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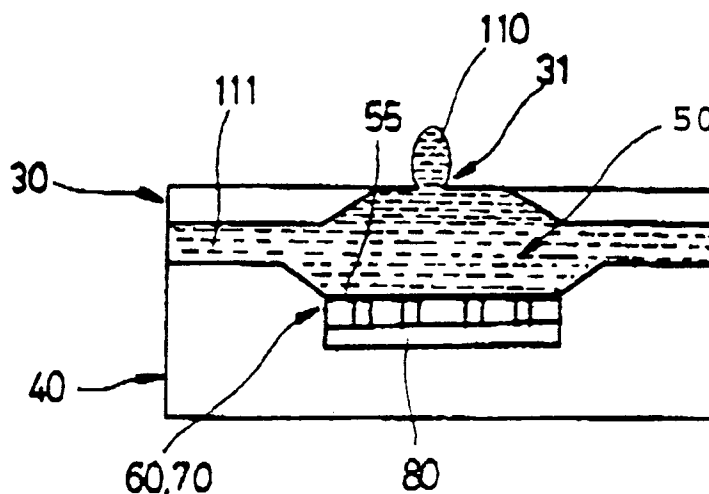
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(54) **Print head for bubble jet printer**

(57) A print head for a bubble jet printer which enables gray scale printing is provided. The print head includes a substrate having a predetermined ink chamber into which ink is supplied, a nozzle plate having a plurality of nozzles disposed above the substrate, a plural-

ity of electrodes attached to the substrate, and a heat generating unit having a plurality of heat generating subunits corresponding to the nozzle and each connected to the plurality of electrodes. Therefore, the size of discharged ink bubbles is controlled by changing the area heated by the heat generating subunits.

**FIG. 3**



**EP 0 775 580 A2**

## Description

### Background of the Invention

The present invention relates to a print head for a bubble jet printer, and more particularly, to a print head for a bubble jet printer which enables gray scale printing.

Generally, a printing apparatus in which ink is discharged by heat-generated bubbles is called a bubble jet printer. That is, in the bubble jet printer, the ink is discharged via a nozzle formed in the print head by bubbles created by heating the ink by a heat generating unit installed in the print head. Accordingly, text and/or graphics can be printed on a paper. In the general print head of a bubble jet printer, ink is discharged in constant amounts.

However, the print quality of the text and graphics printed by the constant amounts of discharged ink is poor, particularly, in the case of graphics printing. As is well known, gray scale printing is desirable for high quality graphics printing. Thus, a technology for controlling the amount of discharged ink in order to attain the gray scale printing has been developed.

A print head for a bubble jet printer for improving print quality is disclosed in U.S. Patent No. 4,339,762 by Yoshiaki *et al.* Referring to FIGS. 1 and 2, the print head proposed by Yoshiaki *et al.* has a structure in which a grooved member 10 and a substrate 20 are connected to each other and ink is discharged from spaces formed therebetween. The grooved member 10 has a plurality of grooves 11a, 11b, 11c, 11d, 11e and 11f which are arranged longitudinally at predetermined intervals placed between a plurality of contact surfaces 12a, 12b, 12c, 12d, 12e, 12f and 12g. Also, the substrate 20 has a plurality of contact layers 24 arranged opposite the contact surfaces 12a to 12g, a plurality of electrodes 23a, 23b, 23c, 23d, 23e and 23f to which current is applied and a heat generating member 22, wherein the electrodes and the heat generating member 22 are placed between the contact layers 24. Also, there is a common electrode 21 on the substrate 20 for applying current to the heat generating member 22. The above print head has a complicated structure in which the volume of ink is controlled by changes of applied pulses, so that the manufacturing process therefor is difficult.

According to a dye dilution method suggested by Suzuki at *SPSE Third International Congress on Advances in Non-Impact Printing Technologies*, San Francisco, Aug. 24-28, 1986, ink having different dye concentrations is separately placed in respective ink containers for three different print heads for discharging ink having different dye concentrations. Thus, manufacturing cost is increased and the structure of the ink cartridge becomes complicated.

Also, according to a technology disclosed in U.S. Patent No. 5,121,143, each area of electrodes corresponding to a plurality of heat generating units is different, so that the heat generating units are of different sizes.

es.

Accordingly, the size of the discharged ink bubble is controlled, thereby providing an effect to improve the print quality. However, this technology requires a nozzle for each heat generating unit, so that integration of the print head is difficult and the manufacturing process of the head is complicated.

