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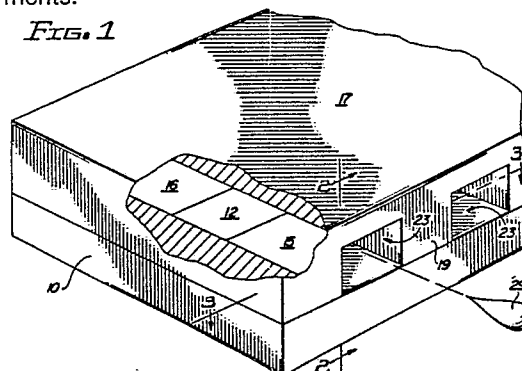
Thermal drop-on-demand ink jet printer print head.

The invention relates to a thermal drop-on-demand ink jet printer print head comprising a thermally conductive substrate member (10), a plurality of spaced apart heating elements (12) on a surface of the substrate member, a first electrical connection member (15) on the surface of the substrate member and in contact with all of the heating elements, a plurality of second electrical connection members (16) on the surface of the substrate member, each of the second electrical connection members being in electrical contact with a respective one of the heating elements, and a heat shield for preventing the flow of heat between adjacent heating elements.

According to the invention, the print head is characterised in that the heat shield comprises a plurality of heat conducting elements on the surface

of the substrate member and extending into the spaces between adjacent heating elements, each of the heat conducting elements being integrally connected to one of the electrical connection members whereby the heat conducting elements conduct heat away from the spaces between the heating elements.

FIG. 1



THERMAL DROP-ON-DEMAND INK JET PRINTER PRINT HEAD

This invention relates to a thermal drop-on-demand ink jet printer print head.

A thermal drop-on-demand ink jet printer is known to include a print head, in which a heater element is selectively energised to form a "bubble" in an adjacent mass of ink. The rapid growth of the bubble causes an ink drop to be ejected from a nearby nozzle. Printing is accomplished by energising the heater element each time a drop is required at that nozzle position, to produce an ink dot in a desired position. The printer usually includes an array of nozzles.

Depending on the frequency of operation and the density of the array of nozzles, adjacent nozzles may affect each other by the transfer of heat from each nozzle to an adjacent nozzle (thermal cross talk), although this has not been a substantial problem with thermal drop-on-demand ink jet printers that are currently marketed. However, in applications where the number of nozzles in a thermal ink jet head is increased for high resolution, colour and page printing, there is a requirement for higher rates of producing ink drops and increased density of printed dots, and these requirements require a solution to the problems caused by the resulting thermal cross-talk. The thermal cross-talk impedes print head performance since it creates an unsteady, non-uniform temperature field which can significantly alter the mechanism of bubble nucleation thereby leading to poor print quality.

US-A-4,502,060 shows a thermal ink jet printer in which barrier walls substantially surround the heater element resistors to define the capillary channels for feeding ink between a source and an orifice plate. The barrier walls also serve to maintain a separation between adjacent resistors to inhibit hydraulic cross-talk.

The object of the present invention is to provide an improved thermal drop-on-demand ink jet printer print head in which thermal cross-talk is substantially eliminated.

The invention relates to a thermal drop-on-demand ink jet printer print head comprising a thermally conductive substrate member, a plurality of spaced apart heating elements on a surface of the substrate member, a first electrical connection member on the surface of the substrate member and in contact with all of the heating elements, a plurality of second electrical connection members on the surface of the substrate member, each of the second electrical connection members being in electrical contact with a respective one of the heating elements, and a heat shield for preventing the flow of heat between adjacent heating elements.

According to the invention, the print head is

characterised in that the heat shield comprises a plurality of heat conducting elements on the surface of the substrate member and extending into the spaces between adjacent heating elements, each of the heat conducting elements being integrally connected to one of the electrical connection members, whereby the heat conducting elements conduct heat away from the spaces between the heating elements.

