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Remarks:
A request for correction of Figures 13 and 14 has been filed pursuant to Rule 88 EPC. A decision on the request will be taken during the proceedings before the Examining Division (Guidelines for Examination in the EPO, A-V, 3.).

(54) An electrical contact

(57) A nonmetallic electrical contact or wiper composed of a composite carbon fiber material through which an electrical signal is transmitted. Carbon fibers can be fused or conductively bonded together and used to form a main signal conductor. A mat formed of nonwoven carbon fibers is arranged on each flat surface of the bonded carbon fibers and then a thermoplastic resin layer is applied over each nonwoven mat. The nonwoven carbon fiber mat also conducts the electrical signal and provides increased mechanical stability to an electrical contact or wiper formed of the composite carbon fiber material.

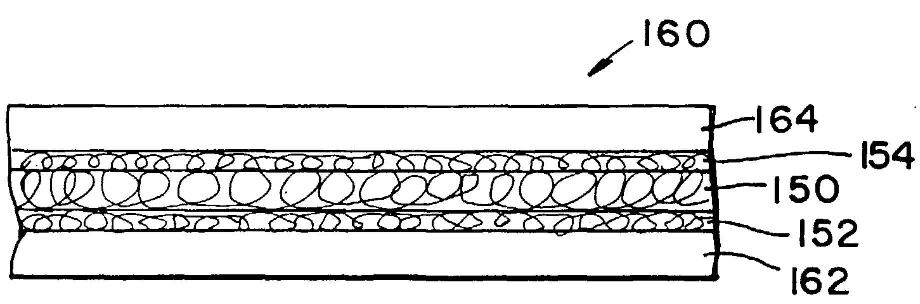

FIG. 14

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Description

[0001] This invention relates generally to an electrical contact or an electrical contact assembly typically used in an electromechanical device and, more particularly, to a contact or contact assembly, which is formed of a composite material using carbon fibers and a nonwoven carbon fiber mat, as the element that makes electrical contact with another element of the electromechanical device.

[0002] Variable resistive devices utilize elements that vary a voltage or current in order to provide an electrical signal that indicates a relationship to a physical position of a contact or wiper on a resistive or conductive element. Because these variable resistive devices are used in a dynamic state they can not be fixed or restricted in their movement and must have the freedom to be positioned along any length of their respective resistive or conductive paths. The contact or wiper must therefore be produced of a material that is electrically, physically, and environmentally compatible with the resistive and/or conductive track when in the presence of an electrically active and physically dynamic system. The contact or wiper must also provide a long useful life, while maintaining uniform positive engagement with the resistive or conductive element and not produce polymers or debris which act as an insulator and distorts the output signal.

[0003] Presently the contact or wiper materials used for these variable resistive devices are composed of various clad or coated metals or precious metal alloys. These precious metal containing contacts, in a dynamic state and in the presence of electrical activity, act as catalysts to generate polymers and debris which degrade the resistive track output signals. This results in the early termination of accurate performance and useful life.

[0004] Initially metal contacts or wipers were used with wirewound resistive or metallic conductive elements, because wirewound elements were the most precise devices. As time evolved great improvements were made in the non-wirewound product area, and they supplanted the wirewound resistive element, but the contact or wiper has always created problems relative to the resistive element because in the presence of an electrical current and dynamic performance, the precious metal components of the metallic contact provide the catalyst to generate polymers and debris, which interfere with the accuracy of the output signal.

[0005] Now that reduction in size, improved accuracy, and a reduction in electrical contact resistance are required in modem servo feed-back positioning systems, non-metallic contact materials must be considered to obtain the necessary and sorely needed improvements in these performance characteristics and elimination of the polymers and debris.

[0006] Accordingly, the need exists for improvements in electrical contacts and contact assemblies and, particularly, for-improvements in the materials and assemblies employed therefor.

[0007] Accordingly, it is an object of the present invention to provide a contact or contact assembly for use in electromechanical applications that can effectively eliminate the above-noted defects inherent in previously proposed systems.

[0008] It is another object of this invention to eliminate the above-described negative conditions and characteristics of previously known systems and to improve considerably the useful life of the system by providing a contact or wiper formed of nonmetallic material, such as one formed of a composite carbon fiber material including carbon fibers and a nonwoven carbon filter mat. This composite carbon fiber material, through special processing, not only overcomes the negative conditions caused by metal composition contacts or wipers, but considerably improves total performance in all other aspects.

[0009] It is a further object of the present invention to provide a wiper contact or contact assembly for use in electromechanical components or applications that is more compatible with present state of the art fabrication techniques and materials used for resistive and conductive track substrates and that appreciably reduces or eliminates the negative aspects inherent in presently used or previously proposed designs or materials.

[0010] According to the present invention there is provided an electrical contact as claimed in claim 1.

[0011] In a preferred embodiment, an existing contact carrier is employed and in place of the previously used metal contacts, and the contacts are specially attached to the carrier.