In addition, according to a technology disclosed in U.S. Patent No. 4,503,444, a plurality of ink bubbles are used to control the size of dots printed on a paper. However, in this method, the printing speed is limited.

### Summary of the Invention

It is one object of the present invention to provide a print head for a bubble jet printer in which the size of ink bubbles discharged via a nozzle is controlled.

According to an aspect of the present invention there is provided a print head for a bubble jet printer comprising: a substrate having a predetermined ink chamber into which ink is supplied, a nozzle plate having a plurality of nozzles disposed above the substrate; a plurality of electrodes attached to the substrate; and a heat generating unit having a plurality of heat generating subunits each connected to the plurality of electrodes.

Preferably, each nozzle corresponds to the plurality of heat generating subunits.

Preferably, the surface areas of the heat generating subunits are different.

Preferably, the electrodes comprise: a common electrode connected to one end of at least one of the heat generating subunits; a coupling electrode for coupling the other end of the heat generating subunit connected to the common electrode to ends of the heat generating subunits which are not connected to the common electrode; and a connection electrode connected to the other ends of the heat generating subunits which are not connected to the common electrode.

In the print head for the bubble jet printer according to the present invention, the heat generating area may be changed by selecting the electrodes connected to the heat generating units, thereby varying the size of bubbles. The print head for the bubble jet printer according to the present invention can control the size of bubbles to control the amount of discharged ink, so that gray scale printing can be attained.

### Brief Description of the Drawings

The present invention and its advantages will become more apparent by describing in detail preferred embodiments thereof with reference to the attached drawings in which:

FIG. 1 is an exploded perspective view showing a conventional print head for a bubble jet printer; FIG. 2 is a cross-sectional view of the conventional print head shown in FIG. 1, cut along line Y-Y;

FIG. 3 is a cross-sectional view of a print head for a bubble jet printer according to a preferred embodiment of the present invention;

FIG. 4 is a perspective view showing a heat generating unit and an electrode of the print head shown FIG. 3;

FIG. 5 is a perspective view of another example of the heat generating unit according to the present invention;

FIG. 6 is a cross-sectional view showing a print head for a bubble jet printer according to another preferred embodiment of the present invention; and

FIG. 7 is a diagram showing the array of pixel structures, representing gray scales, which can be printed by the print head of the bubble jet printer according to the present invention.

### Detailed Description of the Invention

In FIG. 3, one cell of a print head for a bubble jet printer according to the present invention is shown. The print head has a nozzle plate having a plurality of nozzles, a substrate, a plurality of ink chambers formed on the substrate, a plurality of electrodes attached to the substrate, and a plurality of heat generating units connected to said plurality of electrodes.

FIGS. 3 and 4 show one cell of the print head for the bubble jet printer according to the present invention, a nozzle 31 formed on a nozzle plate 30 and a substrate 40 for forming a predetermined chamber 50 into which ink 111 is supplied. Opposite the nozzle 31 and on the substrate 40, there are a plurality of electrodes 70 to which a predetermined current is applied. Between the electrodes and the substrate 40, there is an insulation layer 80. Also, there is a heat generating unit 60 appropriately connected to the electrodes 70 on the insulation layer 80. The set of electrodes includes one common electrode and several coupling electrodes. In FIG. 4, the electrodes 70 include a common electrode 71, first, second and third coupling electrodes 72, 73 and 74, and first, second and third connection electrodes 75, 76 and 77. The heat generating unit 60 includes first through sixth heat generating subunits 61 through 66.

The common electrode 71 is connected to one end of the fourth, fifth and sixth heat generating subunits 64, 65 and 66, and the first, second and third connection electrodes 75, 76 and 77 are connected to an end of each of the first, second and third heat generating subunits 61, 62 and 63, respectively. Also, the first coupling electrode 72 couples the first and sixth heat generating subunits 61 and 66, the second coupling electrode 73 couples the second and fifth heat generating subunits 62 and 65, and the third coupling electrode 74 couples the third and fourth heat generating subunits 63 and 64.

As power is selectively applied to the first, second and third connection electrodes 75, 76 and 77, the heat generating area of the heat generating unit 60 changes when the heat generating subunits have different areas

one another. That is, the first and sixth heat generating subunits 61 and 66 are simultaneously heated when power is applied to the first connection electrode 75, the second and fifth heat generating subunits 62 and 65 are simultaneously heated when power is applied to the second connection electrode 76, and the third and fourth heat generating subunits 63 and 64 are simultaneously heated when power is applied to the third connection electrode 77.

