(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 077 394 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
**08.07.2009 Bulletin 2009/28**

(21) Application number: **06822363.5**

(22) Date of filing: **26.10.2006**

(51) Int Cl.:
***F04B 43/04*** *(2006.01)*

(86) International application number:
**PCT/JP2006/321394**

(87) International publication number:
**WO 2008/050432 (02.05.2008 Gazette 2008/18)**

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR**

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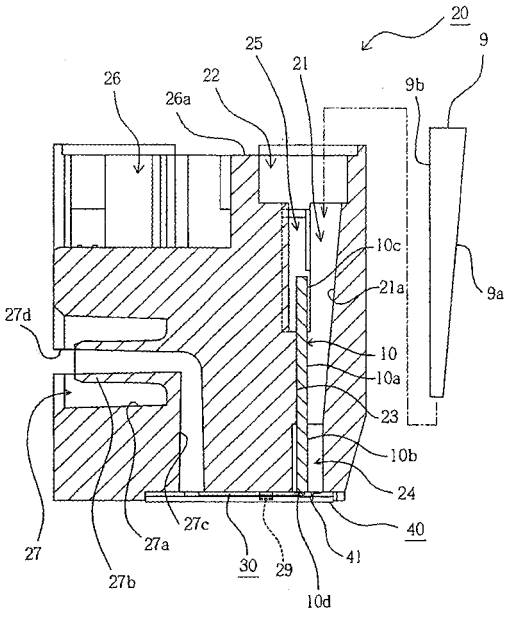
# (54) DROPLET EJECTING APPARATUS AND METHOD FOR MANUFACTURING THE SAME

(57) Provided is an efficient droplet ejecting apparatus, which has high assembly accuracy even with a simple structure and simple assembly steps and transmits expansion and contraction of a piezoelectric element to a protruding section. A method for manufacturing such droplet ejecting apparatus is also provided. The droplet ejecting apparatus is provided with a pressurizing chamber communicating with a nozzle (41); a vibrating membrane forming a part of the pressurizing chamber; a piezoelectric element (10) for vibrating the vibrating membrane; a protruding section provided on the vibrating membrane by being connected to the piezoelectric element (10), for transmitting vibration to the vibrating membrane; and a bracket (20). The droplet ejecting apparatus ejects a droplet from the nozzle (41). A member provided with the pressurizing chamber, the vibrating membrane and the protruding section can be fixed to the bracket (20). The bracket (20) is provided with a groove section between a releasing section and the protruding section, for guiding the bar-shaped piezoelectric element (10). The piezoelectric element (10) is adhered in the groove section.

Fig. 5




EP 2 077 394 A1

## Description

### Field of the Invention

**[0001]** The present invention relates to a droplet discharging apparatus and its manufacturing method. More particularly, the present invention relates to a droplet discharging apparatus which has a pressure chamber communicated with anozzle, a diaphragm which is member of the pressure chamber, a piezoelectric device for driving the diaphragm, a projection provided on the diaphragm to stay in direct contact with the piezoelectric device for transmitting the oscillating action of the piezoelectric device to the diaphragm, and a bracket and also to a method of manufacturing the droplet discharging apparatus where droplets of liquid are discharged from its nozzle.

### Background of the Invention

**[0002]** One of such conventional droplet discharging apparatuses is known as disclosed in Patent Citation 1. Also as disclosed in Patent Citation 2, a group of transducers 204 acting as piezoelectric devices are mounted in a group of slots 232 provided in a plate 228 which acts as a bracket, as shown in Figs. 7 to 9. The arrangement disclosed in Patent Citation 2 causes the transducers 204 to be fixedly mounted to the plate 228 with some difficulties and may be declined in the precision and the quality. According to Patent Citation 1, each piezoelectric device is first joined to a stationary plate to build a unit and then fitted into the corresponding slot provided in a member which acts as a bracket. Patent Citation 3 also discloses a technology similar to that of Patent Citation 1 where each piezoelectric device is mounted on a base plate.

**[0003]** However, according to Patent Citations 1 and 3, the piezoelectric device is flatly bonded to a stationary plate. Also, Patent Citation 2 allows the piezoelectric device to be fitted into the corresponding slot 232 with the help of a soft, elastic material 230 such as silicone rubber. They also fail to describe the fact that the piezoelectric device is adversely effected in the expansion and contraction by the mounting or bonding of the piezoelectric device.

**[0004]** As particularly known in Patent Citation 1, the stationaryplate has to be provided in addition to a structure 16 which acts as the bracket, whereby the overall structure and production steps will be increased in the complexity. Also, the number of components fails to decrease thus increasing the troublesome action of maintaining the production accuracy and controlling the labor management for production steps.

Patent Citation 1: JP 2000-85126A (Application No. 3-956 divisional application).
Patent Citation 2: JP 57-188372A.
Patent Citation 3: JP 5-77431A.

### Disclosure of the Invention

(Problems that the invention is to solve)

**[0005]** It is an object of the prevent invention, in view of the above aspects, to provide a droplet discharging apparatus which is simple in the structure, easy in the assembling operation, and high in the assembling accuracy while the expansion and contraction of its piezoelectric device can be transmitted to the projection at higher efficiency and to a method of manufacturing the droplet discharging apparatus.

(Means for solving the Problems)

**[0006]** For achievement of the above object, a droplet discharging apparatus according to the present invention which has a pressure chamber communicated with a nozzle, a diaphragm which is a member of the pressure chamber, a piezoelectric device for driving the diaphragm, a projection provided on the diaphragm to stay in direct contact with the piezoelectric device for transmitting the oscillating action of the piezoelectric device to the diaphragm, and a bracket is provided as **characterized in that**
an assembly including the pressure chamber, the diaphragm, and the projection can be fixedly mounted to the bracket, and the bracket has a channel provided therein in which the piezoelectric device of a bar-like form is bonded to the channel as is guided from an open region to the projection by channel.

**[0007]** According the above arrangement, the piezoelectric device is secured directly to the bracket with no use of a stationary plate, whereby the overall number of the components can be decreased while the assembly step is simplified. Since the piezoelectric device is inserted and secured in the channel of the bracket between the open region and the projection, the assembly step can be simplified and also improved in the accuracy because the piezoelectric device has been guided. Moreover, the piezoelectric device is secured three-dimensionallyat the surfaces in the channel and its bonding strength is greater as compared with when bonded plainly, whereby its counter-force can firmly be supported during the oscillating action thus to transmit the oscillating motion to the projection at higher efficiency.

**[0008]** More preferably, the piezoelectric device may be arranged of a square shape in the cross section across the lengthwise direction and bonded with at least two sides of the square at the channel. Also, the bracket may be arranged to have a non-mounting region thereof located in the proximity of the projection where the piezoelectric device is free from the bonding, whereby the oscillating action can be improved in the efficiency without interrupting the displacement of the piezoelectric device.

**[0009]** The piezoelectric device may also have external electrodes provided at the open region side thereof while the bracket has a second channel provided therein

for guiding contactors from correspond to external electrodes from the open region. This develops the energizing paths through the contactors while the piezoelectric device which is highly brittle and easily breakable remains protected.

