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(71) Applicant: Gore Enterprise Holdings, Inc.
Newark, DE 19714-9206 (US)

(72) Inventors:
- Kesler, Matt C.
Phoenix AZ 85044 (US)
- Russell,Robert A.
Phoenix AZ 85018 (US)
- Reynolds, J. Scott
Tempe AZ 85283 (US)

(74) Representative: Shanks, Andrew et al
Cruikshank & Fairweather,
19 Royal Exchange Square
Glasgow G1 3AE (GB)

(54) Planar display apparatus

(57) An article includes a flat panel display unit having a plurality of electrically conductive lead pads which are disposed on a surface thereof. The article further includes a microminiature planar signal transmission cable having opposite first and second ends. The first end of the cable is electrically connected to a selected amount of lead pads. The cable also has at least one support film having opposite first and second surfaces, and a thickness of less than about 0.003 inch. At least one layer of adhesive is disposed on the first surface of the support film, the adhesive having a thickness of less than about 0.001 inch. At least one preformed signal transmission conductor, having a widthwise dimension of less than about 0.002 inch, is embedded within the layer of adhesive. The article also includes means for electrically controlling the flat panel display electrically connected to the second end of the cable.

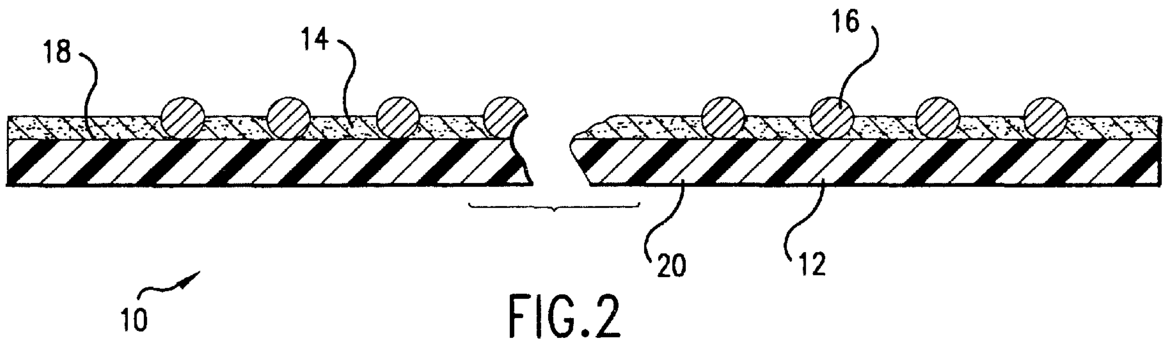

FIG.2

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Description

FIELD OF THE INVENTION

[0001] This invention generally relates to a planar display apparatus, and more particularly to an improved electrical interconnect for electrically coupling a planar display apparatus to electronic driver circuitry.

BACKGROUND OF THE INVENTION

[0002] Prior to the development of planar or flat panel displays, the cathode ray tube or CRT has been the primary electronic apparatus for displaying information. As recognized in U.S. Patent No. 5,577,944 to Taylor, CRTs are of limited use for laptop or portable computers, for example, in that they require a significant amount of depth and are relatively fragile and heavy. Since planar or flat panel displays, as their name implies, are relatively narrow in depth, and have comparable display characteristics to that of CRTs, a considerable amount of interest in these displays has developed over the past few years.

[0003] Currently, flat panel displays including liquid crystal displays are almost universally used for laptop computers, cellular telephones, pagers, and other electronic devices. Also, such displays are commonly used in avionics for commercial and military aircraft. A conventionally designed flat panel display includes a substrate such as a glass plate having a plurality of row and column conductors etched upon the plate. Each of the row conductors and column conductors extend to the periphery of the plate for connection to driver circuitry which is selectively energized to form patterns on a display area in accordance with data to be displayed. Typically the driver circuitry is in the form of integrated circuits that are employed to drive a designated group of conductors from the periphery of the column and row. A typical driver circuit is capable of driving individual conductors where the driver circuit receives inputs provided by the electronics external to the panel.

[0004] Increasing attention is being given to the interconnect between the driver circuitry and the display substrate. Current technology for interconnections between driver circuitry and the substrate consists of a flexible printed circuit, or flex circuit, and anisotropic conductive film (referred to as "ACF"). The flex circuit is terminated to the display glass plate by applying heat and pressure to the ACF which is sandwiched between the flex circuit and the display glass plate. This process results in the formation of a conductive path from the conductive traces on the underside of the flex circuit through the ACF to the conductive traces on the top surface of the display substrate (e.g. glass plate). The ACF also creates a mechanical bond between the flex circuit and the display glass.

[0005] Flex circuit/ACF bonding does include several drawbacks. For example, known ACF materials have limited operating temperatures. However, many applications for flat panel displays require use and/or storage in environments having temperatures exceeding the operating temperature limits of readily-available materials. In the past, liquid crystal display material has been the temperature limitation, but newer display technologies, such as a field emission display ("FED") enable storage or use in temperatures higher than the operating temperatures of readily-available ACFs. Thus, the flex circuit /ACF interconnect is the limiting element in enabling the display to be used or stored in high temperature environments.

[0006] Another limitation attributable to flex circuit/ ACF interconnects is that ACF requires a high temperature curing process to make the connection. Currently known ACF materials cannot be terminated (connected) at room temperature. Thus, emerging display materials, such as those fabricated from thermoplastic material, cannot withstand the ACF termination process.

[0007] Another drawback with flex circuit/ACF bonding techniques is that ACF requires a minimum border width of typically about 1.5 mm for termination, due to the need for adequate contact area to compensate for the high contact resistance per unit contact area between the flex circuit and the ACF and again between the ACF and the display substrate. A reduced border width is possible only if the pitch of the pads is increased. Many flat panel display applications, such as displays used in avionics, require a minimum border width. Some of the reasons for this include: weight savings, more efficient use of space available, and cost savings due to the increased number of display devices that can be produced for a given panel size.

[0008] Additionally, ACF requires a termination circuit board which is connected to the driver die or chip package; that is, neither the ACF nor the interconnect can be directly connected to the driver die, In fact, no other interconnect method presently available allows for direct attachment of the interconnect to a driver die. Direct die termination eliminates one level of packaging in the assembly process, thereby resulting in cost savings and reliability improvements.

[0009] There are other known methods of interconnecting the driver to the glass plate. For example, the driver die can be mounted directly onto the glass periphery. The connection of the driver die to the glass can be achieved by any suitable conventional method. A major disadvantage with this technology is that increased border area is required to mount the die. This application has also been known to be difficult to rework and can result in discarded displays. Heat sealing has also been used to interconnect the driver to the glass plate; however, while heat sealing has the advantage of being able to withstand higher temperatures than ACF, it has a pitch limitation of at least 120 microns, well above the 70 microns or less required for most displays.