In order that the invention may be more readily understood, an embodiment will now be described with reference to the accompanying drawings in which:

Fig. 1 is a perspective view, with some parts cut away, of a print head for a thermal drop-on-demand ink jet printer embodying the present invention,

Fig. 2 is a side view of the print head illustrated in Fig. 1 sectioned along the lines 2-2,

Fig. 3 is a plan view of the print head illustrated in Fig. 1 sectioned along the lines 3-3,

Fig. 4 is an end view of the print head illustrated in Fig. 1 sectioned along the lines 4-4 of Fig. 3,

Fig. 5 is a plan view in section of another print head also embodying the present invention,

Fig. 6 is a plan view in section of a further print head also embodying the present invention,

Fig. 7 is a plan view in section of a still further print head also embodying the present invention,

Fig. 8 is an end view of the print head illustrated in Fig. 7 sectioned along lines 8-8, and

Fig. 9 is a side view of the print head illustrated in Fig. 2 sectioned along lines 9-9.

Referring to Figs. 1 and 2, a print head for a thermal drop-on-demand ink jet printer comprises a suitable substrate member 10, upon one surface 11 of which is formed an array of resistive heater elements 12, only one of which is shown in Fig. 1. Each of the resistive heater elements 12 is formed on a multilayer thin-film structure comprising a heat insulation layer 13 common to all the heater elements and a resistive heater film 14. Layer 13 must also be electrically insulating. Each one of a plurality of control electrodes 16 makes electrical contact with a respective one of the heater films 14 and a common electrode 15 makes electrical contact with each of the resistive heater films 14 and electrically short circuits all parts of the heater films 14 except the portions between the electrodes 15 and 16 which form the resistive heater elements 12.

A passivation layer (not illustrated) may be deposited over the array of the resistive heater

elements 12 and the associated electrodes 15 and 16 to prevent both chemical and mechanical damage to the resistive heater elements 12 and the electrodes 15 and 16. However, the passivation layer is not shown in the drawings so that the underlying structure can be more easily shown. A second substrate member 17 is fixed in position relative to the substrate 10 so that wall members 19 formed in the member 17 define a plurality of channels 21 each associated with a respective one of the resistive heater elements 12. A nozzle 23 is provided formed by one end of each channel 21. An ink supply (not shown) is provided to supply a marking fluid such as ink to each of the channels 21.

In operation, a data pulse is supplied to a selected control electrode 16 to energise the associated resistive heater element 12 resulting in the production of a bubble 25 in the ink adjacent to the heater element 12. The inertial effects of controlled motion of the bubble to the right as shown by arrow 27 forces a drop 29 of ink from the associated nozzle 23.

According to the present invention a heat shield is provided which extends into the spaces between adjacent resistive heater elements 12 to eliminate thermal cross-talk between adjacent resistive heating elements 12. The heat shield serves as a heat sink so that the lateral heat flow reaching the heat shield is conducted both along the electrodes and also down to the substrate member 10.

In the embodiment of the invention shown in Figs. 3 and 4, the heat shield 18 comprises an array of thin-film metal fingers 20 deposited on the surface of the heat insulation layer 13 within the spaces on layer 13 between the resistive heater elements 12. In the embodiment shown, the metal fingers 20 are of the same material as and are integrally connected to the common electrode 15, so that the metal fingers 20 can be produced very easily by a simple change in the mask used in the fabrication of the common electrode 15.

Analysis has shown that a major portion of the heat generated by the resistive heater elements 12 is conducted away by the common electrode 15 and the control electrodes 16. However, in known arrangements, there has been no way to conduct away heat from the space between the resistive heater elements 12. In accordance with the embodiment being described, the metal fingers 20 not only conduct away heat from this space directly into the substrate but also conduct heat along the fingers back to the common electrode 15, and in this way tend to eliminate the thermal cross-talk problem.

In the embodiment illustrated in Fig. 5 thin-film metal fingers 22 forming a heat shield 18 are attached to the control electrodes 16 and extend

into the space on the surface of layer 13 between adjacent resistive heater elements 12. The operation of these metal fingers 22 is similar to that of the previously described embodiment, in that heat is conducted to the substrate 10 by the fingers 22 and along the fingers 22 back to the control electrodes 16.