[0012] In a preferred embodiment, the contact is processed and formed in such a manner as to allow-the multiple strands of carbon fiber at the center layer of the composite material when properly positioned to be electrically conductive for transmitting umimpeded electrical signals along their longitudinal length. Such carbon fiber strands may be fused or conductively bonded by any of various techniques to provide essentially uniform conductivity and redundant transmission of the electrical signal. Additional, off-axis electrical conductivity is provided by nonwoven carbon fiber mats placed on the sides of the multiple strands of carbon fiber. The composite carbon fiber material can be affixed to a carrier or the material may be utilized without a carrier. Such a carrier, if used, may be metallic or non-metallic and may be affixed to the composite carbon fiber material by any of various bonding, fusing, and fastening techniques. The carrier can also be electrically nonconductive, depending upon the application. Alternatively, the carrier can be formed of the same homogenous composite carbon fiber material as that used for the actual contact. Forming of the carbon fiber contact layer of the composite material can involve cross-layering of the material in nonparallel orientations to provide additional structural integrity, as well as to assist in the post-forming operation.

[0013] The contact can be rigid enough to sustain and maintain a consistent position relative to its parallel alignment to the resistive or conductive track of the substrate element and yet be flexible enough in a perpendicular position to the track to allow some variation in movement to sustain uniform contact position, spring rate and pressure. Thus, the electrical output signal maintains its integrity.

[0014] In a further preferred embodiment, the contact surface of the wiper contact that is adjacent to the resistive or conductive track is composed of multiple points of contact, rather than either a small number of metal fibers or just one broad band of a rigid beam contact. This ensures a more redundant positive footprint with the resistive or conductive track, which reduces contact resistance and variable electrical noise.

[0015] Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figs. 1A-1D are side elevations showing respective embodiments of electrical contacts according to the present invention;

Figs. 2A-2C are front elevations and respective enlargements showing embodiments of electrical contacts corresponding to Figs. 1A-1C, respectively;

Fig. 3 shows two views of a carbon fiber contact formed as a matrix of layers of carbon fibers;

Fig. 4 shows two views of a carbon fiber contact formed as a matrix of layers of carbon fibers;

Fig. 5 shows two views of an electrical contact formed solely of carbon fibers according to an embodiment of the present invention;

Fig. 6 shows two views of an electrical contact formed solely of carbon fibers according to another embodiment of the present invention;

Fig. 7 shows two views of a carbon fiber electrical contact affixed to an electrically conductive beam according to an embodiment of the present invention;

Fig. 8 shows two views of an electrical contact in which the carbon fibers are mechanically captured and chemically fused accordingly to an embodiment of the present invention;

Fig. 9 shows two views of an electrical contact in which the carbon fibers are mechanically captured and chemically fused according to an embodiment of the present invention;

Fig. 10 shows two views of an electrical contact in which the carbon fibers are mechanically captured and chemically fused accordingly to an embodiment of the present invention;

Fig. 11 shows two views of an electrical contact employing multiple layers on a carrier according to an embodiment of the present invention;

Fig. 12 shows two views of an electrical contact formed as a single carbon fiber element;

Fig. 13 is an exploded view showing the carbon fibers in juxtaposition with two carbon fiber nonwoven mats; and

Fig. 14 is an end view showing the several layers making up an embodiment of the inventive composite carbon fiber material.

[0016] The present invention provides a contact or wiper element for transmitting electrical signals, either in a low voltage mode (under 15 volts) or a low current mode (under 500 ma) between a resistive and/or a conductive track and some external circuit termination. In one embodiment-the contact or wiper element comprises one or more thin, single layers of carbon fiber elements, all aligned in one direction bonded together and firmly fixed in a very low-resistance, synthetic resin compound for structural stability and electrical continuity and which form part of a composite carbon fiber material described below.

[0017] Although in the following description of several embodiments of the inventive electrical contact various forms of the carbon fiber bundles or strands are described, it is to be understood that the electrical contacts are formed of the composite carbon fiber material described below in relation to Figs. 13 and 14.

[0018] As shown in Figs. 1A-1C, the ends of the contact or wiper may be specially formed to give the engagement portion of the contact or wiper added strength and permit better mating of the carbon fiber element to the track of the device. In Fig. 1A, the contact 10 has a rake end 12. In Fig. 1B, the contact 14 has a knuckle end 16. In Fig. 1C, the contact 18 has a pointed end 20.

[0019] The contact or wiper 22, as shown in Fig. 1D, may also engage a mechanical strip 24 for support or for attachment purposes. The mechanical strip 24 may be electrically conductive or not, depending upon the desired application.

[0020] Figs. 2A, 2B, and 2C correspond, respectively, to Figs. 1A, 1B. and 1C and show the arrangement of the carbon fiber bundles that are part of the composite material forming the specialized end constructions 12, 16, and 20, respectively. That is, the enlargement of Fig. 2A shows carbon fiber bundles 26 arranged in one layer forming the rake end 12. Similarly, bundles 28 and 30 respectively form knuckle end 16 and pointed end 20 in Figs. 2B and 2C, respectively. The other layers of the composite material are not shown because the structures of the carbon fiber bundles would be obscured.

[0021] In the embodiment shown in Fig. 3, the contact or wiper element 40 is formed of a carbon fiber matrix, whose adjacent three carbon fiber layers 42, 44, 46 are essentially perpendicular to each other. The carbon fibers forming layers 42, 44, 46 are not bundled but are discretely placed-in a cross-hatching matrix, wherein the fibers in alternate layers may be parallel to each other, but those in adjacent layers are essentially nonparallel and may be perpendicular to each other.

[0022] Fig. 4 shows a similarly constructed contact 50 in which the carbon fibers of only one layer 52 perform the actual contacting and an inner layer 54 and second outer layer provide structural support. The additional layers of the composite material are shown in Fig. 14.