**[0010]** The channel may include a clearance in which the piezoelectric device can travel along one direction which extends at a right angle to the lengthwise direction, thus allowing the piezoelectric device to be secured with accuracy while offsetting any manufacturing error. It may be modified in this case that an inclined side which form at the clearance is provided as arranged so that it becomes more spaced from the piezoelectric device towards the open region along the direction of insertion of the piezoelectric device. Accordingly, the piezoelectric device can firmly be fitted into the channel with a tooling inserted into the clearance. The clearance may be adapted so that the oscillating movement of the projection can be viewed through the clearance. This permits the bonding between the piezoelectric device and the projection to be observed carefully.

**[0011]** The nozzle, the pressure chamber, the diaphragm, and the projection may be provided on a plate-like member which is positioned and fixedly joined to the bracket. Also, the joining may be implemented by a recessed portion of the plate-like member and a projected portion of the bracket, whereby the head will be prevented at the lower side from being fouled with any leakage of the liquid from the nozzle. Alternatively, the joining may be implemented by a projected portion of the plate-like member and a recessed portion of the bracket.

**[0012]** More preferably, the bracket may be arranged to have a third channel provided therein at the open region side in which a cable is fitted for supplying the piezoelectric device with a driving signal. This allows the piezoelectric device to be supplied with a driving current from the open region side of the bracket.

**[0013]** A method of manufacturing the droplet discharging apparatus described above is provided as characterized by inserting the contactors from the open region into the second channel and guiding and contacting to the external electrodes respectively. Accordingly, any unwanted injury of the piezoelectric device can be avoided. The method of manufacturing the droplet discharging apparatus may further be characterized by inserting a tooling into the clearance thus to position and secure the piezoelectric device to the bracket. Preferably, the piezoelectric device can be secured with the inclined surface.

## Advantages of the Invention

**[0014]** The droplet discharging apparatus and its manufacturing method according to the present invention are advantageous in that the structure is simple as well as its assembly operation and its assembly operation is carried out at a higher level of the accuracy, while the expanding and contracting movement of the piezoelectric device can be transmitted to the projection at higher efficiency.

**[0015]** Other objects, arrangements, and advantages of the present invention will be apparent from the following description of embodiments of the present invention.

## Brief Description of the Drawings

**[0016]**

Fig. 1A is an exploded perspective view of a head and Fig. 1B is a perspective view of an arrangement in the proximity of a projection;
Fig. 2 is a longitudinally cross sectional view of the head;
Fig. 3 is a perspective view of the head shown in Fig. 2;
Figs. 4A, 4B, 4C, and 4D are cross sectional views taken along the line A-A of Fig. 2, the line B-B of Fig. 2, the line C-C of Fig. 2, and the line D-D of Fig. 2 respectively;
Fig. 5 is a longitudinally cross sectional view of the head;
Fig. 6 is a partial perspective view of the head shown in Fig. 5;
Fig. 7 is a perspective view showing a tooling inserted;
Fig. 8 is a longitudinally cross sectional view of an arrangement in the proximity of an oscillator plate and a nozzle plate;
Fig. 9 is a view, similar to Fig. 4A, showing another embodiment of the present invention; and
Fig. 10A is a view, similar to Fig. 4A, showing a further embodiment of the present invention and Fig. 10B is a cross sectional view of a tooling.

(Description of Numerals)

**[0017]** 1: droplet discharging apparatus, 2: head, 6: upper cover, 7: cable, 7a, 7b: leads, 8: retainer, 9: tooling, 9a: inclined side, 9b, 9c: contact side, 10: piezoelectric device, 10a: holding portion, 10b: activating portion, 10c: connecting portion, 10d: lower end, 10f1, 10f2: external electrode, 11: adhesive, 20: bracket, 21: channel, 21a, 21b: inclined surfaces, 22: upper open region, 23: mounting region, 23a: sidesurface, 23b: bottomsurface, 23c: inclined surface, 24: non-mounting region, 25: second channel, 25a: projected surface, 25b: opposite surface, 25c: sub channel, 26: third channel, 26a: partition, 27: communication inlet, 27a: recess, 27b: projected portion, 27c: flowpassage, 27d: stopper, 29: projection, 30: oscillator plate, 31: projection, 32: diaphragm(oscillating diaphragm), 33: recessed portion, 34: upper side, 35: flow passage, 35x: recess, 36: communication aperture, 39a: round slot, 39b: long slot, 40: nozzle plate, 41 : nozzle, 42: pressure chamber, 42x: recess, 43: fast passage, 49a: round slot, 49b: long slot, 50: contactor, 50a: first contactor, 50b: second contactor, 51: base portion, 52:

bent portion, 54: intermediate portion, 55: connector strip.

**Best Modes for embodying the Invention**

**[0018]** Some embodiments of the present invention will be described referring to the relevant drawings.
As shown in Figs. 1 to 8, a droplet discharging apparatus 1 according to the present invention includes a head 2 for discharging from a nozzle 41 droplets of a liquid which has been supplied from a cartridge not shown. The head 2 comprises a piezoelectric device 10, an oscillator plate 30, a nozzle plate 40, contactors 50, an upper cover 6, and a cable 7 which all are fixedly mounted to a bracket 20. More specifically, the bracket 20, the oscillator plate 30, the nozzle plate 40, and the upper cover 6 are fabricated respectively by injection molding of resin materials. The components may be fabricated using glass, metals, and other appropriate materials while the molding may be replaced with etching or electro-forming technique.

**[0019]** The bracket 20 has a channel 21 provided therethrough from the upper end to the lower end for accepting the piezoelectric device 10. The channel 21 comprises from the upper an upper open region 22, a mounting region 23, and a non-mounting region 24 which forms a cavity. Also, the bracket 20 has a second channel 25 provided in the proximity of the upper open zone 22 and a third channel 26 provided in the upper side thereof to extend from the upper open zone 22 to the back side of the bracket 20 where the cable 7 is fitted in. The bracket 20 furthermore has a communication inlet 27 provided in the back side thereof for communication withacartridge. The bracket 20 has projections 29 provided on the lower side thereof and arranged to fit and engage with both the oscillator plate 30 and the nozzle plate 40. A pressure chamber and a nozzle are provided in the lower front of the head 2 for being driven with the oscillator plate 30, the nozzle plate 40, and the piezoelectric device 10. The contactors 50 are fitted into the second channel 25 for electrically connecting between the piezoelectric device 10 and the cable 7.

**[0020]** The piezoelectric device 10 may be implemented by a PZT (leadzirconatetitanate) material so that its activating portion 10b at the lower end can be expanded and contracted when being energized. As the piezoelectric device 10 is fixedly mounted at its center mounting portion 10a to the bracket 20, its lower end 10d oscillates up and down for driving the diaphragm 32 through a projection 31 which will be explained later. A pair of external electrodes 10f1, 10f2 are provided on the connecting portion 10c of the piezoelectric device 10 for connection to the contactors 50. The piezoelectric device 10 is arranged of a square in the cross section and secured to the mounting region 23 with its distal end positioned in the non-mounting region 24 when having been inserted from the upper open region 22. More particularly, the piezoelectric device 10 is fixedly mounted by an adhesive 11 to the mounting region 23 of the bracket 20 as shown in Fig. 4A. As shown in Fig. 4, the channel 21 where the piezoelectric device 10 is installed extends from the upper end to the lower end of the bracket 20, thus allowing the projection 31 to be viewed from the upper opening region 22. The other side of the channel 21 opposite to the piezoelectric device 10 mounted side has an inclined surface 21a which becomes closer to the piezoelectric device 10 from the upper open region 22 towards the lower end of the channel 21. The inclined surface 21a is configured to come into direct contact with the inclined surface 9a of a tooling 9 for ensuring the precise fitness between the piezoelectric device 10 and the mounting region 23 when the tooling 9 has been inserted.