Also, when power is applied to the first connection electrode 75 or to the first and second connection electrodes 75, 76 or to the first, second, and third connection electrodes 75, 76, 77, the first and sixth heat generating subunits 61, 66 or the first, second, fifth and sixth heat generating subunits 61, 62, 65, 66 or the first, second, third, fourth, fifth, and sixth heat generating subunits 61, 62, 63, 64, 65, 66 are heated respectively.

As described above, selecting the number of connection electrodes from the heat generating unit can change the number of the heat generating subunits resulting in the modulation of the heat generating area.

The electrodes 70, connected to the heat generating unit 60, the first through sixth heat generating subunits 61 to 66, can be arranged in the same plane without being overlapped. If the heat generating unit 60 is manufactured by overlapping the heat generating subunits 61 to 66, the manufacturing cost is increased and the manufacturing process is complicated.

Referring to FIG. 3, the nozzle 31 and the heat generating unit 60 are positioned opposite each other such that the ink discharge direction through the nozzle 31 is perpendicular to the surface of heat generating unit 60. Referring to FIG. 6, according to another embodiment of the present invention, a nozzle 53 may be formed at one end of the ink chamber 50 such that the surface of heat generating unit 60 is co-linear to the ink discharge direction through the nozzle 53. In this case, the direction of the nozzle 53 is perpendicular to the plane of the heat generating unit 60.

A protection layer 55 (see FIG. 3) for protecting the heat generating unit 60 from the ink 111, made of a compound including Ta,  $\text{Si}_3\text{N}_4$  and SiC, is formed on the heat generating unit 60. The heat generating subunits 61-66 of the heat generating unit 60 may be made of Ta-Al alloy or  $\text{HfB}_2$ , and the electrodes 70 may be made of Al-Cu alloy.

In the print head for the bubble jet printer according to the above-described embodiment, current corresponding to a print signal is selectively applied to each electrode 70, the heat generating subunits 61-66 are selectively heated and then bubbles are generated in the ink 111, corresponding to the area of the selectively heated heat generating subunits 61 to 66. Then, ink 111 is discharged through the nozzle 31; 53 by the generated bubbles. In the bubble jet printer according to the present embodiment, current is selectively applied to the heat generating subunits 61-66, so that the size of an ink bubble 110 can be controlled to a desired size.

According to another embodiment of the present invention, ink bubbles of varying sizes may be obtained by varying the sizes of heat generating subunits 61', 62' and 63' as shown in FIG. 5.

Thus, a pixel formed of four dots having a matrix structure can be printed in eleven scales of gray as shown in FIG. 7. That is, when a pixel is printed while the dots form a matrix structure, for example, when a pixel comprised of a 2x2 matrix and having two dot sizes whose diameter ratio is 1:3, is used, printing in eleven gray scales can be attained.

As described above, in the print head for the bubble jet printer according to embodiments of the present invention, the heating area of the heat generating unit is controlled, so that the size of the ink bubbles discharged via a nozzle can be controlled. As a result, the printing can be attained in various gray scales.

Although the present invention has been described with reference to specific embodiments, further modifications and alterations will occur to those skilled in the art within the scope of the accompanying claims.

## Claims

1. A print head for a bubble jet printer comprising:

a substrate having a predetermined ink chamber into which ink is supplied;  
a nozzle plate having a plurality of nozzles disposed above said substrate;  
a plurality of electrodes attached to said substrate; and  
a heat generating unit having a plurality of heat generating subunits each connected to said plurality of electrodes.

2. A print head for a bubble jet printer as claimed in claim 1, wherein said nozzle corresponds to said plurality of heat generating subunits.

3. A print head for a bubble jet printer as claimed in claim 1, wherein said heat generating subunits have different surface areas.

4. A print head for a bubble jet printer as claimed in claim 1, wherein said plurality of electrodes comprise:

a common electrode connected to one end of said heat generating subunits;  
a plurality of coupling electrodes for coupling the other end of said heat generating subunits connected to said common electrode to ends of the heat generating subunits which are not connected to said common electrode; and  
a connection electrode connected to the other ends of said heat generating subunits which are

not connected to said common electrode.

5. A print head for a bubble jet printer as claimed in claim 4, wherein current is applied directly to said connection electrode.

6. A print head for a bubble jet printer as claimed in claim 1, wherein said nozzle is installed opposite said heat generating unit such that an ink supply direction in said chamber is perpendicular to an ink discharge direction through said nozzle.