[0023] The matrix composition shown in the embodiments of Figs. 3 and 4 reinforces and strengthens the minuscule carbon fiber strands to provide support for retaining stable contact position. The carbon fiber strands may be continuous or discontinuous and the matrix need not necessarily be homogeneous.

[0024] Corresponding to the structure shown in Fig. 1D, the matrix compositions of Figs. 3 and 4 can use an additional mechanical support strip, which can be electrically conductive depending upon the desired application. The carbon fibers of the matrix composition shown in Figs. 3 and 4 are firmly fixed in a very low resistance synthetic resin compound to restrict movement, add structural stability, and provide multidirectional electrical continuity.

[0025] As shown in Fig. 5, the planar form of a carbon fiber contact element 60 can consist of a single layer, not a matrix of carbon fiber strands, arranged in a horseshoe shape or upside-down U to provide a continuous, unbroken path from one end 62 of the carbon fiber element strands, one of which is shown typically at 64, to the other end 66, even though the carbon fiber strands may change direction by more than 90 degrees. In this embodiment each carbon fiber strand 64 will be both perpendicular and parallel to the resistive or conductive track, not shown, and each opposing end 62,66 of the continuous carbon fiber strands 64 will essentially contact different parallel resistive or conductive tracks, not shown. The horseshoe shaped contact 60 can employ a carrier, not shown, which can be electrically conductive or not, depending on the desired application.

[0026] A similar construction is shown in Fig. 6, wherein the contact 70 has a right-angle transition portion 72 in the path from one end 74 to the other end 76.

[0027] In the embodiment shown in Fig. 7, a contact assembly 80 has a carbon fiber element formed as a very short strip 82 firmly and conductively attached at 84 by a conductive adhesive to a parallel portion 84 of a thin beam 86 composed of electrically conductive material. This beam construction provides a means for the current or voltage signal to flow unimpeded from the resistive or conductive track to the end terminus, thereby incorporating the compatible and desirable characteristics of the carbon fiber contact material with beam members formed of materials other than carbon fiber. When this embodiment is in use, the carbon fiber element 82 will be essentially perpendicular to the plane of the resistive or conductive track at all times.

[0028] In the embodiment of the present shown in Figs. 2A, 2B, and 2C, the planar form of the carbon fiber element consists of one or more parallel layers of carbon fiber strip arranged so that the free ends 12, 16, 20 of the carbon fiber elements 10, 14, 18, respectively, are designated as the ends that will contact the tracks of the resistive element or conductive element. It is a feature of the present invention that those ends 12, 16, 20 can he fabricated free of any other material, such as the low-resistance, synthetic resin compound or the like, for a length less than 3/16' (4.7625mm) to permit only the actual carbon fiber material to contact the respective tracks, thereby providing improved mating between the ends 12, 16, 20 of the contacts 10, 14, 18 and the tracks, not shown, of the respective conductive elements. The free end of the contact may remain parallel in the same plane or, as shown in Figs. 2A, 2B, and 2C, the free end may be bent or formed to an angle perpendicular to the primary length of the strip or formed into a knuckle shape depending upon the application.

[0029] In the embodiments shown in Figs. 8, 9, and 10, each contact or wiper element 90, 92, 94, respectively, is fabricated in narrow strips of carbon fiber element, one of which is shown at 96, 98, 100, respectively, wherein each strip is less than 0.015'(0.3810mm) in width and is composed or one or more parallel strands of carbon fibers. A number of these strips are arranged in a single flat plane, with each strip being essentially parallel to, but not fused or chemically bonded to, each other. The multiple independent parallel strips are mechanically captured by respective collars 102, 104, 106, in a single plane and/or chemically bonded with a low-resistance, electrically conductive synthetic resin compound at one end of the assembled strips, so that the independent multiple strip sections will be electrically uniform in their output signal and also be receptive to further assembly operations.

[0030] As shown in Figs. 8, 9, and 10, the free ends 108, 110, 112 of the respective multiple strip sections 90, 92, 94 that are to function as the intimate contact points with the track of the resistive or conductive element can remain coplanar to the strip or be formed as a rake as shown in Fig. 8, a knuckle as shown in Fig. 9, or other compatible contact geometry, such as the point as shown in Fig. 10. This feature permits the assembly to contain multiple contact strips, such as 96, 98, 100, each with relatively independent mechanical movement in a direction perpendicular to the resistive or conductive track of the substrate element.

[0031] Fig. 11 is an embodiment similar to that of Fig. 7 wherein multiple layers 120, 122, 124, of carbon fiber elements are attached to a shorter leg 126 of an L-shaped carrier 128. The carbon fibers in each layer 120, 122, 124 are substantially aligned to be parallel and the layers may be attached to the carrier by an electrically conductive synthetic resin compound shown generally at 130.

[0032] As shown in the embodiments of Figs. 3, 4, and 11, the electrical contact devices are formed of multiple layers of carbon fibers in various alignments, Similarly, all other embodiments herein shown and described can be formed of multiple layers. So too, the various embodiments of the present invention can be used with a carrier that can be electrically conductive or not, depending upon the desired application.