**[0021]** As shown in Fig. 4A, the mounting region 23 comprises a pair of side surfaces 23a and a bottom surface 23b. The piezoelectric device 10 of a square shape in the cross section is bonded by the adhesive 11 to the three surfaces in the channel 21. In case that the piezoelectric device 10 is bonded to a single flat surface, denoted by 23b, of the mounting region, its supporting force against a displacement along the direction of the z-axis will be declined as spaced further along the direction of the x-axis from the surface 23b. Since the piezoelectric device 10 is securely bonded to all the three surfaces 23a and 23b of the mounting region 23 in this embodiment, its counter-force along the direction of the x-axis can satisfactorily be transmitted, hence improving the efficiency of the action of oscillating the projection 31. More specifically, the clearance of the the piezoelectric device 10 and the mounting region 23. The adhesive 11 may preferably be high in the rigidity at its cured phase in view of ensuring the counter-force of the piezoelectric device 10 at the oscillating action. Namely, the adhesive 11 is favorably used of, for example, a thermo-set type epoxy adhesive agent.

**[0022]** Each of the contactors 50 fitted in the second channel 25 comprises, as shown in Figs. 1 to 3 and Figs. 4C and 4D, a bent portion 52 narrowed in the width and joined to the distal end of a base portion 51, an intermediate portion 54 extended at a right angle from the base portion 51, and a connector strip 55 extended at a right angle from the intermediate portion 54. The second channel 25 is provided with a projected portion 25a extending in a rail-like form from the center to the front side of the upper open region 22, a pair of opposite surfaces 25b disposed on both, left and right, sides of the projected portion 25a, and a pair of sub channels 25c configured for accepting both sides of the base portion 51. Since their base portion 51 extended widthwisely from the bent portion 52 is securely received at both sides by the sub channels 25c, the contactors 50a and 50b remain inhibited from tilting towards each other. The insertion of the piezoelectric device 10 into the mounting region 23 of the channel 21 is followed by the insertion of the two, first and second, contactors 50a, 50b into their respective second channels 25. While the projected portion 25a comes into direct contact with the bent portions 52 and the opposite surface 25b receives directly the base portion 51, its thickness is arranged slightly smaller than the

thickness of the connect ing port ion 10c so that the piezoelectric device 10 can be avoided from being injured by the unexpected effect of an elastic force of the bent portion 52 . This also ensures the contact between the bent portions 52 and the external electrodes 10f1, 10f2.

**[0023]** The cable 7 with its leads 7a, 7b stripped at the distal end is fitted into the third channel 26 and securely held with the retainer 8. The leads 7a, 7b are separated to left and right by a partition 26a provided at the center in the upper open region 22 and connected to the first and second contactors 50a, 50b respectively by the connecting strips 55 folded down. Then, the upper cover 6 is mounted for protection at the upper end.

**[0024]** The oscillator plate 30 and the nozzle plate 40 are placed one over the other and bonded together before joined to the lower side of the bracket 20. The oscillator plate 30 has a round slot 39a and a long slot 39b provided therein through which the projections 29 provided outwardly on the lower side of the bracket 20 extend for determining the position. The nozzle plate 40 also has a round slot 49a and a long slot 49b provided therein at the locations corresponding to the round slot 39a and the long slot 39b respectively of the oscillator plate 30. The two projections 29 are fitted into the round slots 39a, 49a and the long slots 39b, 49b for accurately determining the position of the bracket 20 in relation to the oscillator plate 30 and the nozzle plate 40. In particular, the round slot 49a and the long slot 49b are provided not through but shut up at the bottom, hence allowing the projections 29 not to extend through the nozzle plate 40 and permitting the nozzle plate 40 to be easily cleaned down even if having been fouled with a leakage of the liquid while avoiding the mixture with unwanted types of liquid.

**[0025]** As shown in Figs. 1, 6, and 8, the oscillator plate 30 includes the projection 31, the diaphragm 32, and a recessed portion 33 which are located beneath the lower end of the channel 21 of the bracket 20. The nozzle plate 40 has a recess 42xprovided in the upper side thereof for forming the pressure chamber 42 while the oscillator plate 30 has a recess 35x provided in the lower side thereof for forming the flow passage 35 which is communicated with the pressure chamber 42. When the two plates have been bonded to each other, the pressure chamber 42 and the flow passage 35 are produced. The flow passage 35 is further communicated across a communication aperture 36 to a flow passage 27c in the bracket 20. The projection 31, the diaphragm 32, and the recessed portion 33 are arranged concentrically at their boundaries and become greater in the diameter towards the outer edge, as shown in Figs. 4 and 6 . The pressure chamber 42 is further communicated across the fast passage 43 to the nozzle 41. The piezoelectric device 10 remains at the lower end 10d partially in direct contact with the projection 31 as the piezoelectric device 10 and the projection 31 are securely bonded to each other. The recessed portion 33 is greater in the outer edge than the lower end 10d of the piezoelectric device 10, whereby the lower end 10d can be avoided from coming into direct contact with the upper side 34 of the oscillator plate 30.

**[0026]** As shown in Figs. 1 and 5, provided at the communication aperture 27 are a recess 27a for accepting the communicating end of a cartridge and a projected portion 27b arranged through the center of which the flow passage 27c extends. Also, a stopper 27d is provided for engaging with a corresponding finger at the communicating end of the cartridge thus to avoid the relative rotating motion of the cartridge.

**[0027]** The action of assembling the above described components of the head 2 starts with applying a coat of the adhesive to the piezoelectric device 10 and inserting the piezoelectric device 10 into the channel 21 from its upper open region 22 and positioned in the mounting region 23. Then, the tooling 9 is inserted into the channel 21 to hold the piezoelectric device 10 with its inclined side 9a and contact side 9b coming into direct contact with the piezoelectric device 10 and the wall of the channel 21 respectively, before the adhesive is cured.

**[0028]** At a separate step, the oscillator plate 30 and the nozzle plate 40 are bonded to each other. Then, their round slots 39a, 49a and the long slots 39b, 49b are engaged with the projections 29 of the bracket 20 and bonded together. Before the two plates 30, 40 are joined to the bracket 20, the lower end 10d of the piezoelectric device 10 is coated with an adhesive and bonded directly to the projection 31 of the oscillator plate 30.

**[0029]** Then, while the contactors 50 are inserted at their distal ends 51 into their respective sub channels 25c of the second channel 25, the cable 7 is inserted into the third channel 26 and its leads 7a, 7bare secured with the connecting strips 55 being folded down, thus completing the electrical connection between the external electrodes 10f1, 10f2, the two, first and second, contactors 50a, 50b, and the leads 7a, 7b respectively. With the cable 7 being supplied with an actuating current, the projection 31 can be observed through the channel 21. This allows the bonding state between the lower end 10d of the piezoelectric device 10 and the projection 31 to be examined from the oscillating movement of the projection 31.

**[0030]** The droplet discharging apparatus 1 according to the present invention may be modified in various modes without departing the scope of the present invention.