A further embodiment is illustrated in Fig. 6 in which thin-film metal fingers 24 extend into some of the spaces between adjacent resistive heater elements 12 and these fingers are attached to the common electrode 15. Interleaved with these metal fingers 24 are thin-film metal fingers 26 which extend into the rest of the spaces between adjacent heating elements 12 and are attached to individual control electrodes 16.

The heat shield 18 described significantly decreases the thermal diffusion time constant with the result that the heat generated by the heater elements 12 is quickly diffused toward the periphery of the heater substrate 10 where heat sink structures (not shown) are available for absorbing the heat. The resultant effect is that the thermal ink jet printer print head temperature can be maintained at a relatively low level so that thermal cross-talk is virtually eliminated.

Additional thermal cooling can be provided by the embodiment illustrated in Figs. 7, 8 and 9. The heat insulation layer 13 acts as a short-term thermal barrier, and this layer comprises a material such as SiO₂, for example. As shown in Fig. 8, the heat shield 18 comprises a plurality of thin-film metal fingers 28 and the portions of the heat insulation layer 13 under the thin-film metal fingers 28 are removed by the use of an additional processing step using standard techniques such as reactive ion etching, for example. In this way the metal fingers 28 are deposited directly on the surface 11 of the substrate member 10 which has a much higher thermal conductivity than the heat insulation layer 13.

In some cases in which the substrate member 10 is electrically conductive, it may not be possible to remove completely the portion of the heat insulation layer 13 under the thin film metal fingers 28. However, in this case, additional cooling can be provided by substantially thinning the portion of the heat insulation layer 13 under the metal fingers 28. Still further thermal cooling can be accomplished by reducing the thickness of the portion of the heat insulation layer 13 in those areas under both the common electrode 15 and the control electrodes 16, as shown in Fig. 9.

It is also possible to provide additional cooling by eliminating the heat insulation layer 13 entirely under the common electrode 15 so that heat flow into the substrate member 10 is maximised. The heat insulation layer 13 under the common elec-

trode 15 can be eliminated entirely when the substrate member 10 is not electrically conductive. The layer 13 under the common electrode 15 can also be eliminated when the common electrode is maintained at ground potential without regard to whether or not the substrate member 10 is electrically conductive.

A simple change in print head substrate structure with the addition of metal cooling fingers, control electrodes metallurgically separated from the electrically and thermally conductive substrate member by a much thinner heat insulation layer, and common electrode areas directly in contact with the thermally conductive substrate member provides improved thermal cooling and minimises thermal cross-talk between adjacent heater elements.

Claims

1. A thermal drop-on-demand ink jet printer print head comprising
a thermally conductive substrate member (10),
a plurality of spaced apart heating elements (12) on
a surface of said substrate member,
a first electrical connection member (15) on said
surface of said substrate member and in contact
with all of said heating elements,
a plurality of second electrical connection members
(16) on said surface of said substrate member,
each of said second electrical connection members
being in electrical contact with a respective one of
said heating elements, and
a heat shield (18) for preventing the flow of heat
between adjacent heating elements,
characterised in that
said heat shield (18) comprises a plurality of heat
conducting elements (20; 22; 24, 26; 28) on said
surface and extending into the spaces between
adjacent heating elements (12), each of said heat
conducting elements being integrally connected to
one of said electrical connection members whereby
said heat conducting elements conduct heat away
from the spaces between said heating elements.

2. A print head as claimed in claim 1 characterised in that said heat conducting elements (12) are all connected to said first electrical connection member (15).

3. A print head as claimed in claim 1 characterised in that each of said heat conducting elements (12) is connected to a respective one of said second electrical connection members (16).

4. A print head as claimed in claim 1 characterised in that a first set (24) of said heat conducting elements are connected to said first electrical connection member (15), a second set (26) of said heat conducting elements are each connected to a

respective one of said array of second electrical connection members (16) and the elements of said first and second sets of heat conducting elements are interleaved.