7. A print head for a bubble jet printer as claimed in claim 1, wherein said nozzle is formed at one end of said chamber such that an ink supply direction in said chamber is parallel to an ink discharge direction through said nozzle.

8. A print head for a bubble jet printer as claimed in claim 1, wherein a protection layer is formed on said heat generating unit to protect said heat generating unit from said ink.

9. A print head for a bubble jet printer as claimed in claim 8, wherein said protection layer is formed of a compound including Ta, Si<sub>3</sub>N<sub>4</sub> and SiC.

10. A print head for a bubble jet printer as claimed in claim 1, wherein an insulation layer is formed between said plurality of electrodes and said substrate.

11. A print head for a bubble jet printer as claimed in claim 1, wherein said heat generating subunits are arranged in the same plane.

12. A print head for a bubble jet printer as claimed in claim 1, wherein said plurality of electrodes comprise:

a plurality of coupling electrodes connected to said heat generating subunits;  
a common electrode; and  
a plurality of connection electrodes selectively connected to said heat generating subunits.

13. A print head for a bubble jet printer as claimed in claim 12, wherein a predetermined current is selectively applied to said plurality of connection electrodes to control the amount of discharged ink.

14. A print head comprising:

a substrate;  
a nozzle plate having at least one nozzle; and  
a predetermined ink chamber disposed between said substrate and said nozzle plate, said ink chamber into which ink is supplied,

wherein respective said nozzles having a plurality of electrodes and a heat generating unit having a plurality of heat generating subunits each connected to said plurality of electrodes.

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15. A print head as claimed in claim 14, wherein a predetermined current is selectively applied to said plurality of electrodes.

16. A print head as claimed in claim 15, wherein said predetermined current is selectively applied to said plurality of electrodes to control the amount of discharged ink.

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17. A print head for a bubble jet printer comprising at least one heater means, supply means for supplying ink thereto and an ink discharge means associated with each said at least one heater means; characterised in that parts of said at least one heater means are selectively operable.

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18. A method of greyscale printing using a bubble jet printer, the method comprising the steps of:

determining the greyscale to be used; and selecting one or more portions of a jet heater means according to the determined greyscale and operating the selected portion or portions.

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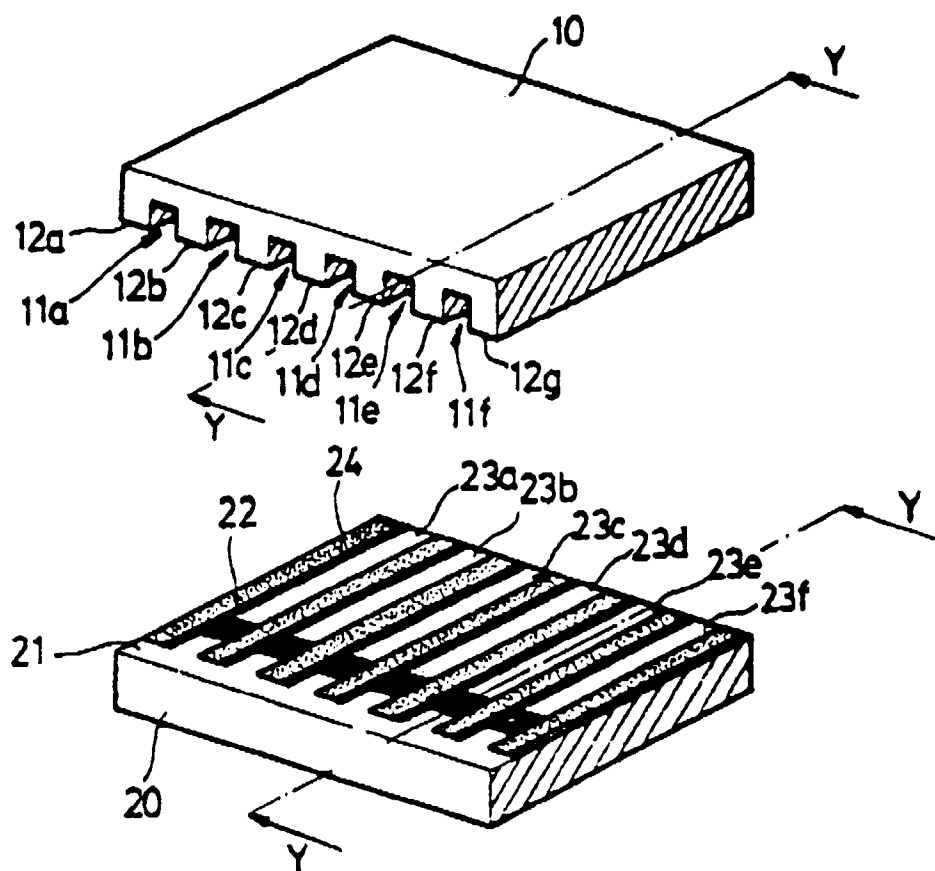
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**FIG. 1 (PRIOR ART)**