In the above described embodiment, the inclined surface 21a of the channel 21 which comes into direct contact with the tooling 9 is provided opposite to the bottom surface 23b. Alternatively, as shown in Fig. 9, another inclined surface 21a may be provided opposite to the side surface 23a for coming into direct contact with the inclined side of the tooling 9. Moreover, as shown in another embodiment of Fig. 10, the piezoelectric device 10 may be secured to at least two surfaces in the channel. In Fig. 10A, the tooling 9 has a contact side 9c arranged of a 90-degree V shape in the cross section the tooling 9 for coming into direct contact with the piezoelectric device 10.

Industrial Applicability

**[0031]** The present invention is applicable to chemical experiments, biotechnology experiments, medical diagnosis, electronics production, and so on. The liquid may be selected from various types. For example, the liquid may contain biological materials such as DNA, protein, or fungus, fluorescent particles, electrically conductive particles, resin particles, ceramic particles, pigments, or dyes. It is suitable for discharging droplets of high surface-tension liquid such as distilled water or expensive liquid. It is also suitable for drawing lines through printing as well as fabricating electrodes and micro-lenses. Moreover, the present invention is favorable for applying an array of droplets at desired locations such as forming biological chips, producing flavors through dispensing or spraying, providing a mixture through controlling the amount to be discharged, or forming films.

**Claims**

**1.** A droplet discharging apparatus having a pressure chamber communicated with a nozzle, a diaphragm which is a member of the pressure chamber, a piezoelectric device for driving the diaphragm, a projection provided on the diaphragm to stay in direct contact with the piezoelectric device for transmitting the oscillating action of the piezoelectric device to the diaphragm, and a bracket, **characterized in that**
an assembly including the pressure chamber, the diaphragm, and the projection can be fixedly mounted to the bracket, and
the bracket has a channel provided therein in which the piezoelectric device of a bar-like form is bonded to the channel as is guided from an open region to the projection by channel.

**2.** The droplet discharging apparatus according to claim 1, wherein
the piezoelectric device is arranged of a square shape in the cross section across the lengthwise direction and bonded with at least two sides of the square at the channel.

**3.** The droplet discharging apparatus according to claim 1, wherein
the bracket has a non-mounting region thereof located in the proximity of the projection where the piezoelectric device is free from the bonding.

**4.** The droplet discharging apparatus according to claim 1, wherein
the piezoelectric device has external electrodes provided at the open region side thereof, and
the bracket has a second channel provided therein for guiding contactors correspond to the external electrodes from the open region.

**5.** The droplet discharging apparatus according to claim 1, wherein
the channel includes a clearance in which the piezoelectric device can travel along one direction which extends at a right angle to the lengthwise direction.

**6.** The droplet discharging apparatus according to claim 5, wherein
an inclined side which form the clearance is provided as arranged so that it becomes more spaced from the piezoelectric device towards the open region along the direction of insertion of the piezoelectric device.

**7.** The droplet discharging apparatus according to claim 5, wherein
the clearance is arranged so that the oscillating movement of the projection can be viewed through the clearance.

**8.** The droplet discharging apparatus according to claim 1, wherein
the nozzle, the pressure chamber, the diaphragm, and the projection are provided on a plate-like member which is positioned and fixedly joined to the bracket.

**9.** The droplet discharging apparatus according to claim 8, wherein
the joining is implemented by a recessed portion of the plate-like member and a proj ectedportion of the bracket.

**10.** The droplet discharging apparatus according to claim 8, wherein
the joining is implemented by a projected portion of the plate-like member and a recessed portion of the bracket.

**11.** The droplet discharging apparatus according to claim 1, wherein
the bracket has a third channel provided therein at the open region side in which a cable is fitted for supplying the piezoelectric device with a driving signal.

**12.** A method of manufacturing a droplet discharging apparatus defined in claim 4, comprising the step of:

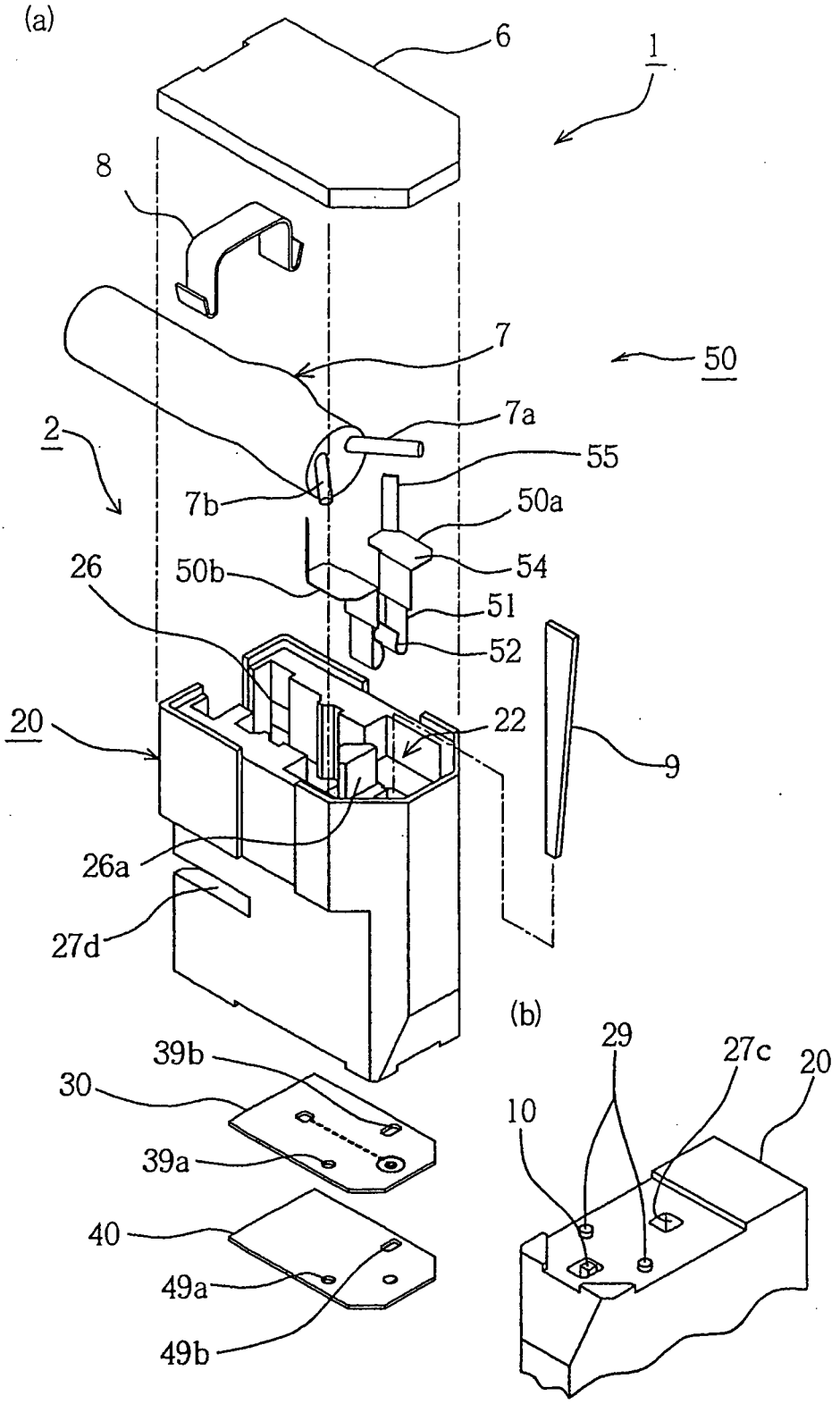
inserting the contactors from the open region into the second channel and guiding and contacting to the external electrodes respectively.