5. A print head as claimed in any one of the preceding claims characterised in that it comprises a heat insulation layer (13) deposited on a surface of said substrate member (10), and in that said heat conducting elements (20; 22; 24, 26; 28) are on said heat insulation layer.

6. A print head as claimed in claim 5 characterised in that said heat insulation layer (13) has a nominal thickness, and in that the thickness of said heat insulation layer under said electrical connection members (15, 16) is less than said nominal thickness, whereby said electrical connection members provide enhanced thermal conduction to said substrate member.

7. A print head as claimed in claim 5 characterised in that said heat insulation layer (13) has a nominal thickness, and in that the thickness of said heat insulation layer under said heat conducting elements (20; 22; 24, 26; 28) is less than said nominal thickness, whereby said heat conducting elements provide enhanced thermal conduction to said substrate member.

8. A print head as claimed in any one of the preceding claims 1 to 4 characterised in that it comprises a heat insulation layer (13) deposited on a surface of said substrate member (10), and in that the portions said heat insulation layer (13) under said heat conducting elements (20; 22; 24, 26; 28) have been removed whereby said heat conducting elements are in direct thermal contact with said surface of said substrate member.

FIG. 1

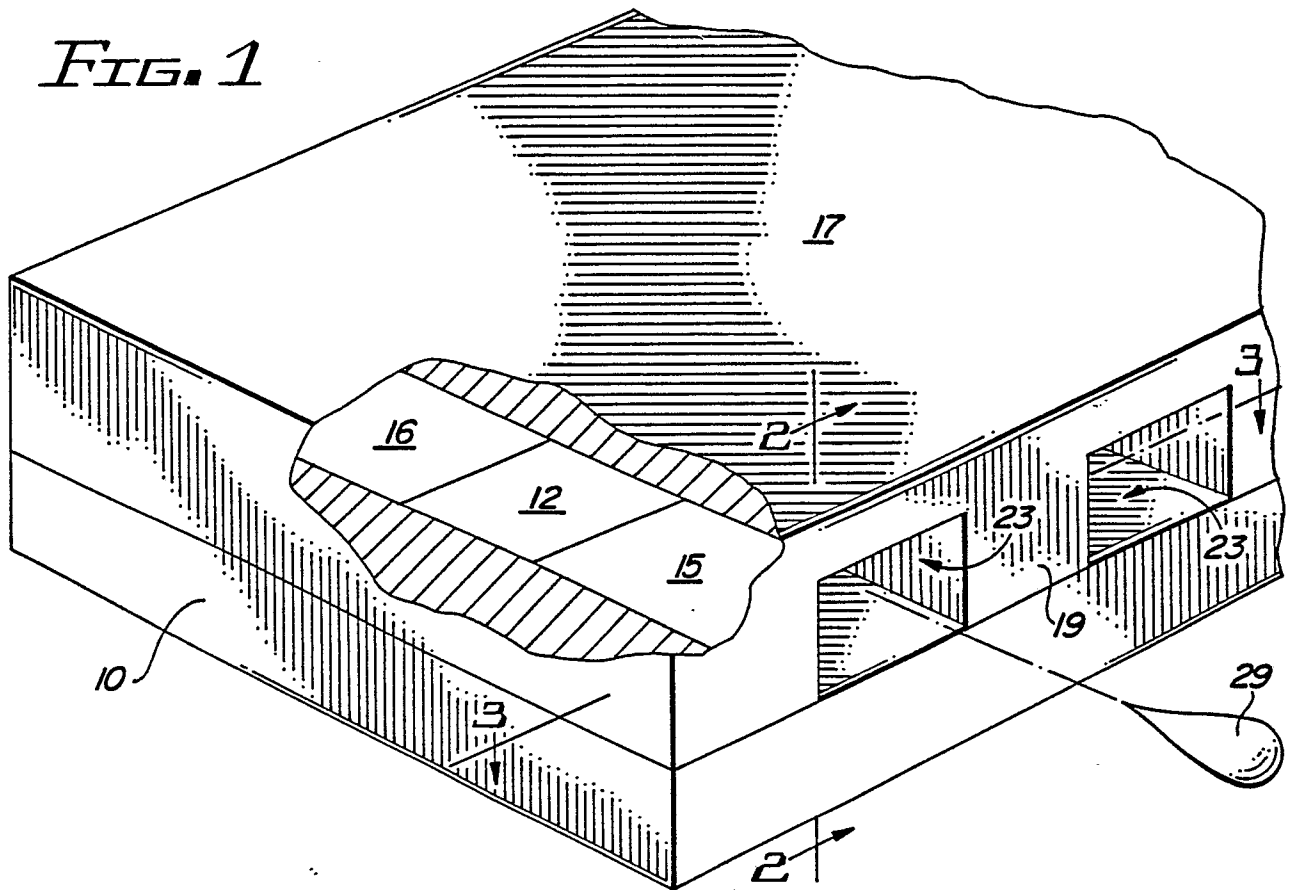


FIG. 2

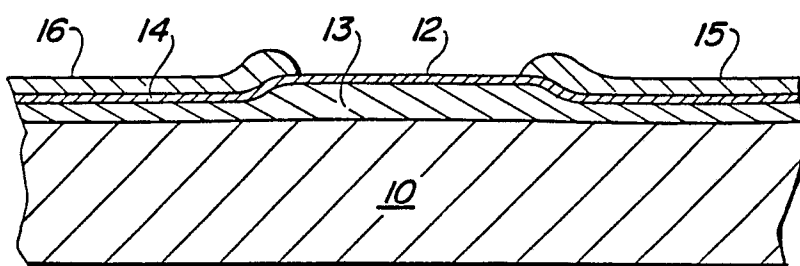
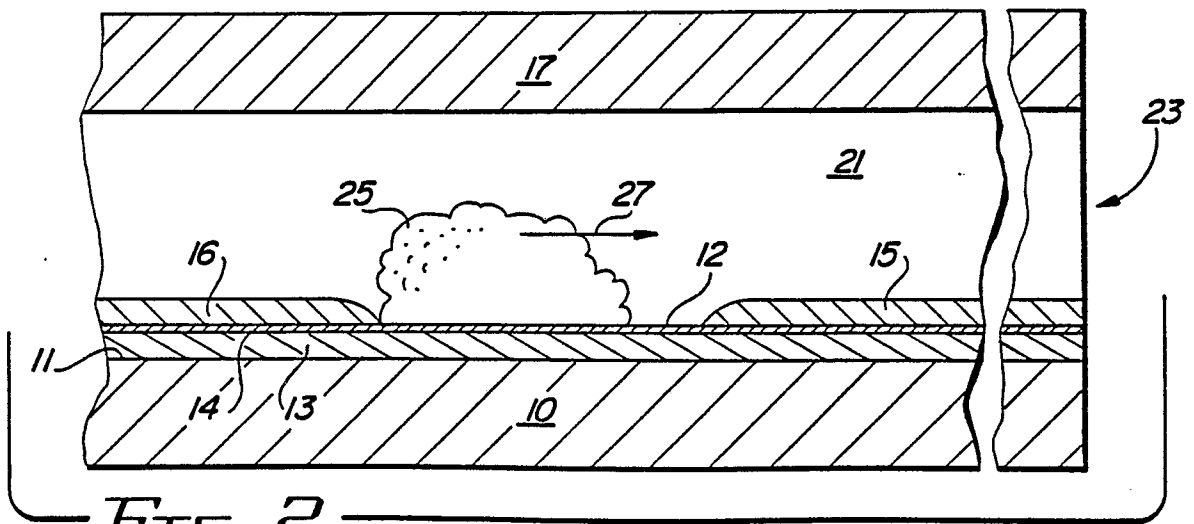


