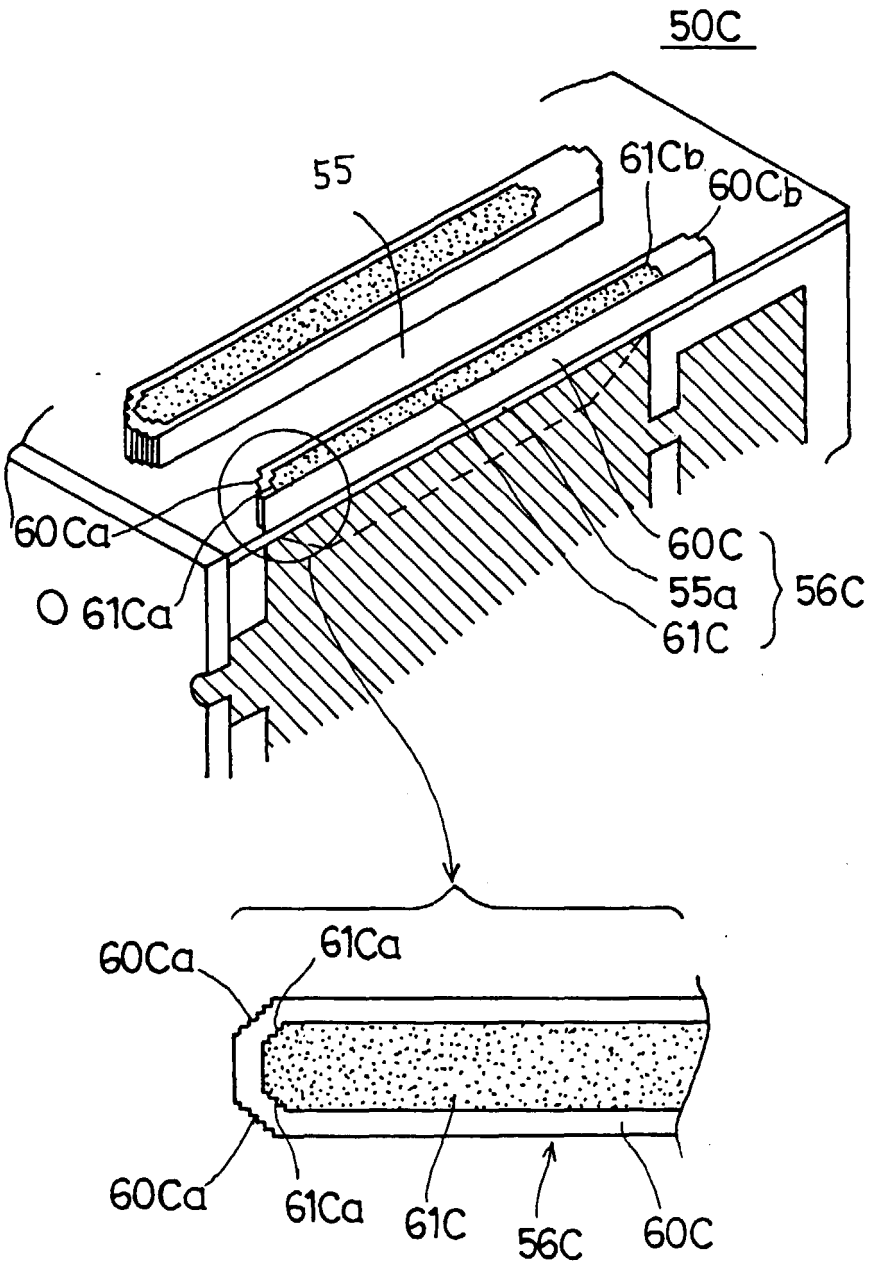
50C
55
61Cb
60Cb
60Ca
61Ca
60C
55a
61C
56C
60Ca
61Ca
60Ca
61Ca
61C
56C
60C

FIG.14