**13.** The method of manufacturing a droplet discharging apparatus defined in claim 6, comprising the step of:

inserting a tooling into the clearance thus to po-

sition and secure the piezoelectric device to the bracket.

Fig. 1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1
8
7
50
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26
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51
52
20
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9
26a
27d
(b)
29
27c
20
10
39b
30
39a
40
49a
49b

Fig. 2

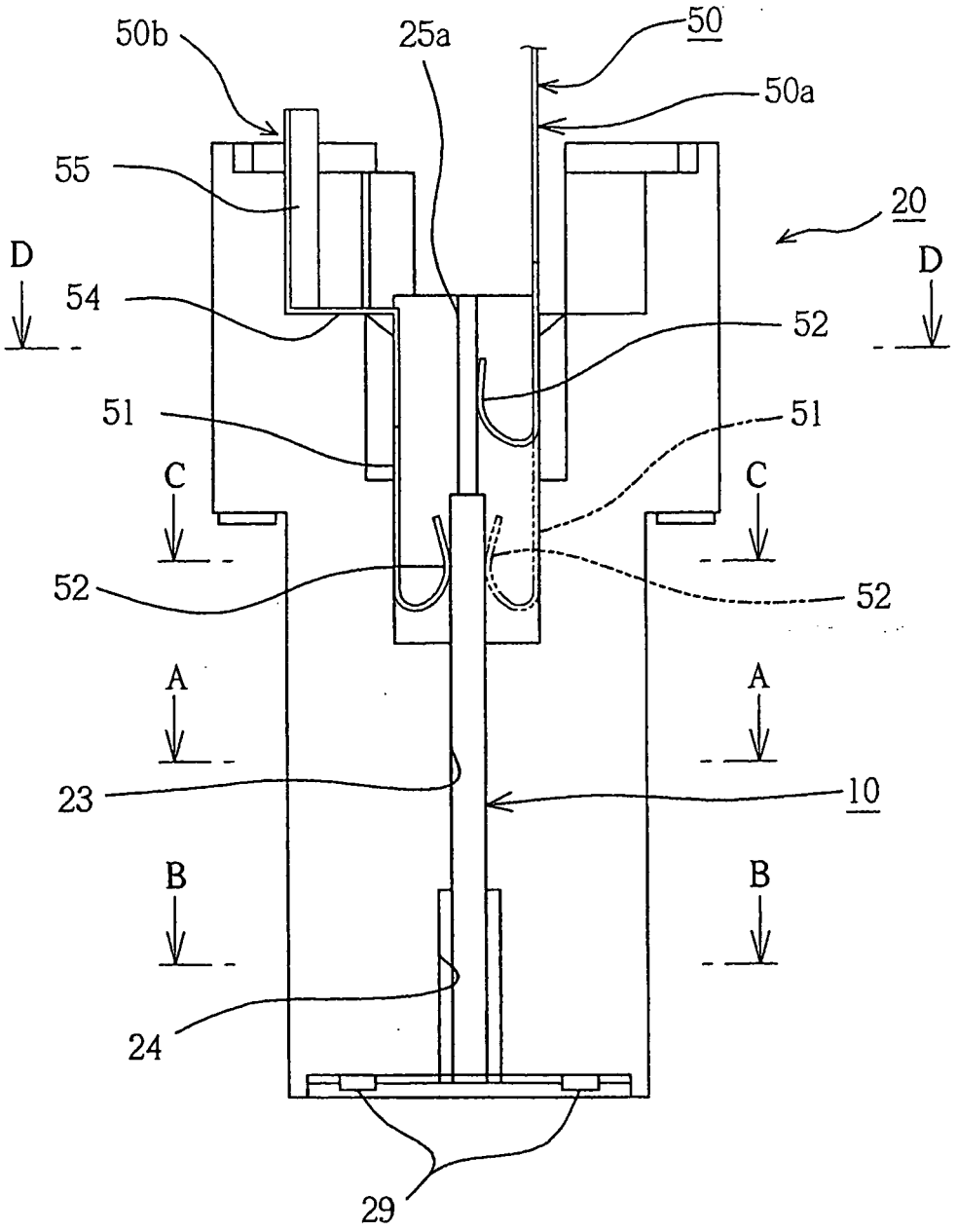


Fig. 3

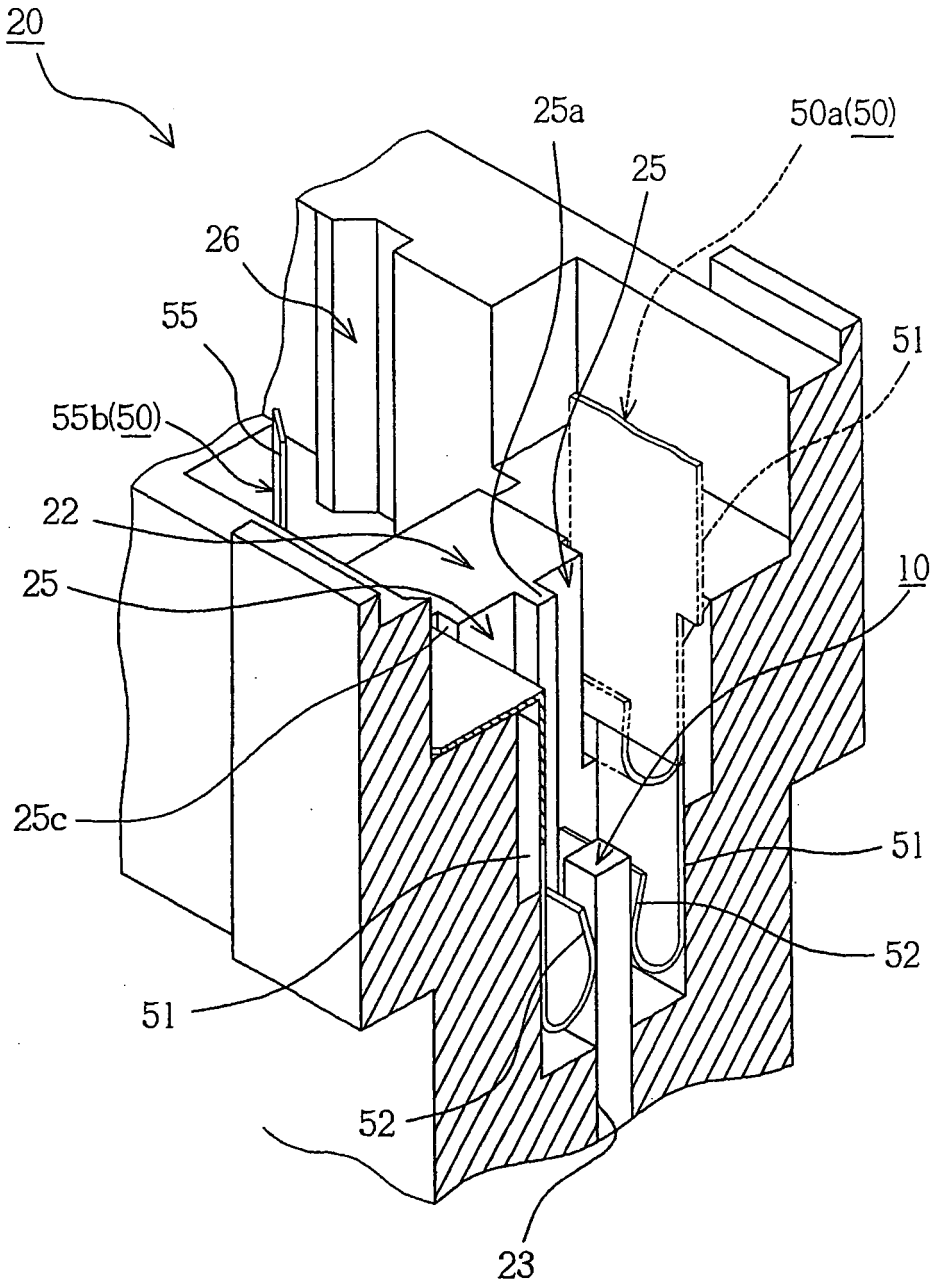
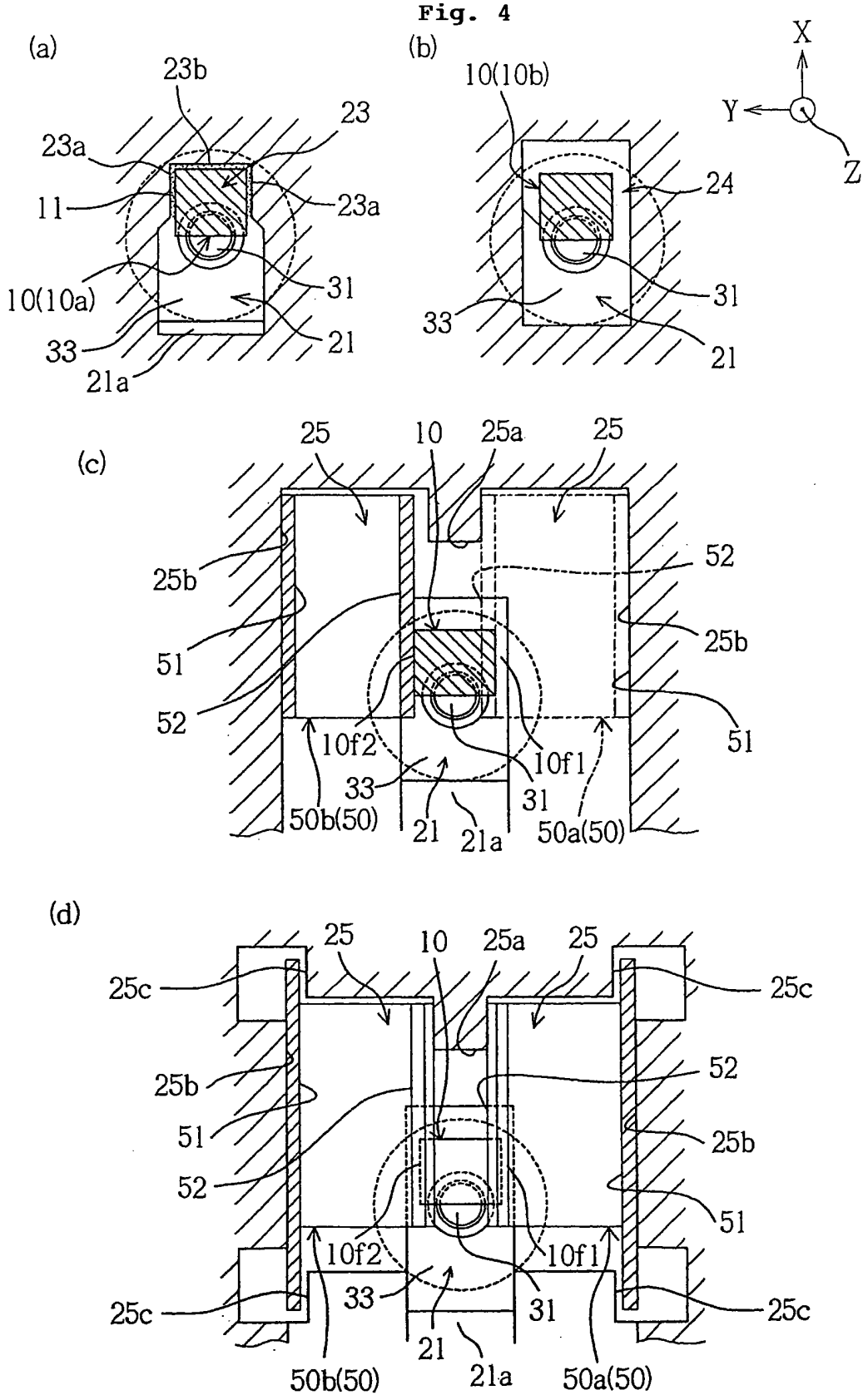


Fig. 4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23a
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(b)
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24
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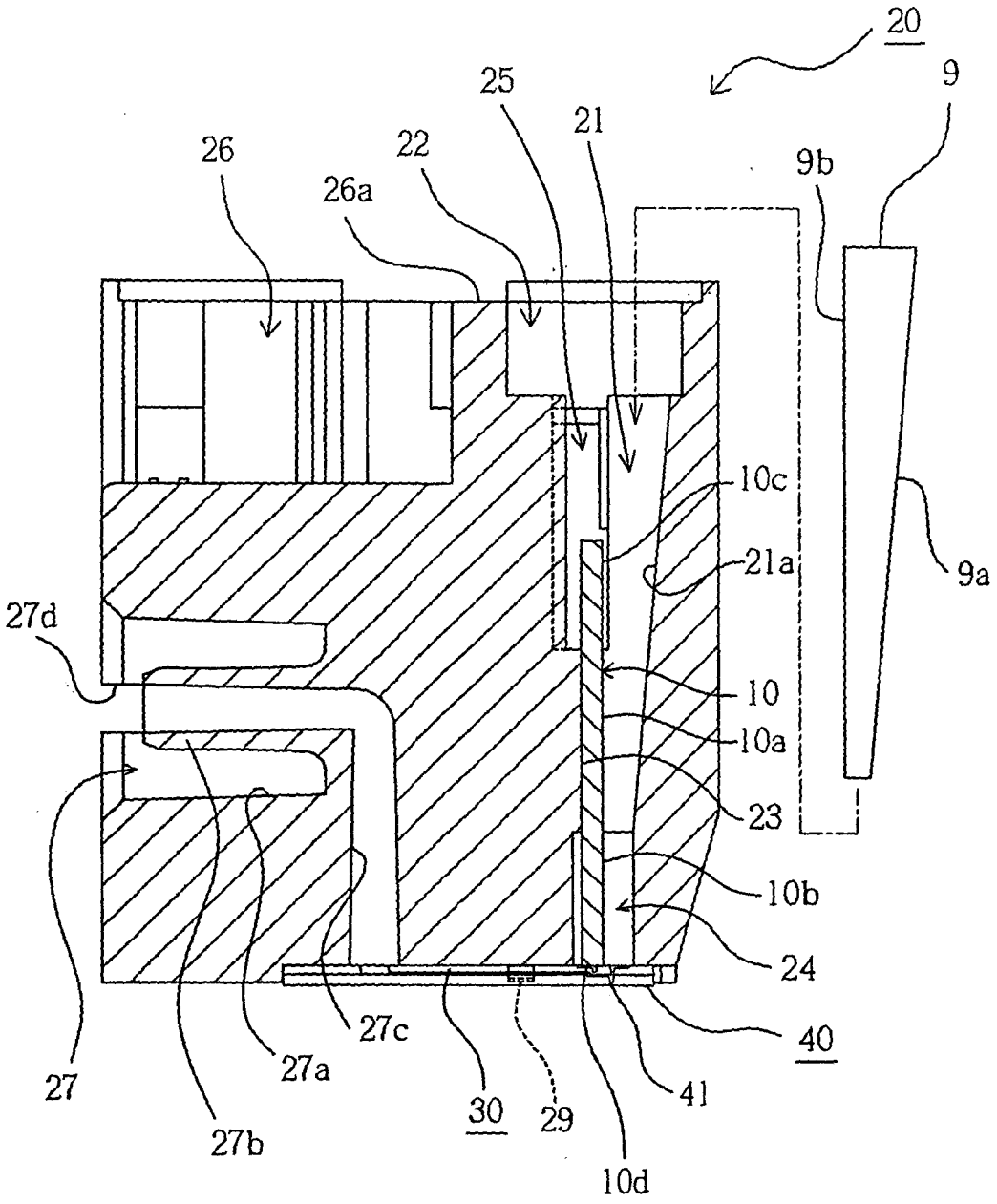
21a
50a(50)