[0033] Conversely, as shown in Fig. 12, an electrical contact or wiper 140 can be formed of only a single carbon fiber element 142 that can be around 0.010' to 0.015' (0.2540 to 0.3810mm) in thickness. Although a rake end 144 is provided in this embodiment, any of the other end treatments described above are also appropriate.

[0034] As noted hereinabove, all of the embodiments described so far can be formed from a composite carbon fiber material that has as its core a carbon fiber structure that has carbon fiber bundles arranged in one layer, as in Figs. 2A-22C, or in multiple layers, as in Fig. 3.

[0035] As shown in Fig. 13, a layer of the carbon fiber bundles 150 has mats 152, 154 formed of nonwoven carbon fibers arranged on each flat side. Although not shown in Fig. 13, following the placement of the mats 152, 154 on the carbon fiber bundle structure 150, a thermoplastic resin is applied to the exterior surfaces of the mats 152, 154. This thermoplastic resin, or polymer, completes the structure and bonds the mats 152, 154 to the carbon fiber bundle structure 150, thereby forming a stable composite material. The nonwoven carbon-fiber mat 152 or 154 is substantially isotropic and the fibers are so randomly arranged as to provide little or no directionality in the plane of the mat.

[0036] The nonwoven carbon fiber mat provides a primary electrical current carrying capacity and also provides improved mechanical strength to the overall construction. More specifically, the nonwoven carbon fiber provides off-axis mechanical stability, as well as off-axis current carrying capability, where the off-axis term relates to a longitudinal direction of the finally manufactured electrical contact.

[0037] The nonwoven carbon fiber mat is available commercially from Hollingsworth & Vose Company, East Walpole, Massachusetts and ranges in thickness from 0.08 mm to 0.79 mm.

[0038] Fig. 14 is an end view of the assembled composite material 160 described above in which the nonwoven carbon fiber mats 152, 154 are arranged on the carbon fiber structure 150 and in which thermoplastic resin layer 162 is applied over the nonwoven carbon fiber layer 152 and a thermoplastic resin layer 164 is applied over the nonwoven carbon fiber mat 154. This results in a stable composite material that can be formed to any desired shape, as described and shown in regard to the several embodiments shown herein.

Claims

1. An electrical device for transmitting electrical signals and for movable contact with an electrically conductive track, the device comprising:

   a contact formed of a composite carbon fiber material having at least one layer of carbon fiber elements and being sandwiched between first and second mats formed of nonwoven carbon fibers with a thermoplastic resin coating on outer surfaces of said first and second mats, wherein the carbon fiber elements in each layer are aligned in substantially the same direction and free ends of the layer of carbon fiber elements are adapted to contact said electrically conductive track.

2. The electrical device according to claim 1, wherein said carbon fiber elements in each layer are bonded together.

3. The electrical device according to claim 2, further comprising a support strip having said electrical contact bonded thereto by a synthetic resin compound.

4. The electrical device according to claim 3, wherein said support strip is electrically conductive.

5. The electrical device according to claim 3, wherein said support strip is bent so as to be L-shaped and said electrical contact is attached to a shorter arm of said L-shaped strip.

6. The electrical device according to claim 2, wherein the free ends of said layer of carbon fiber elements are formed in a knuckle shape.

7. The electrical device according to claim 2, wherein the free ends of said layer of carbon fiber elements are formed in an angularly pointed shape.

8. The electrical device according to claim 2, further comprising support elements arranged on either side of said thermoplastic resin coating on said first and second mats at an end opposite said free ends and being set back from said free ends.

9. The electrical device according to claim 2, further comprising:

   fastening means arranged at one end of said electrical contact for holding together said layer of carbon fiber elements and preventing relative movement there among at a holding lodation, whereby free ends of said electrical contact opposite said one end are moveable relative to one another.

10. The electrical device according to claim 9, wherein the free ends of said layer of carbon fiber elements are formed in a knuckle shape.

11. The electrical device accordingly to claim 9, wherein the free ends of said layer of carbon fiber elements are found in an angularly pointed shape.

12. The electrical device according to claim 2, wherein electrical contact has a first arm portion and a second arm portion spaced apart from and in a same plane as said first arm portion, wherein the carbon fiber elements therein are aligned substantially in the same first direction, and a transition portion connecting respective first ends of said first arm portion and said second arm portion, wherein the carbon fiber elements of said transition portion are substantially aligned with each other in a second direction different from said first direction of said first and second arm portions, wherein second ends of said first and second arm portions opposite said first ends are adapted to contact said electrically conductive tracks.

13. The electrical device accordingly to claim 12, wherein said transition portion is arranged at right angles to said first and second arm portions, so that said second direction is substantially perpendicular to said first direction.

14. The electrical device according to claim 12, wherein said transition portion is semicircular in shape and is coplanar with said first and second arm portions.

15. The electrical device according to claim 2, comprising a plurality of overlying layers of carbon fibers formed as a matrix, wherein the carbon fibers in each of said plurality of layers are aligned so as to be substantially parallel and adjacent layers are aligned so that the carbon fibers therein are substantially nonparallel, wherein an electrically conductive synthetic resin compound binds together said carbon fibers in each layer so that said plurality of overlying layers solidify said electrical contact.

16. The electrical device according to claim 15, wherein said electrical contact is formed having a body portion and first and second arm portions extending therefrom, wherein free ends of said first and second arm portions are adapted to contact the electrically conductive tracks.