[0010] The foregoing illustrates limitations known to exist in present display device interconnects. Thus, it is apparent that it would be advantageous to provide an improved interconnect directed to overcoming one or more of the limitations set forth above. Accordingly, a suitable alternative is provided including features more fully disclosed hereinafter.

SUMMARY OF THE INVENTION

[0011] The present invention advances the art of planar or flat panel display devices and related methods of manufacture, beyond which is known to date. In one aspect of the present invention, an article comprises a flat panel display unit having a plurality of electrically conductive lead pads which are disposed on a surface thereof. The article further comprises a microminiature planar signal transmission cable having opposed first and second ends. The first end of the cable is electrically connected to a selected number of the electrically conductive lead pads. The cable also has at least one support film having opposite first and second surfaces, and a thickness of less than about 0.003 inch. At least one layer of adhesive is disposed on the first surface of the support film, the adhesive having a thickness of less than about 0.001 inch. At least one preformed signal transmission conductor, having a widthwise dimension of less than about 0.002 inch, is embedded within the layer of adhesive. The article also comprises means for electrically controlling the flat panel display electrically connected to the second end of the cable.

[0012] It is, therefore, an object of the present invention to provide an article comprising a display panel, driver electronic circuitry, and an interconnect therebetween that can be wire-bondably terminated to low temperature plastic substrates at room temperature by means of an ultrasonic process.

[0013] Another object of the present invention is that of an article which permits higher maximum storage and/or use temperatures than prior art interconnects.

[0014] Yet another object of the present invention is that of an article which permits reduced border area around the periphery of the display area.

[0015] A further object of the present invention is that of an article which can be connected directly to the driver die, thus eliminating at least one packaging step.

[0016] Yet a further object of the present invention is that of an article which is less expensive to produce in high-volume production than other articles, and which is less time consuming to manufacture and install than the other prior art interconnects.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The foregoing summary, as well as the following detailed description of a preferred embodiment of the invention, will be better understood when read in conjunction with the appended drawings. For purposes of illustrating the invention, there is shown in the drawings an embodiment which is presently preferred. It should be understood, however, that the invention is not limited to the precise arrangement and instrumentality shown. In the drawings:

Figure 1 is an enlarged top plan view of a microminiature planar signal transmission cable used to connect electronic controlled circuitry (not shown) to a planar display apparatus (not shown);

Figure 2 is an enlarged cross-sectional view of the transmission cable shown in Figure 1;

Figure 3 is an enlarged top plan view of a transmission cable similar to the one illustrated in Figures 1 and 2 disposed on a flat panel display;

Figure 4 is a further enlarged top plan view of a transmission cable connected to metalized traces provided on the flat panel display;

Figure 5 is an enlarged perspective view of the transmission cable connecting driver circuitry to the flat panel display;

Figure 6 is an enlarged side elevational view of the planar display apparatus illustrated in Figure 5;

Figure 7 is a view similar to Figure 6 illustrating the transmission cable being connected directly to a driver die; and

Figure 8 is a partial plan view of a microminiature planar signal transmission cable electrically connected to a driver die upon which a display substrate is mounted.

DETAILED DESCRIPTION OF THE INVENTION

[0018] Referring now to the drawings, wherein similar reference characters designate corresponding parts throughout the several views, a microminiature planar signal transmission cable of the present invention is generally illustrated at 10 in Figures 1 and 2. As shown, the cable 10 comprises three principal . components, namely, a support film 12, a layer of adhesive 14 applied on the support film, and a plurality of conductors 16 attached to the layer of adhesive. It should be understood that the cable 10 can have any number of support films 12 and adhesive layers 14, as required for strength and rigidity, and still fall within the scope of the present invention. In addition, the cable 10 can be fabricated with any number of conductors 16 as well.

[0019] The support film 12 includes an upwardly facing (first) surface 18 and an opposite, downwardly facing (second) surface 20. As shown in Figure 2, the upwardly facing surface 18 has the layer of adhesive 14 disposed thereon. Preferably, the support film 12 of the cable 10 is fabricated from any suitable polymeric material, such as polyimide, for example. (This material is sold commercially on spools or reels, and can be purchased from UBE Industries, Ltd., under the registered trademark UPILEX.) The support film 12 gives the cable 10 its required strength and rigidity. Preferably, the support film 12 has a thickness of less than about 0.003 inch. The support film 12 can also be fabricated from polyester, or a fluoropolymer, such as porous polytetrafluoroethylene, polytetrafluoroethylene, fluorinated ethylenepropylene, or perfluoroalkoxy polymer.

[0020] In this regard, as the term porous polytetrafluoroethylene ("PTFE") is used herein, it shall mean a membrane which may be prepared by any number of known processes, for example, by stretching or drawing processes, by papermaking processes, by processes in which filler materials are incorporated with the PTFE resin and which are subsequently removed to leave a porous structure, or by powder sintering processes. Preferably, the porous PTFE is a porous expanded polytetrafluoroethylene membrane having a microstructure of interconnected nodes and fibrils, as described in U.S. Patent Nos. 3,953,566 and 4,187,390, which are incorporated herein by reference, and which fully describe the preferred materials and processes for making them.

[0021] The layer of adhesive 14 is applied onto the first surface 18 of the support film by any suitable apparatus. It is somewhat important that the layer of adhesive 14 have a uniform thickness and density since voids in the layer can cause inadequate bonding of the conductors 16 to the support film 12. Preferably; the layer of adhesive 14 is a cross-linked, blended polyester polymer. The layer of adhesive 14 preferably has a thickness of less than 0.001 inch.

[0022] One preferred method of applying the layer of adhesive 14 to the support film 12 is by adding a solvent to the adhesive which results in it being liquified, and applying the liquified adhesive/solvent mix to the first surface 18 of the support film. After applying the mix, the support film 12 is then dried (either by air or mechanically), thereby dissolving the solvent. This results in the layer of adhesive 14 which can then be manipulated by a doctor blade, or some other similar apparatus, for evening out the layer. During this application process, the support film 12 is removed from its spool or reel and rewound onto another spool after the layer of adhesive 14 has cured.

[0023] The preformed conductors may be any suitable shape and define a width dimension of less than about 0.002 inch. Cylindrically-shaped conductors are typically used and respond well to ultrasonic bonding. Rectangularly-shaped conductors can also be utilized. The conductors 16 are fabricated from metal, such as gold, aluminum, gold plated copper, aluminum with silicon, copper, aluminum, aluminum magnesium alloy and tungsten, so that bonding between the conductors and flat metallic pads is enabled by conventional bonding methods. If more than one conductor 16 is required, the conductors are disposed in parallel, co-planar relation at spaced-apart, predetermined intervals. Typically the conductors 16 are spaced at intervals ranging from about 0.0015 inch to about 0.0100 inch.