Fig. 5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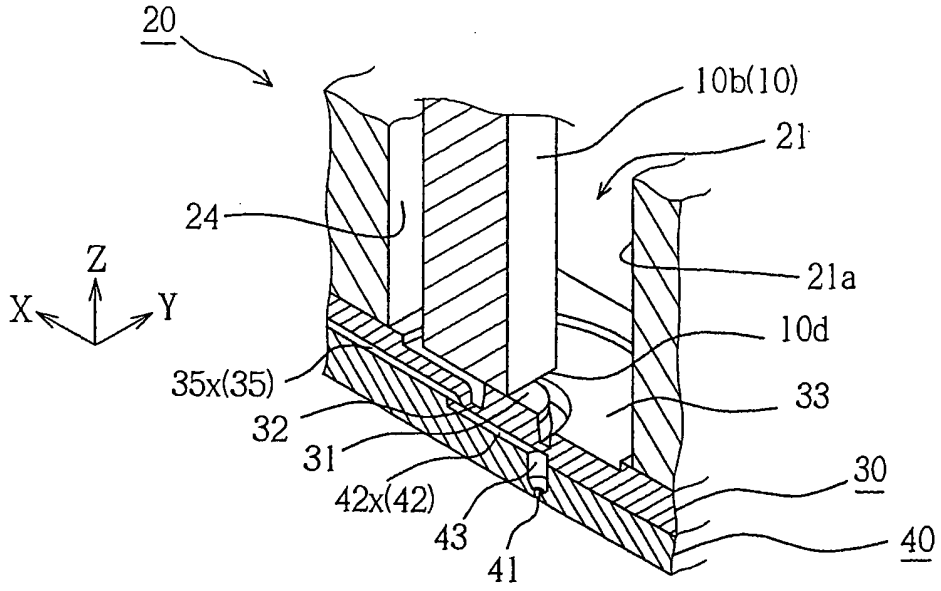
29
27b
10d

Fig. 6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Y
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10d
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32
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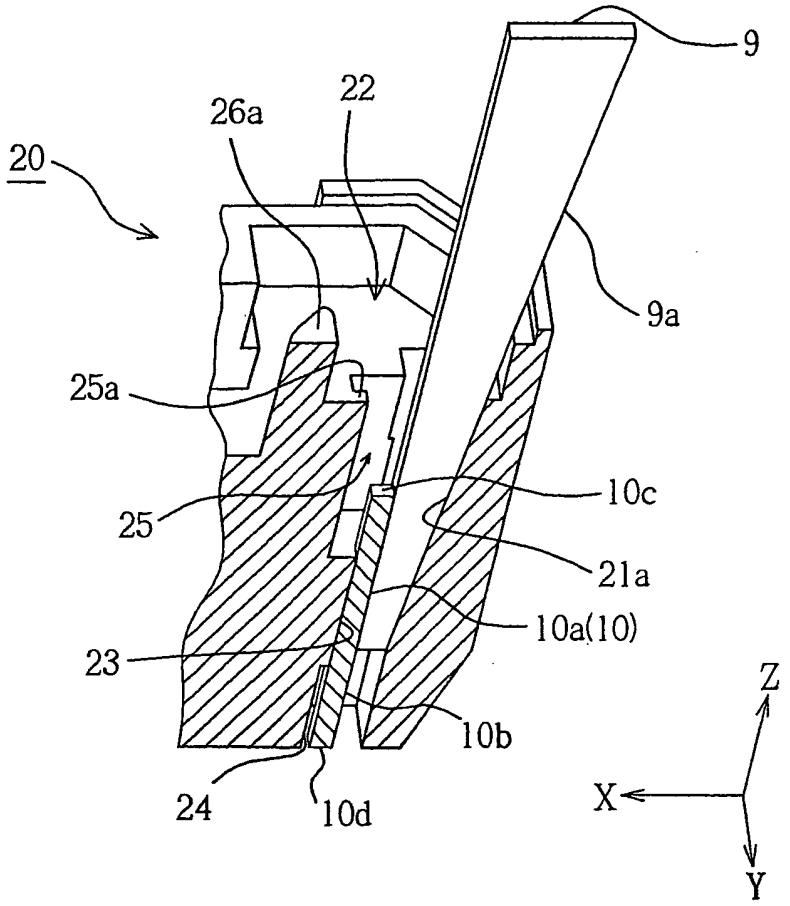
30
42x(42)
43
40
41

Fig. 7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22
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24
10d
Y