FIG. 9

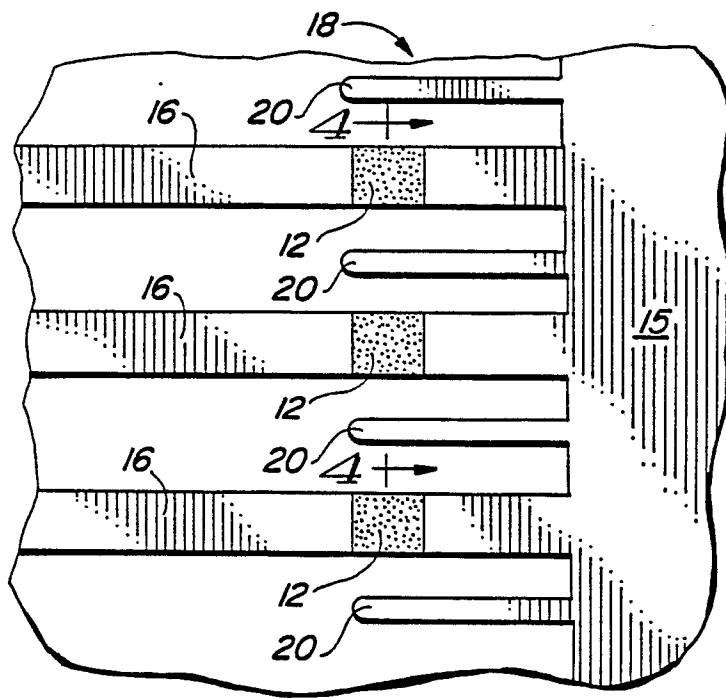


FIG. 3

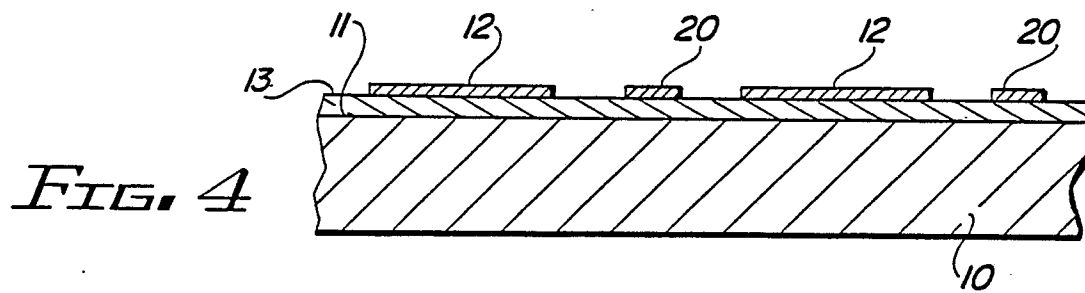


FIG. 4

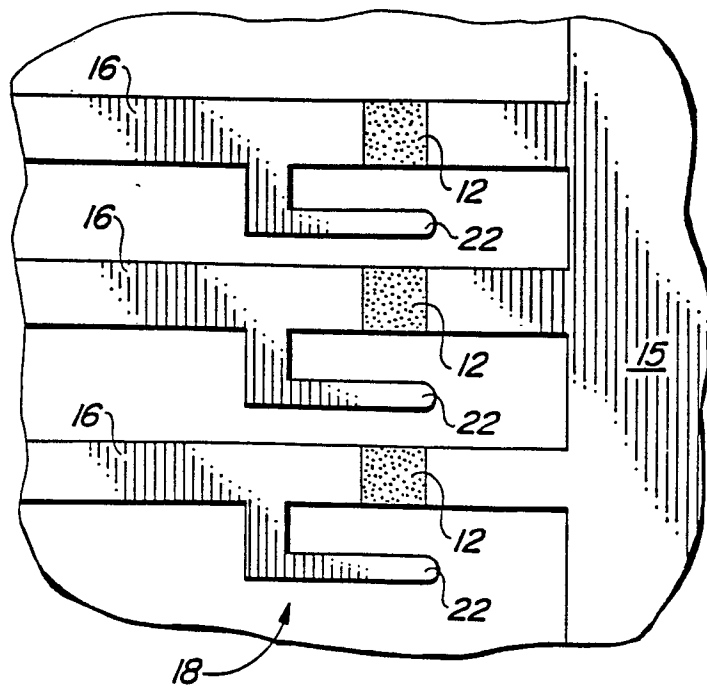