17. The electrical device according to claim 16, wherein said free ends are formed in a rake shape.

18. The electrical device according to claim 16, wherein said plurality of overlying layers are coextensive.

19. The electrical device according to claim 16, wherein said first and second arm portions are formed of a single layer of carbon fibers.

20. The electrical device as claimed in claim 1 further comprising:

an electrically conductive carrier;

a plurality of layers of carbon fiber elements arranged in overlaying relationship and affixed on said carrier.

21. The electrical device according to claim 20, wherein said carrier is substantially L-shaped and said plurality of layers of carbon fiber elements are affixed to a shorter leg of said L-shaped carrier.

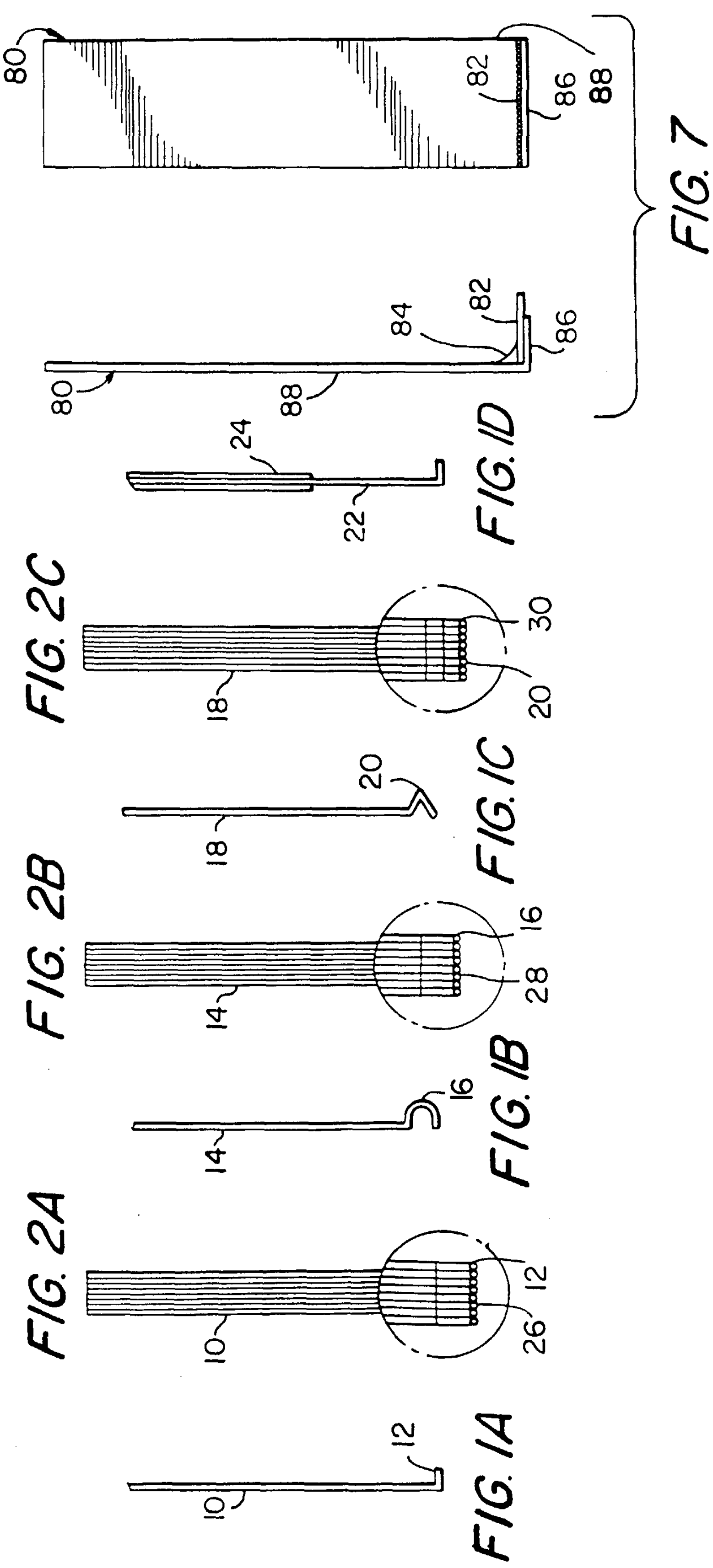
FIG. 1A
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FIG. 2A
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FIG. 1B
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FIG. 2B
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FIG. 1C
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FIG. 2C
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FIG. 1D
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FIG. 7
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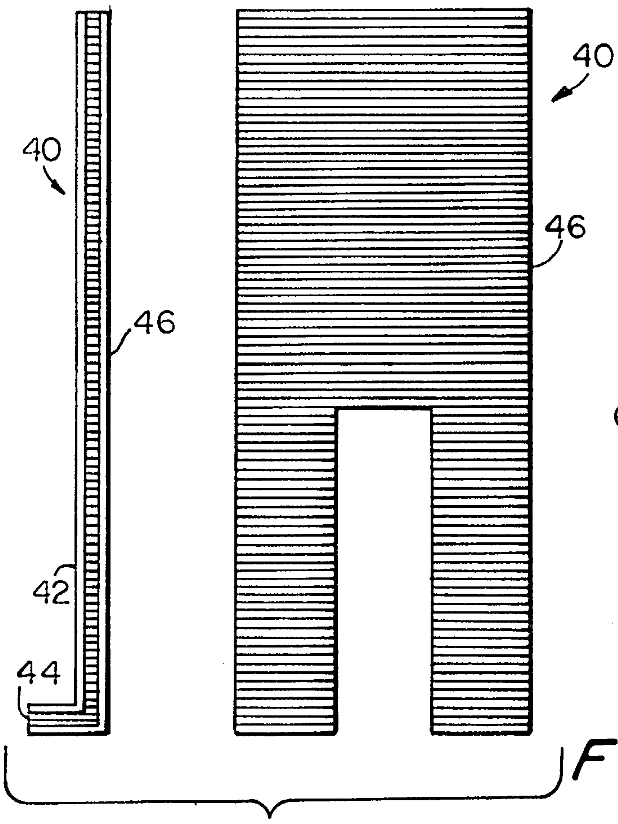