[0024] The conductor 16 material selection is based on a number of criteria, the most important of which is compatibility with the material to which it is terminated. One combination that has been used is aluminum doped with one percent silicon, which is manufactured by American Fine Wire. Conductors 16 fabricated from this material are effectively terminated to molybdenum dioxide pads (or "traces"). Other factors that influence conductor material selection include yield strength, hardness, conductivity and elongation.

[0025] The conductor 16 can further be pre-insulated or bare. If they are pre-insulated, the insulation may be removed or bonded through with ultrasonic methods. If the insulation is removed, the preferred method is with an excimer laser because of its high precision and ability to completely remove the insulation from the conductor.

[0026] The conductors 16 are embedded within the layer of adhesive 14 by any suitable method that employs either force or temperature. The conductors 16 are aligned and spaced-apart to the desired configuration, and preferably passed through a nip point (as through rollers) where temperature can also be applied to ensure proper bonding between the support film 12 and the conductors 16. After securing the conductors 16 to the support film 12, the cable 10 is cooled and collected in any well-known fashion.

[0027] As stated above, the individual conductors 16 may be insulated with a layer (not shown) of suitable insulation material, such as, for example, polyurethane, polyimide, porous polytetrafluoroethylene, polytetrafluoroethylene, or fluorinated ethylenepropylene. The individual conductors 16 may be individually insulated by conventional methods, such as by extrusion, tape wrapping, or dip coating, for example. It is also anticipated that a material may be employed for the conductor insulation which has a higher melt temperature than the material used for the support film 12 to facilitate processing in certain instances.

[0028] It should be observed that in addition to the foregoing, one or more ground planes (not shown) may be included in any embodiment of the present invention. Suitable ground plane material may be metal foil or another conductive material. Specific embodiments of the present invention are many, so long as the thicknesses of the support film 12 and layer of adhesive 14 are less than 0.003 inch and 0.001 inch, respectively. As described above, one or more support film(s) 12 can be used. Each support film 12 must be approximately the width of the finished cable 10, or wider. Alternately, one or more adhesive layers 14 may be used eitber as free films and/or as coatings on one or more of the support films 12.

[0029] Tooling to construct the cable 10 of the present invention consists of machined drums and/or rollers, such that the cable components (e.g., support film 12, adhesive layer 14 and conductors 16 described above are formed together, by a continuous process, under heat and/or pressure. Conductors 16 and/or support films 12 can be guided so that their positions with respect to each other are controlled. Tooling may be machined so as to hold each conductor 16 in position. Tooling may also be heated, and/or heat may be applied to some or all of the cable components before they enter the tooling. Process temperatures and the time at which the components are held at elevated temperature are chosen such that the conductors 16 are embedded into the adhesive layer 14.

[0030] After the cable 10 is formed, it may be necessary to trim the edges to remove excess material and to control the dimensions of the finished cable and/or the distance from each edge to each conductor 16. This may be done by any suitable method, such as rolling blades, by stationary blades, and/or by laser. The cable 10 of the present invention may be prepared for termination by having a portion of the support film 12 near one end or both ends removed prior to the conductor embedding process (e.g., by laser stripping). This will allow the free multi-axis movement of the cable 10 for routing onto termination pads, for example.

[0031] Turning now to Figures 3 and 4 which illustrate one embodiment of the present invention, there is generally indicated at 22 a planar or flat panel display device or article. As should be understood, the flat panel display device may be any embodiment, such as a liquid crystal display, a field emission display or a CMOS type display, for example. For purposes of illustration only, flat panel display device 22 has a cathode plate 24, an anode plate 26 and a display area 28. As shown in Figure 3, surrounding the display area 28 is a border 30 of sufficient width to accommodate the connection of transmission cables 10 thereto. Referring to Figure 4, the cathode plate 24 of the display device 22 has a plurality of lead pads or traces, each indicated at 32. The lead pads 32 are fabricated from metallic material suitable for electrically bonding to the conductors 16 of the cable 10. A preferred method of bonding the conductors 16 of the cable to the metalized lead pads 32 is ultrasonic bonding. Anisotropic conductive film ("ACF") can also be used to bond the materials to one another. Specifically, ACF bonding consists of placing a conductive particle-filled material (e.g., ACF film, liquid or paste) between the conductors 16 and lead pads 32. A heated tool is forced down onto the cable 10 such that heat and pressure create an electrical contact between the conductors 16, conductive ACF particles, and the lead pads 32. The conductors 16 can also be bonded to the lead pads 32 by cold termination when the cathode plate 24 is fabricated from polymeric material, which is incapable of withstanding high temperatures. Cold termination methods are also well known in the art.

[0032] Turning now to Figs. 5 and 6, in one embodiment of the present invention the transmission cable 10 connects driver circuitry 34, e.g., a display driver, to the cathode plate 24. As shown, the driver circuitry 34 is mounted on the underside of a printed wiring board 36 which is laminated to the underside of . the cathode plate 24. At least one bonding wire 38 electrically interconnects the transmission cable 10 to the driver circuitry 34. The microminiature nature of the cable 10 enables it to electrically interconnect the conductors 16 to the lead pads 32 (Figure 4) for reducing the overall border area 30 of the display device 22.

[0033] Referring now to Fig. 7, in another embodiment of the present invention the transmission cable 10 is connected directly to the driver circuitry 34. This is another advantage associated with using the transmission cable 10 of the present invention.

[0034] As best seen by reference to Fig. 8, the transmission cable 10 is electrically connected to a semi-conductor device, such as a video display driver die 40, for example. In the embodiment of the invention illustrated in Fig. 8, a display panel 42 is mounted upon driver die 40.

[0035] Although a few exemplary embodiments of the present invention have been described in detail above, those skilled in the art readily appreciate that many modifications are possible without materially departing from the novel teachings and advantages which are described herein. Accordingly, all such modifications are intended to be included within the scope of the present invention, as defined by the following claims.

Claims

1. An article comprising:

> a planar display unit (22),
> a microminiature planar signal transmission cable (10) having opposed first and second ends, said first end being electrically connected to said planar display unit, said microminiature planar signal transmission cable (10) having at least one support film (12) having opposite first and second surfaces (18, 20), and a thickness of less than about 0.0762 mm (0.003 inch), at least one layer of adhesive (14) disposed on said first surface of said support film (12), said layer of adhesive (14) having a thickness of less than about 0.0254 mm (0.001 inch), and at least one preformed signal transmission conductor (16) having a widthwise dimension of less than about 0.0508 mm (0.002 inch), said conductor (16) being embedded within said layer of adhesive (14); and
> means (34) for electrically controlling said planar display unit (22) electrically connected to said second end of said microminiature planar signal transmission cable (10).