**FIG. 2 (PRIOR ART)**

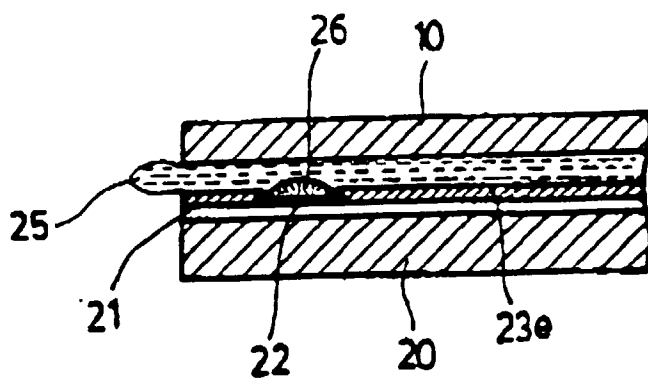


FIG. 4

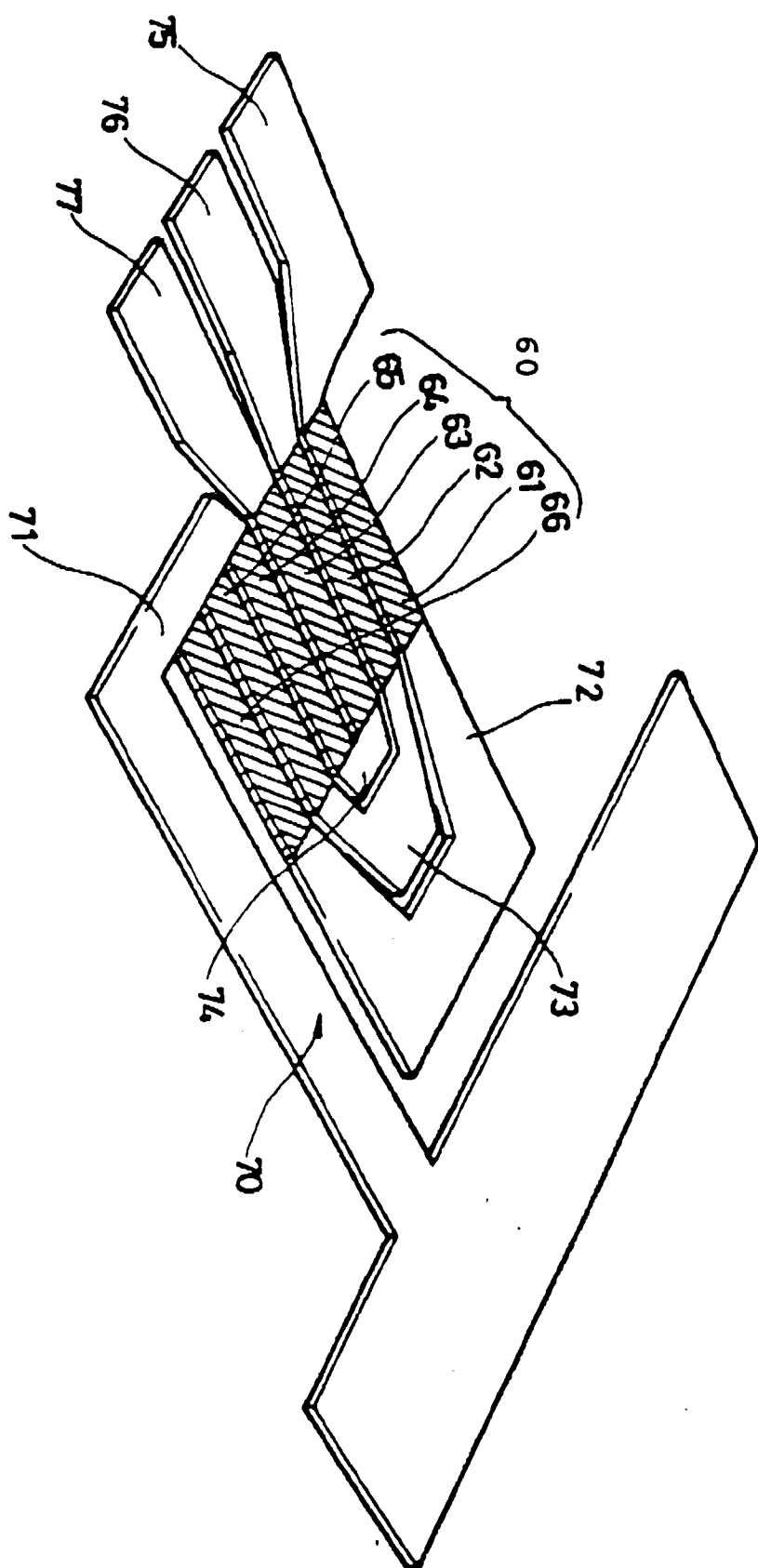


FIG. 3