FIG. 3

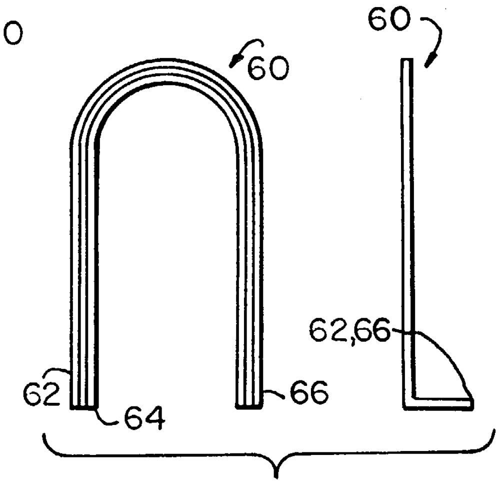

FIG. 5

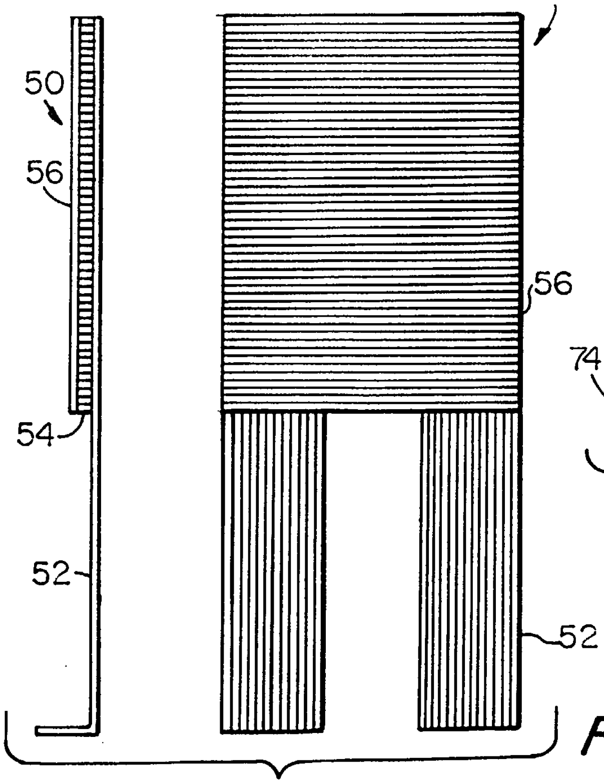

FIG. 4

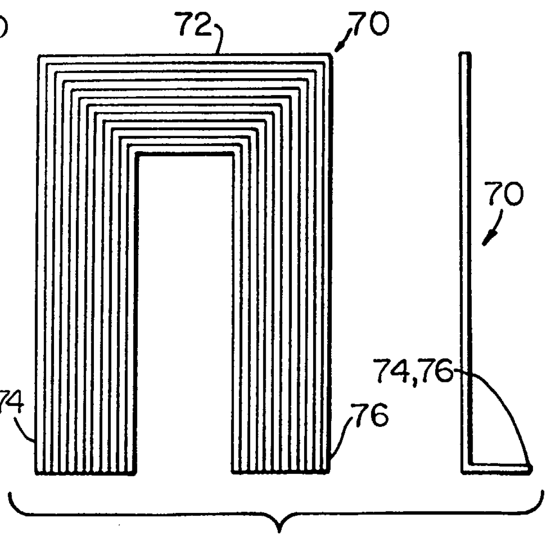

FIG. 6

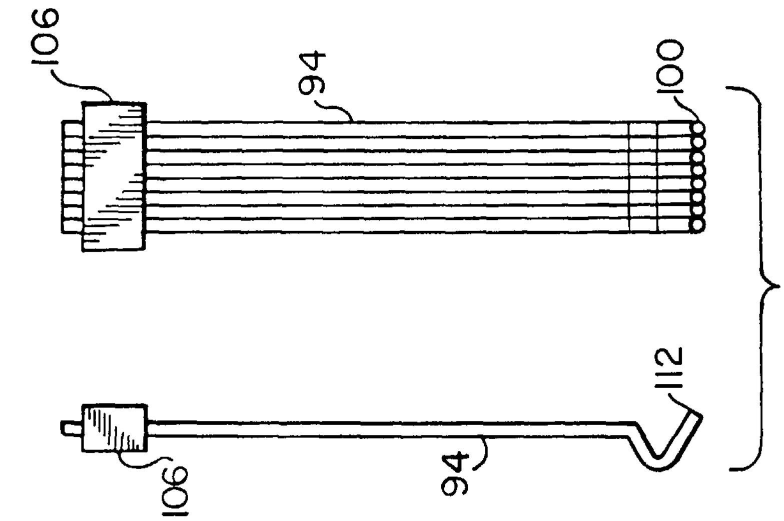

FIG. 10

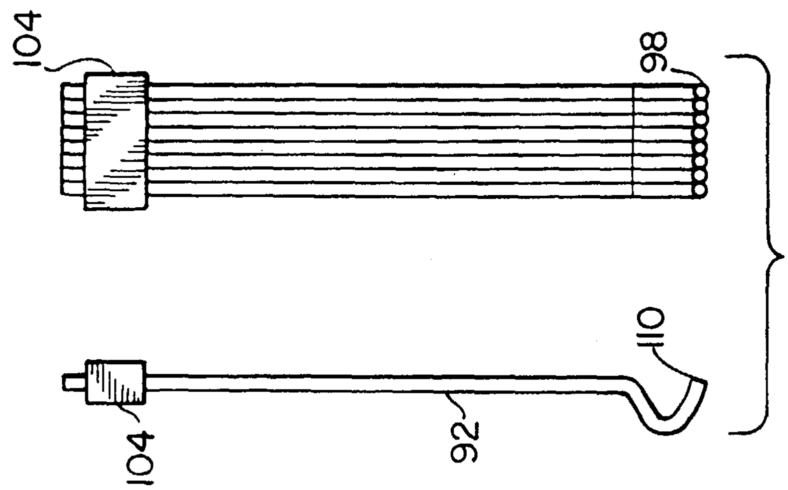

FIG. 9

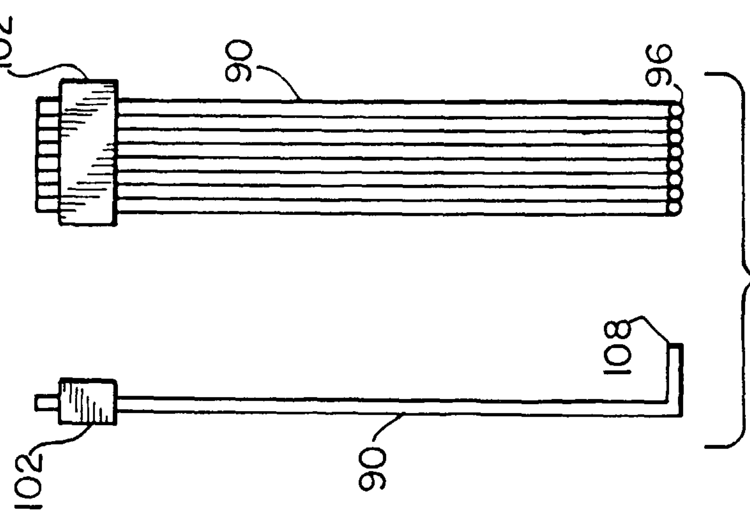

FIG. 8

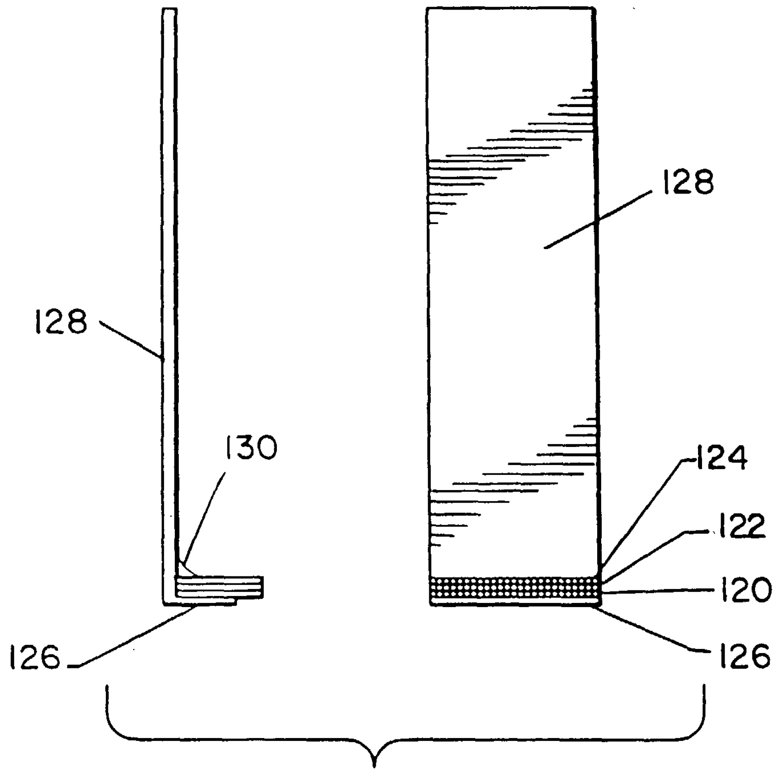

FIG. 11

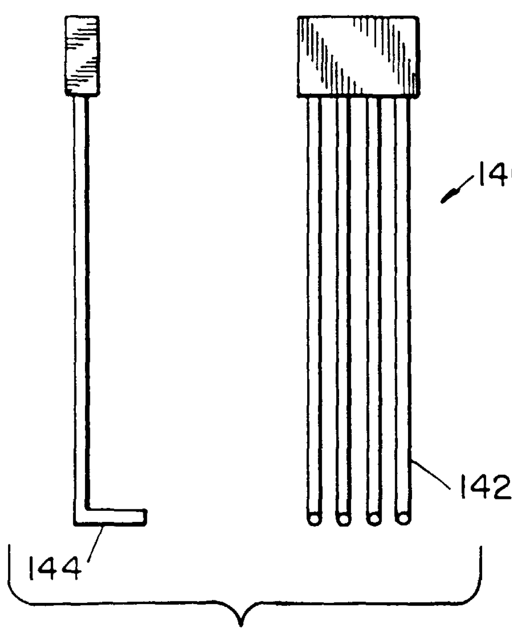

FIG. 12

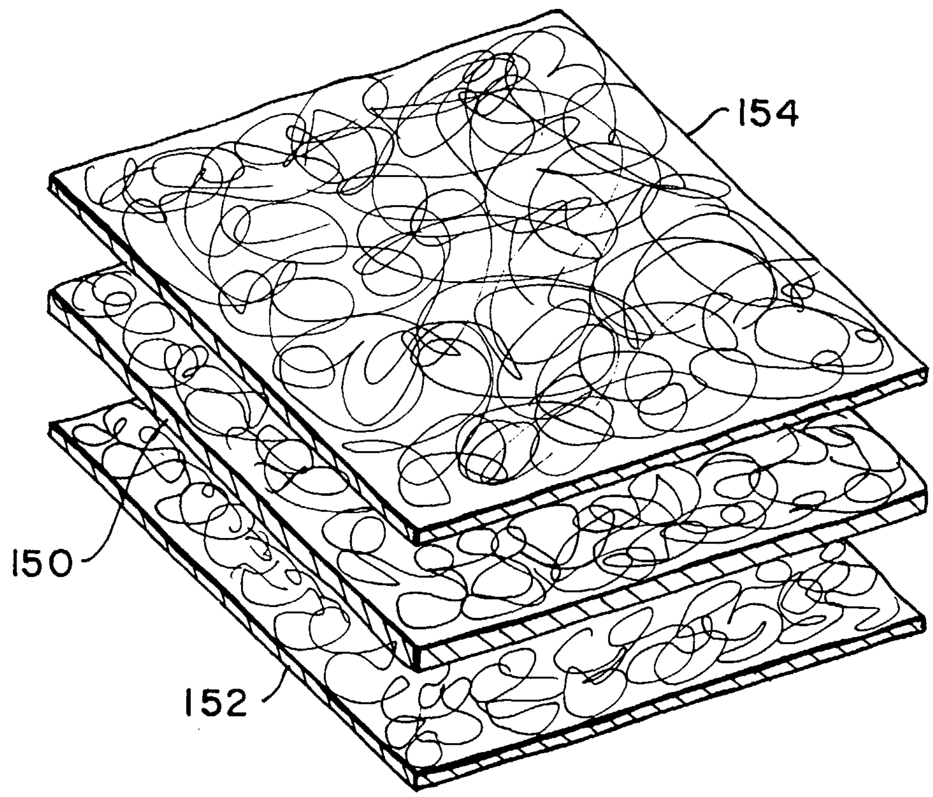

FIG. 13

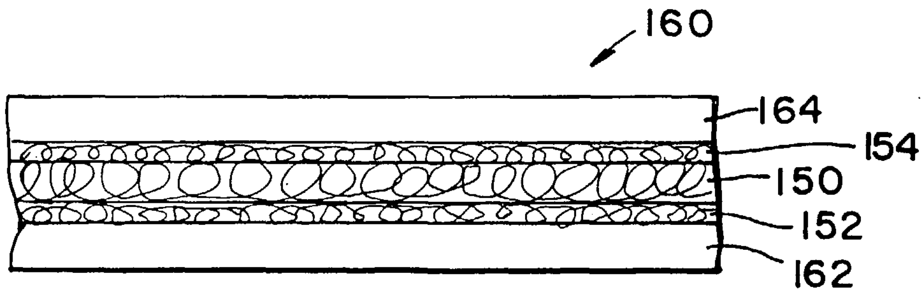

FIG. 14

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 39 4117

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
E	US 2003/008125 A1 (DELANOY CURT ET AL) 9 January 2003 (2003-01-09) * the whole document * ---	1-21	H01R39/24
A	US 6 444 102 B1 (VESELASKI STEPHEN ET AL) 3 September 2002 (2002-09-03) * column 3, line 39 - column 5, line 59 * ---	1	
A	US 4 460 633 A (KOBAYASHI HIROYASU ET AL) 17 July 1984 (1984-07-17) -----		

TECHNICAL FIELDS SEARCHED (Int.Cl.7)
H01R
H01H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	14 May 2003	Bertin, M

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03 82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 02 39 4117

This annex lists the patent family membersrelating to the patent documents cited in the above-mentioned European search report.
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14-05-2003

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2003008125 A1	09-01-2003	JP 2003103679 A	09-04-2003
US 6444102 B1	03-09-2002	NONE	
US 4460633 A	17-07-1984	JP 59083619 A	15-05-1984
		JP 1038904 B	17-08-1989
		JP 1599283 C	31-01-1991
		JP 58104255 A	21-06-1983
		CA 1210683 A1	02-09-1986
		EP 0081843 A2	22-06-1983

EPO FORM P0459

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