2. The article as claimed in claim 1, said conductor (16) being fabricated from a group consisting of: aluminum with silicon; copper; gold plated copper; aluminum; aluminum magnesium alloy; gold; and tungsten.

3. The article as claimed in claim 1, said support film

(12) being fabricated from polyimide.

4. The article as claimed in claim 1, said support film (12) being fabricated from a group consisting of: polyester, polyimide; porous polytetrafluoroethylene; polytetrafluoroethylene; and fluorinated ethylenepropylene.

5. The article as claimed in claim 1, said layer of adhesive (14) comprising cross-linked blended polyester polymer.

6. The article as claimed in claim 1, said support film (12) having first and second ends, a portion being removed from said first and second ends of the support film for facilitating attachment of the conductor (16) to a lead pad.

7. The article as claimed in claim 1, said conductor (16) being bonded to a lead pad.

8. The article as claimed in claim 7, said conductor (16) being bonded to said lead pad by ultrasonic welding.

9. The article as claimed in claim 1, said flat panel display unit (22) having a plastic substrate.

10. An article comprising:

a flat panel display unit (22) having a plurality of electrically conductive lead pads (32) disposed on a surface thereof; and
a microminiature planar signal transmission cable (10) having opposed first and second ends, said first end being electrically connected to a selected number of said lead pads (32), said microminiature planar signal transmission cable (10) having at least one support film (12) having opposite first and second surfaces (18, 20), and a thickness of less than about 0.0762 mm (0.003 inch), at least one layer of adhesive (14) disposed on said first surface of said support film (12), said layer of adhesive (14) having a thickness of less than 0.0254 mm (0.001 inch) and at least one preformed signal transmission conductor (16) having a widthwise dimension of less than about 0.0508 mm (0.002 inch), said conductor (16) being embedded within said layer of adhesive (14).

11. The article as claimed in claim 10 further comprising means (34) for electrically controlling said flat panel display unit (22) electrically connected to said second end of said microminiature planar signal transmission cable (10).

12. The article as claimed in claim 10, said conductor (16) being fabricated from a group consisting of: aluminium with silicon; copper; gold plated copper; aluminum; aluminum magnesium alloy; gold; and tungsten.

13. The article as claimed in claim 10, said support film (12) being fabricated from polyimide.

14. The article as claimed in claim 10, said support film (12) being fabricated from a group consisting of: polyester, polyimide; porous polytetrafluoroethylene; polytetrafluoroethylene; and fluorinated ethylenepropylene.

15. The article as claimed in claim 10, said layer of adhesive (14) comprising cross-linked blended polyester polymer.

16. The article as claimed in claim 10, said support film (12) having first and second ends, a predetermined portion being removed from said first and second ends of the support film for facilitating attachment of the conductor (16) to a lead pad (32).

17. The article as claimed in claim 10, said conductor (16) being bonded to a lead pad (32).

18. The article as claimed in claim 17, said conductor (16) being bonded to said lead pad (32) by ultrasonic welding.

19. The article as claimed in claim 10, said flat panel display unit (22) having a plastic substrate.

20. An article comprising:

a flat panel display unit (22) having a plurality of electrically conductive lead pads (32) disposed on a surface thereof; and
a microminiature planar signal transmission cable (10) having opposed first and second ends, said first end being electrically connected to a selected number of said lead pads (32) said microminiature planar signal transmission cable (10) having at least one support film (12) having opposite first and second surfaces (18, 20); at least one layer of adhesive (14) disposed on said first surface of said support film (18); and at least one preformed signal transmission conductor (16) which is secured to a lead pad (32) of the flat panel display unit by ultrasonic bonding.

21. An article comprising:

a planar display unit having a display panel (42) and a driver die (40);
a microminiature planar signal transmission ca-

ble (10) having opposed first and second ends, said first end being electrically connected to said driver (40), said microminiature planar signal transmission cable having at least one support film (12) having opposite first and second surfaces (18, 20), and a thickness of less than about 0.0762 mm (0.003 inch), at least one layer of adhesive (14) disposed on said first surface of said support film (18), said layer of adhesive (14) having a thickness of less than about 0.0254 mm (0.001 inch) and at least one preformed signal transmission conductor (16) having a widthwise dimension of less than about 0.0508 mm (0.002 inch) said conductor (16) being embedded within said layer of adhesive (14); and

means (34) for electrically controlling said planar display unit electrically connected to said second end of said microminiature planar signal transmission cable (10).