Fig. 8

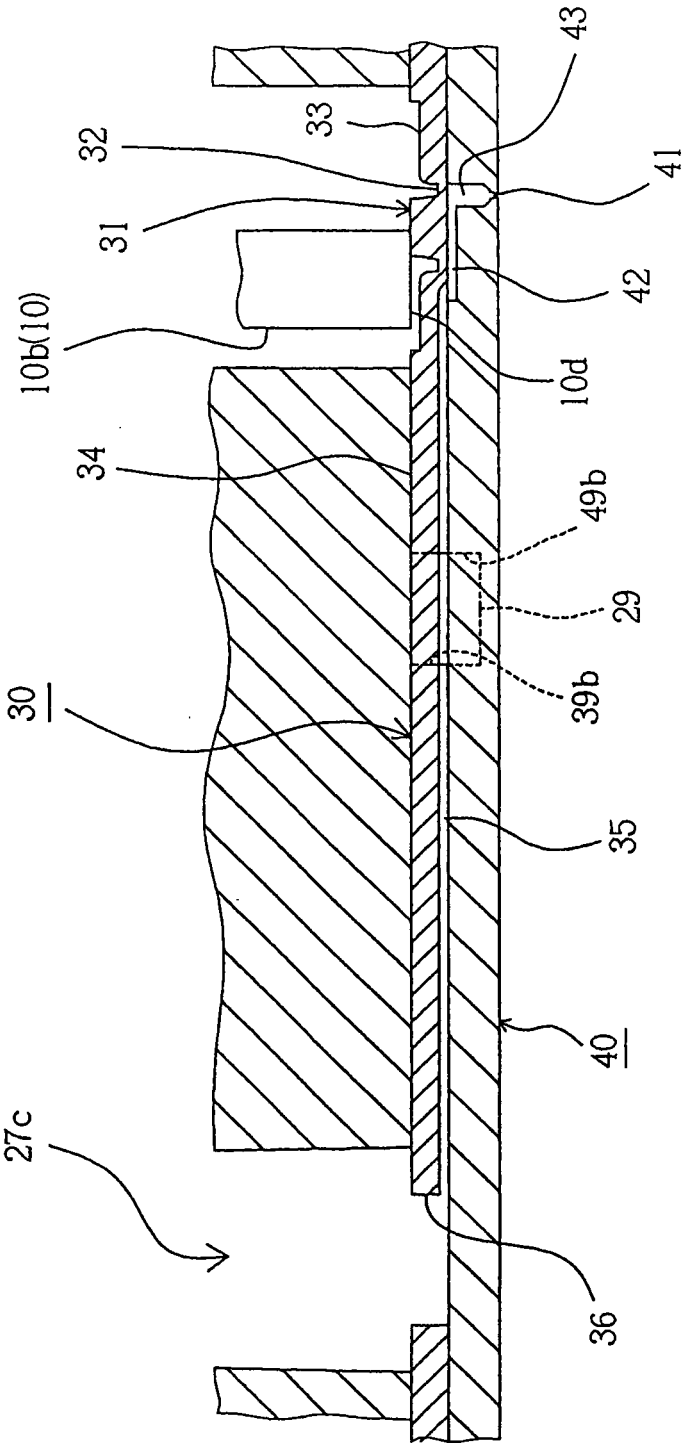


Fig. 9

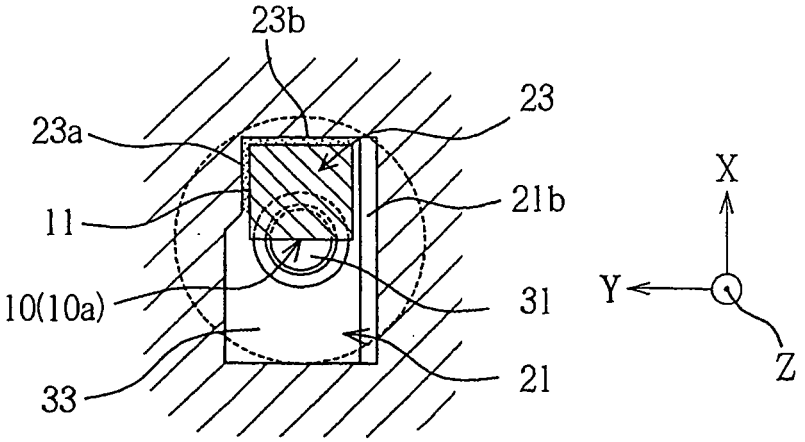
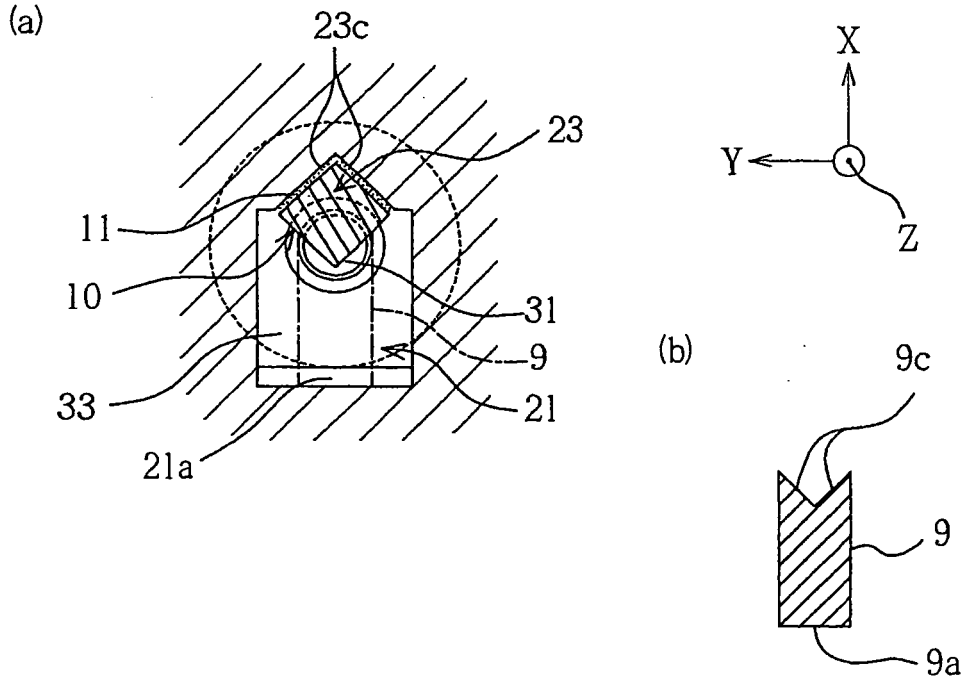

23b
23
23a
21b
11
10(10a)
31
33
21
X
Y
Z

Fig. 10


(a)
23c
23
11
10
31
9
33
21
21a
X
Y
Z
(b)
9c
9
9a

**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2006/321394

A. CLASSIFICATION OF SUBJECT MATTER
*F04B43/04*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04B43/04, B41J2/01

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2007
Kokai Jitsuyo Shinan Koho 1971-2007 Toroku Jitsuyo Shinan Koho 1994-2007

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y<br>A | JP 57-188372 A (Exxon Research & Engineering Co.),<br>19 November, 1982 (19.11.82),<br>Page 7, lower right column, line 9 to page 8, lower right column, line 7; Figs. 7, 8<br>& US 4459601 A1 & GB 2094233 A<br>& DE 3202937 A & FR 2498988 A | 1-3,5,8<br>4,6,7,9-13 |
| Y<br>A | JP 2004-116327 A (Fuji Electric Holdings Co., Ltd.),<br>15 April, 2004 (15.04.04),<br>Par. No. [0019]; Fig. 1<br>(Family: none) | 1-3,5,8<br>4,6,7,9-13 |

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
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"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 22 January, 2007 (22.01.07) | 30 January, 2007 (30.01.07) |
| Name and mailing address of the ISA/<br>Japanese Patent Office<br><br>Facsimile No. | Authorized officer<br><br>Telephone No. |

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**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2006/321394

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | JP 2000-85126 A (Seiko Epson Corp.), 28 March, 2000 (28.03.00), Full text; all drawings (Family: none) | 1-13 |

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## REFERENCES CITED IN THE DESCRIPTION

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### Patent documents cited in the description


- JP 2000085126 A **[0004]**
- JP 57188372 A **[0004]**
- JP 5077431 A **[0004]**