FIG. 5

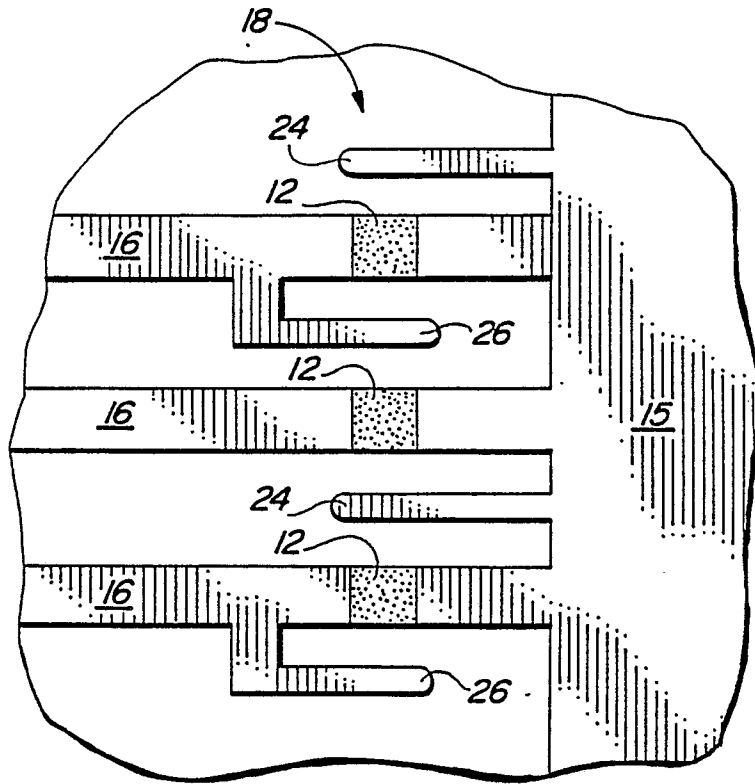


FIG. 6

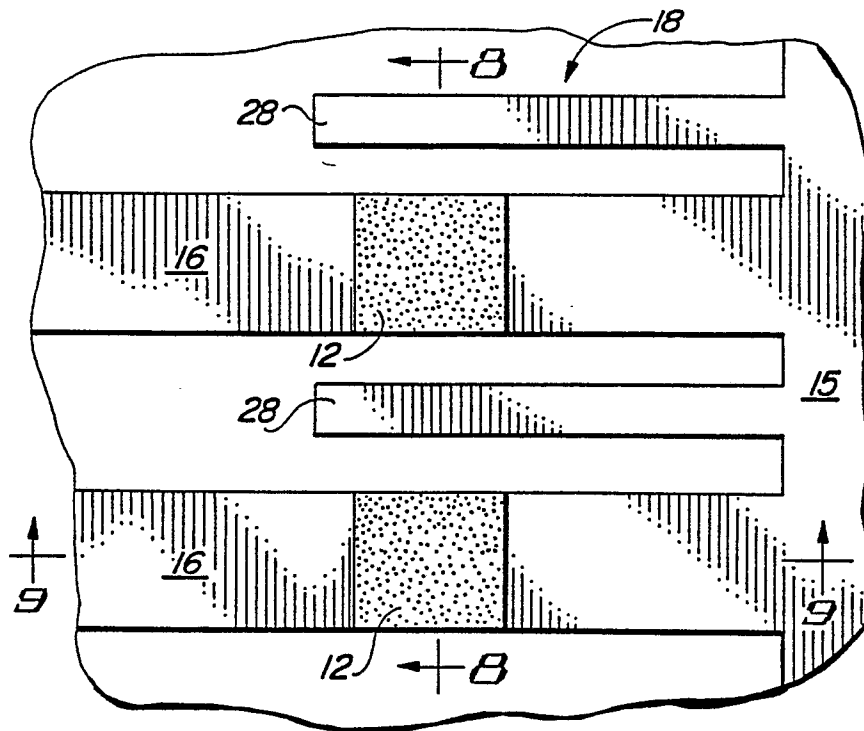


FIG. 7

FIG. 8