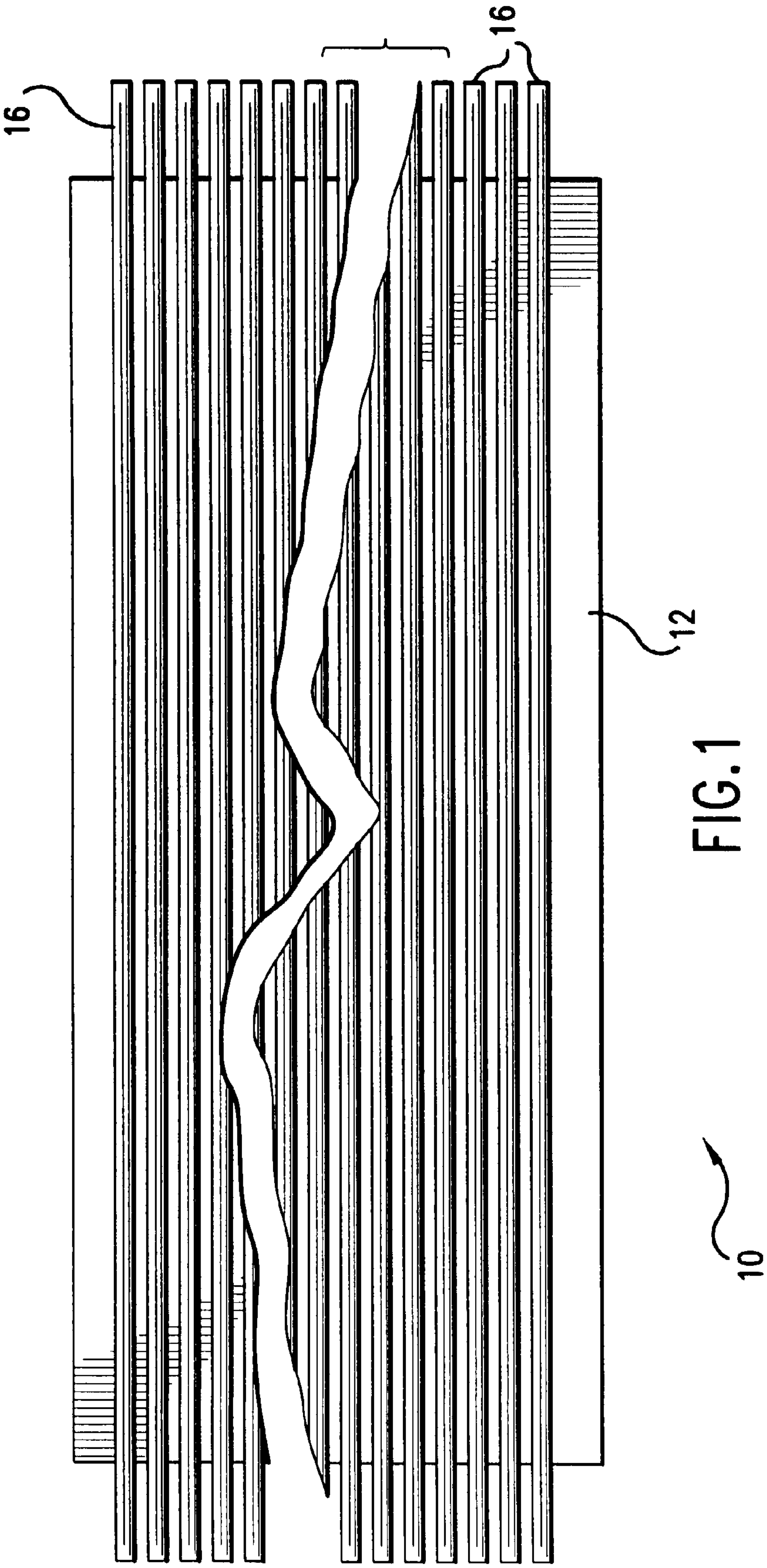

FIG.1

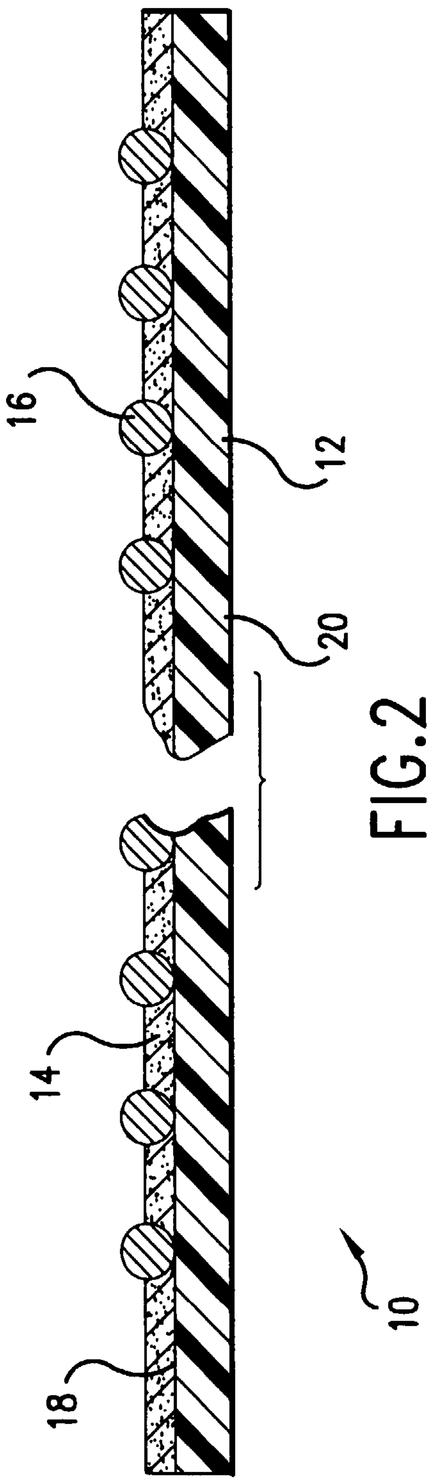

FIG.2