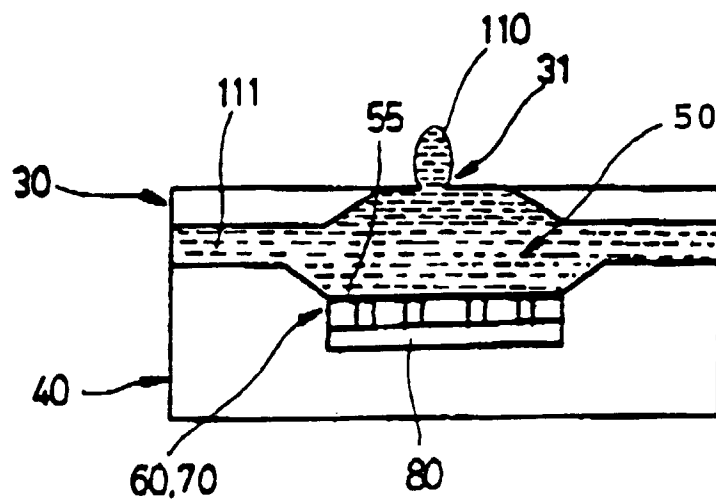


FIG. 5

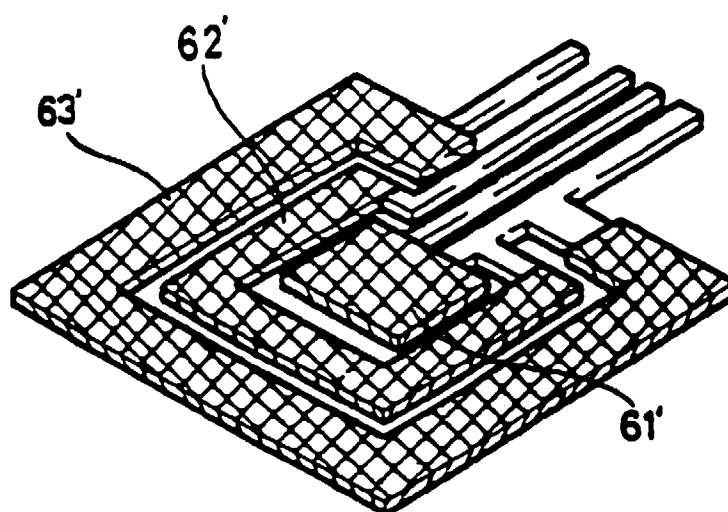




FIG. 6

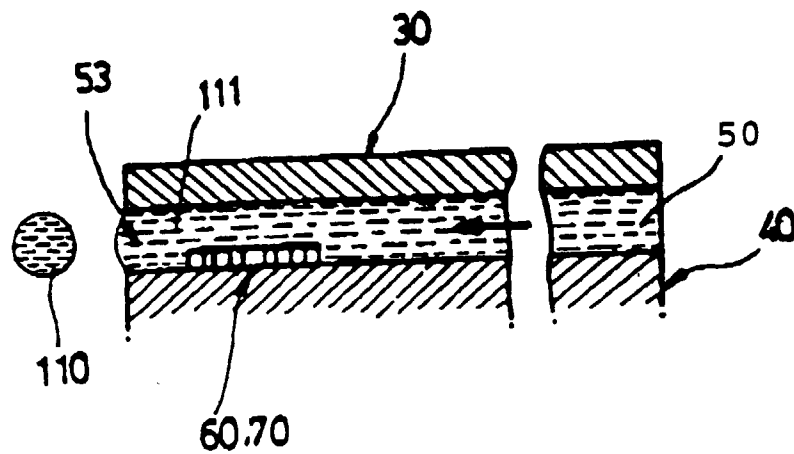


FIG. 7