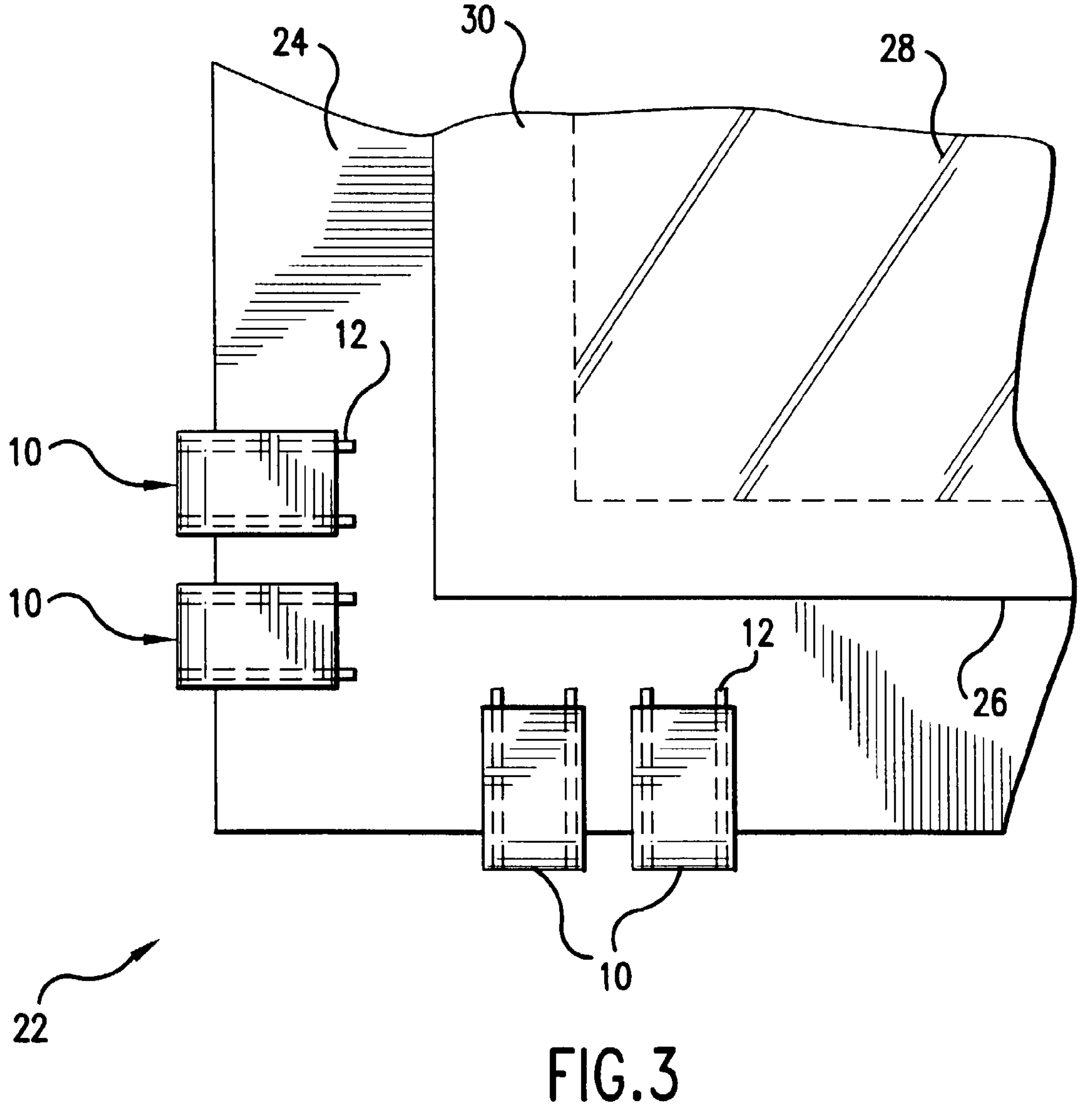

FIG.3

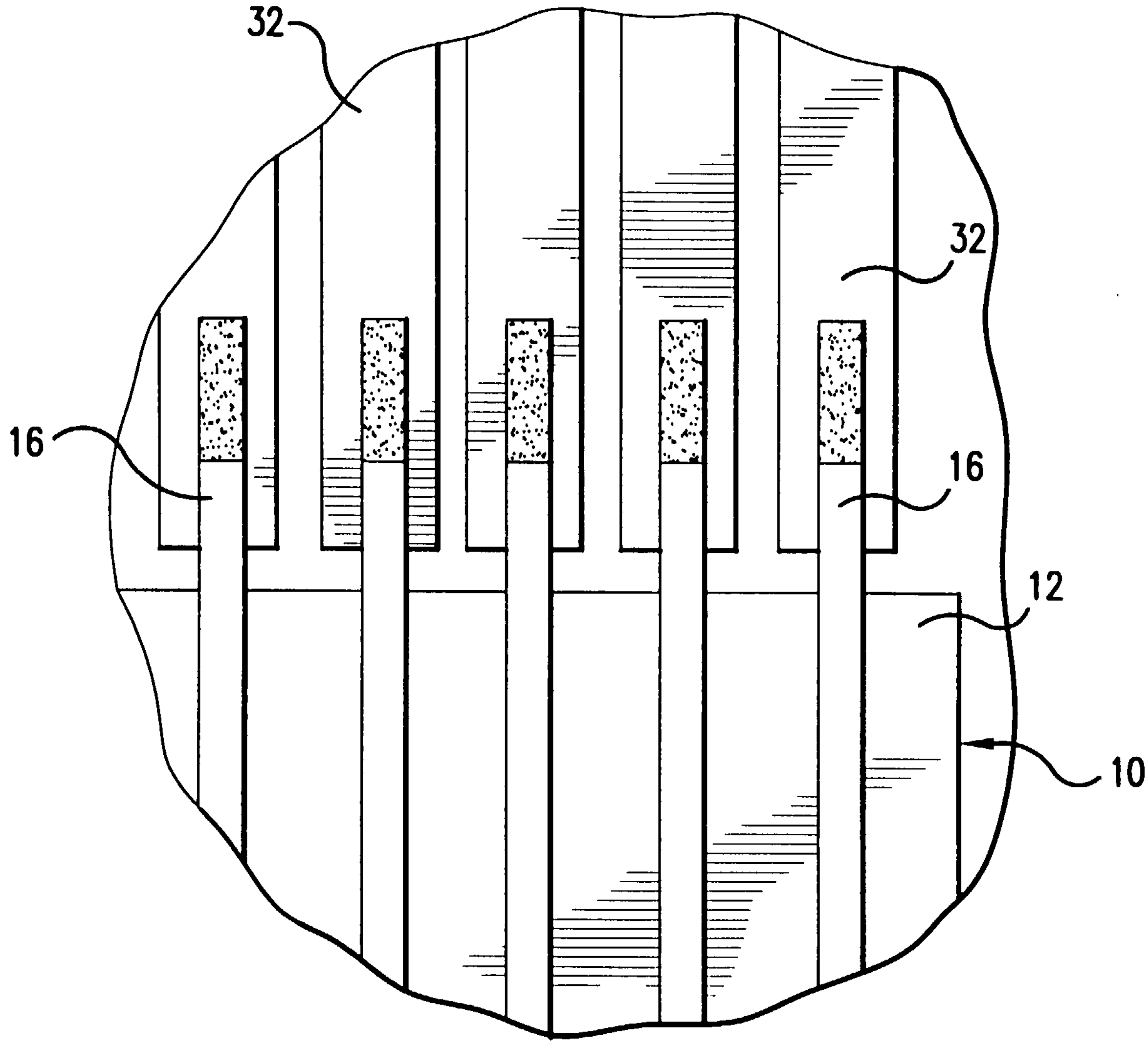

FIG.4

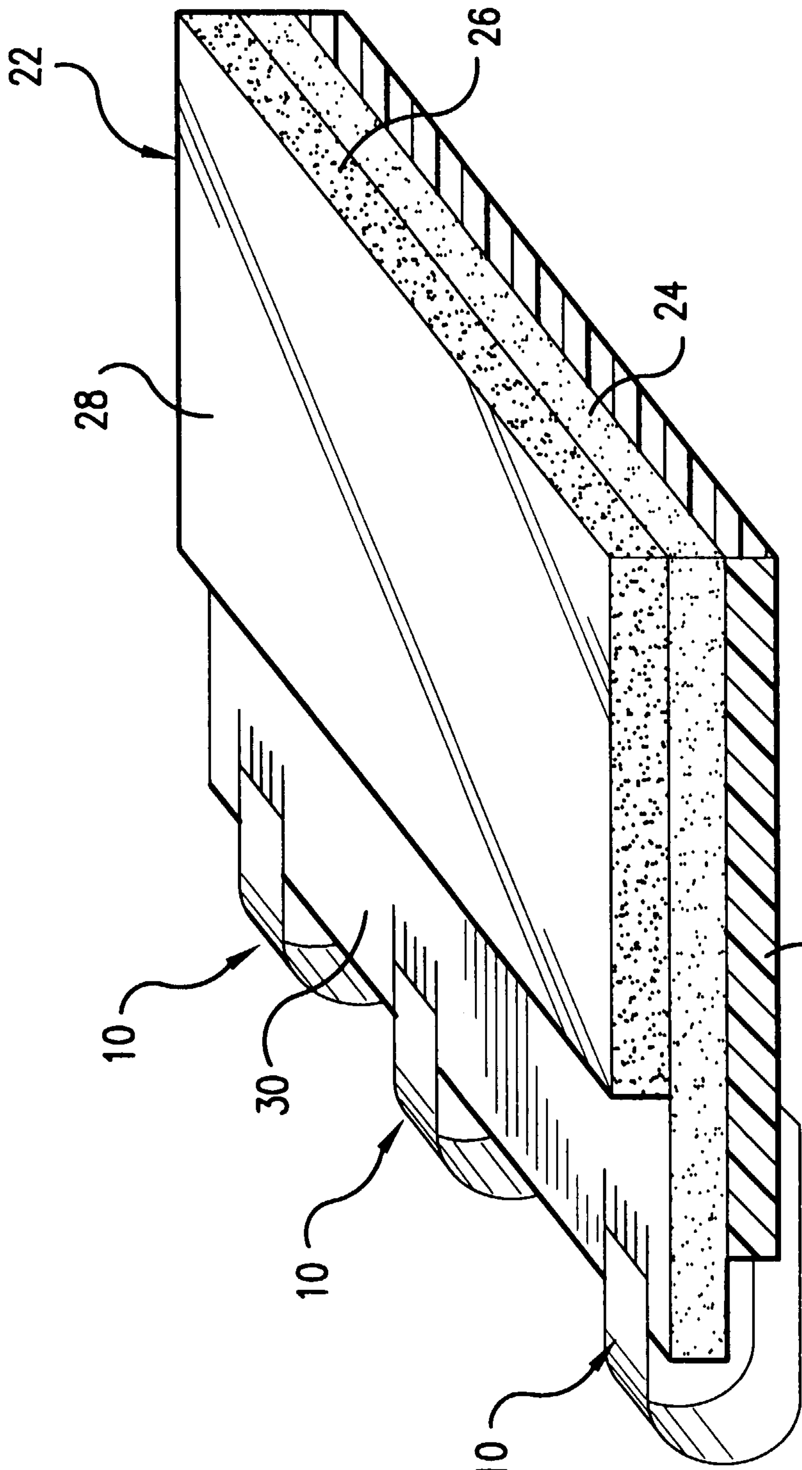

FIG.5

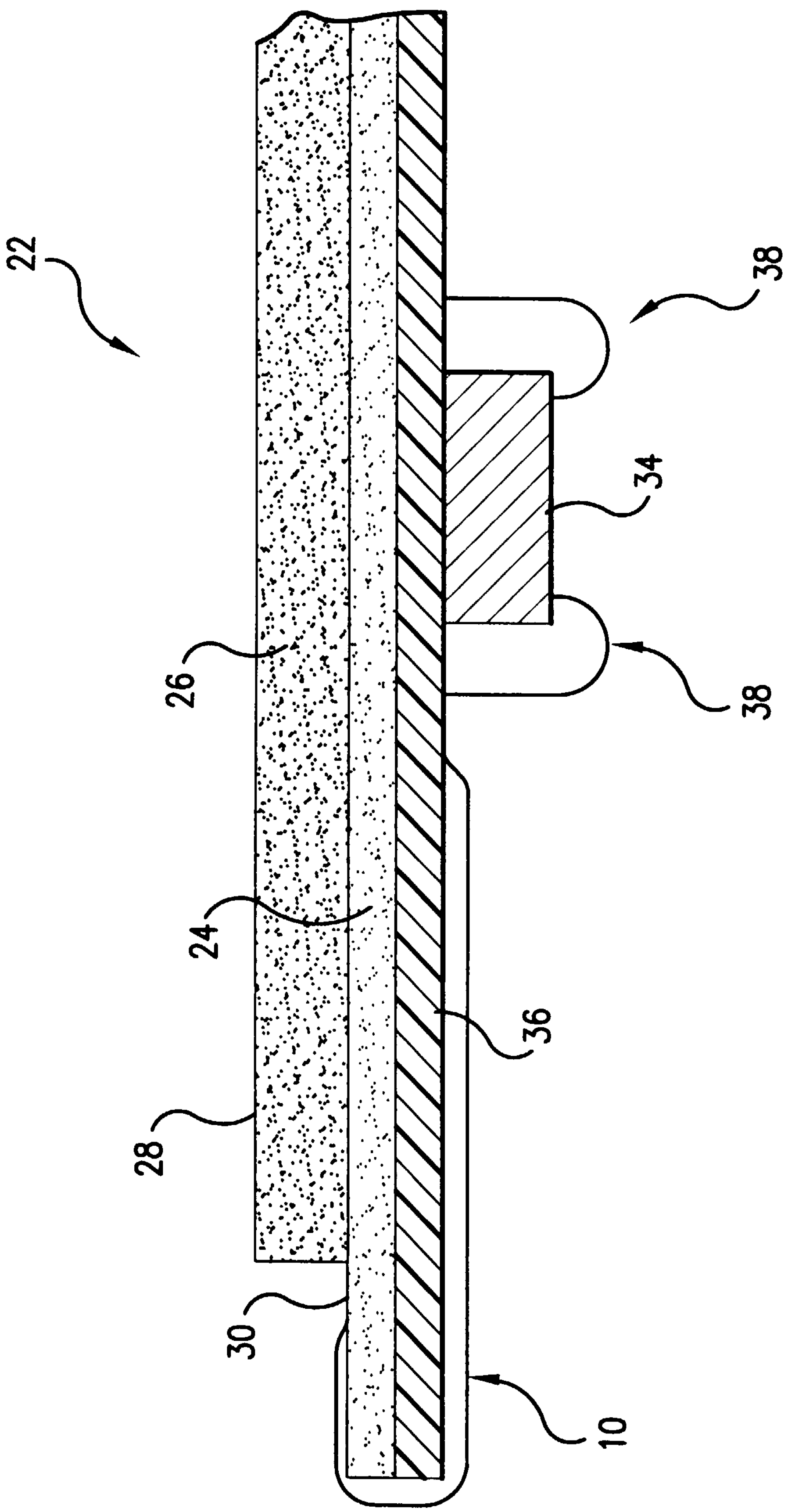

FIG.6

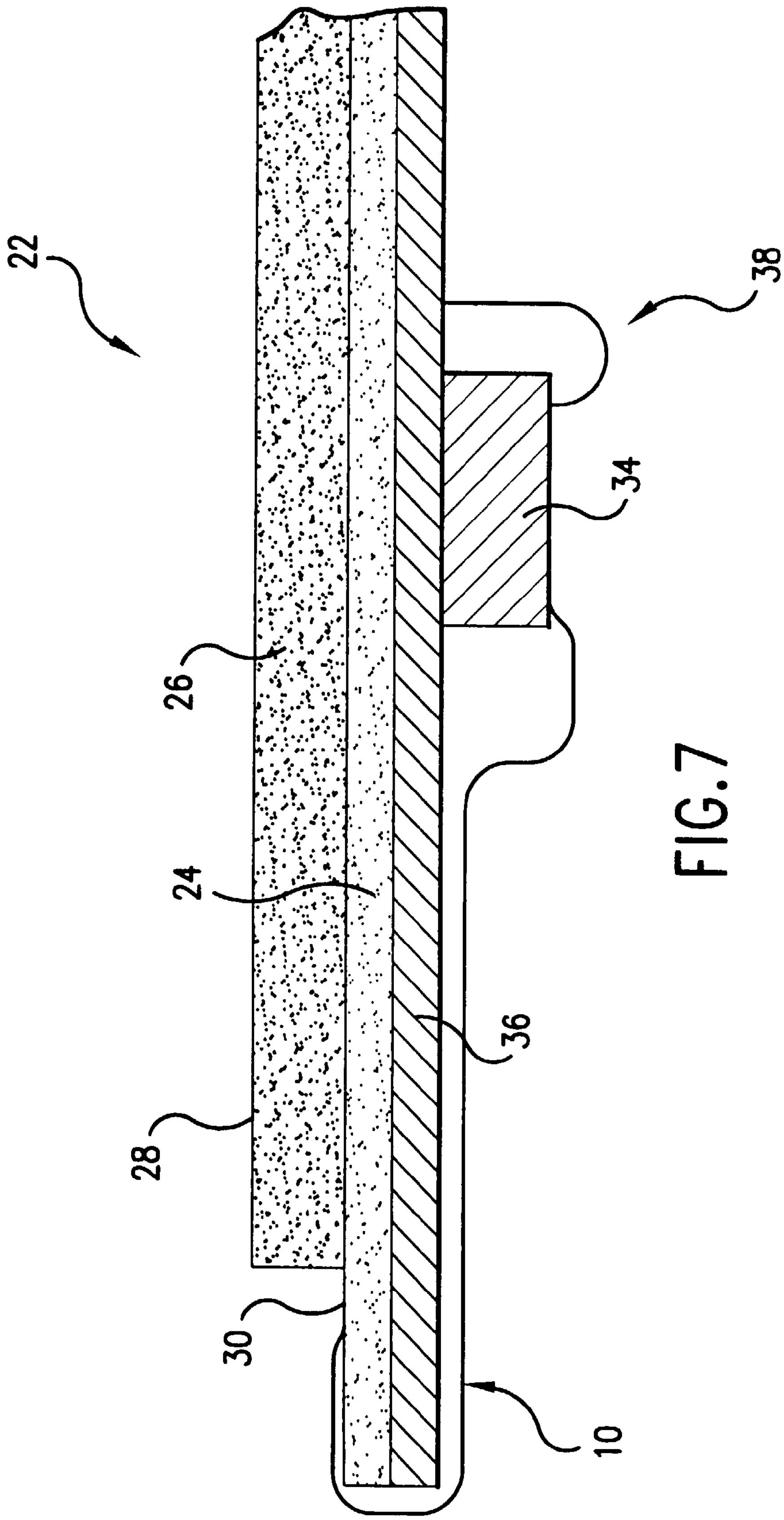

FIG.7

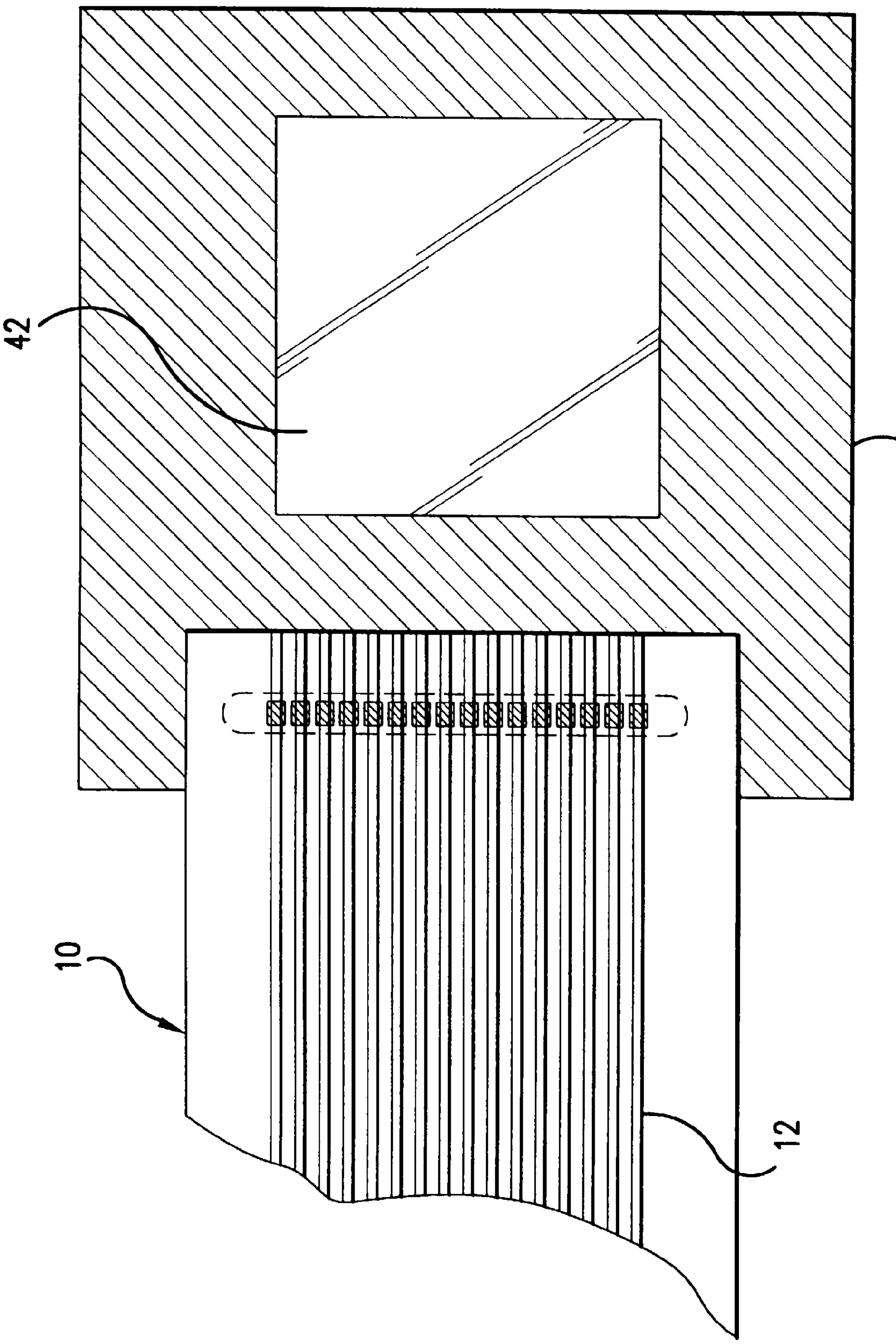

FIG.8