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(72) Inventor: **Belopolsky, Yakov**
Harrisburg, PA 17112 (US)

(74) Representative:
Beetz & Partner
Patentanwälte
Steinsdorfstrasse 10
80538 München (DE)

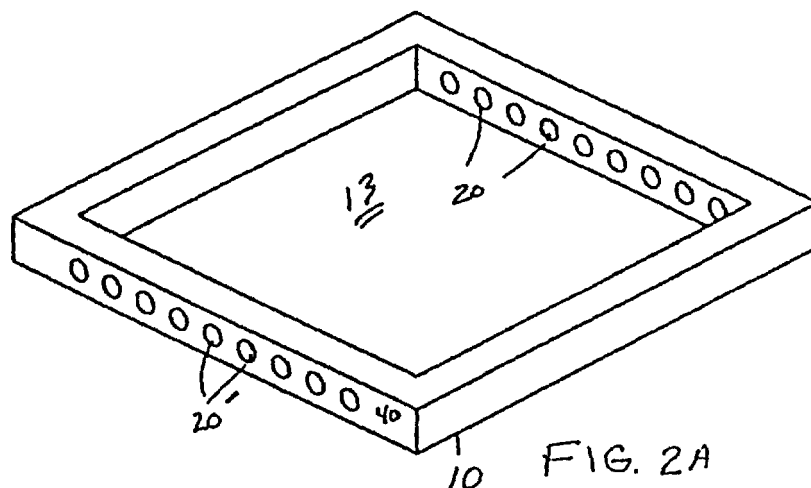
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(71) Applicant:
BERG ELECTRONICS MANUFACTURING B.V.
5202 CB'S-Hertogenbosch (NL)

(54) **Low profile high density sockets and related method of manufacturing**

(57) The invention resides in an electrical connector (2) capable of being used in an array of contact element (12, 12', 12'') disposed between two parallel spaced apart plates defining a gap (70) into which the connector (2) is inserted. The connector (2) employs a plurality of spacer bars (14) on which are carried a plurality of contact rings which are spaced apart from one another by one or more spacer elements (16, 16'). The position of the contact elements (12, 12', 12'') can be readily var-

ied from one spacer bar (14) to the other by the addition or elimination of one or more spacers to customize the contact array for adapting to the contact placement on the contact plates. Another embodiment of the invention may include using spacer rods made from an elastomeric material which can be stretched to allow the contact rings to be slid over a necked down portion of the rod (16).



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Description

[0001] The present invention relates to electrical connectors and relates more particularly to high density electrical connectors used to interconnect electrical components such as land grid array (LGA) packages, ball grid array (BGA) packages, single in-line type modules, or other possible configurations.

[0002] High density electrical connectors adapted to be disposed for example, intermediate a pair of parallel circuit board units for establishing electrical connections therebetween, are old. Examples of such devices are as follows:

U.S. Patent No. 3,638,163, issued on 1/25/72 to Loosme discloses a connector made from a non-conductive resilient tube and contacts which are equally spaced longitudinally along the cylindrical surface of the tube.

U.S. Patent No. 3,795,884, issued on 3/5/74 to Kotaka discloses an electrical connector having a coil spring, the turns of which serve as conductors extending between terminal pads on PC boards.

U.S. Patent No. 3,818,414, issued on 6/18/74 to Davies et al. discloses electrical connectors which have support members having a spiral groove into which C-shaped conductive members are formed by wire wrapping and gluing.

U.S. Patent No. 3,951,493, issued on 4/20/76 to Kozel et al. discloses a connector in which an elongated non-conductive tubular-like member of resilient material is provided and about which is wound and secured a continuous strip of conductive material.

U.S. Patent No. 4,421,370, issued on 12/20/83 to Treacle et al. discloses cylindrical contacts which have a hole for receiving a supporting thread and a plastic boat for supporting the contacts.

U.S. Patent No. 4,952,156, issued on 8/28/90 to Schmedding discloses a connector having a plurality of contact terminals wherein the contact terminals are each crimped onto a continuous length of electrically insulating material.

[0003] In the above cited references, there can be seen numerous devices which connect within a contact array environment. However, the connectors disclosed in these prior art patents are problematic in that each do not address the heretofore known problem of varying contacts spacing, variations in pitch in orthogonal directions, implementation of missing contacts, joint grounding, and connectors of nonstandard shapes. Furthermore, the ability of these array connectors to vary and work with differing design options with respect to overall size, number of contacts in contact spacing is highly limited, if not entirely impossible. Even if such devices could be modified to accept a greater variety of different array contact settings, the cost associated with

the fabrication of such adaptive connectors from standard production and labor costs would be prohibitive.

[0004] Accordingly, it is an object of the invention to provide a highly versatile low induction contact array capable of being very tolerant of differences in contact spacing, number, size, height, pitch and being highly adaptive to variation in shapes so as to be capable of being used between two planar members having surface contacts thereon.

[0005] It is still a further object of the invention to provide a device of the aforementioned type wherein different array patterns of contacts can be accommodated by a connector assembly which is infinitely adaptable to accommodate varying contact in arrays.

[0006] Still a further objection of the invention is to provide a device and method of the aforementioned type wherein such a device is capable of being fabricated with ease of manufacture and relatively little additional labor costs.

[0007] Other objects and advantages of the invention will become apparent from the following specification in the appended claims.

SUMMARY OF THE INVENTION

[0008] The invention relates to a method and related assembly for fabricating a connector with plural contacts arranged in an array which can readily be varied in row position from row to row depending on the arrangement of contacts on opposed contact plate surfaces between which the connector is inserted.

[0009] More specifically, the invention involves an electrical connector for connecting contacts disposed between two spaced apart contact surfaces and comprises a frame having at least two opposed portions to define a space therebetween and at least one spacer bar supported on the frame within the space. The spacer bar has at least one separate contact element disposed in spatial arrangement therealong and has at least two non-conductive spacer elements disposed on either side of the contact element for positioning the at least one contact element in a given location along the spacer bar. The at least one spacer bar has a non conductive surface.

[0010] In one embodiment, the spacers are separate elements mountable on the spacer bar, yet in another embodiment the spacer bar is an elongated length of elastomeric material having portions of narrowed diameter followed by larger diameter portions to define a series of bosses and gaps thereon and wherein the contact elements are disposed on the spacer bar between the bosses.

[0011] Ideally, the contact elements have an inner opening having a diameter which is slightly greater than the outer diameter of the spacer bar. The contact elements may be formed as split spiral rings each having a first and second free end which are laterally offset from one another allowing the rings to be radially compliant

and the rings have an inner opening of a diameter which is slightly greater than the outer diameter of the spacer bar.

[0012] Ideally, the frame is a closed shape having opposed pairs of openings formed therein for receiving the at least one spacer bar therein and a retainer is associated with each of the opposed pairs of openings in the frame for securing a corresponding one of the spacer bars within the opening, and wherein the connector has a plurality of spacer bars supported on the frame.

[0013] The invention also resides in a connector with a frame and a plurality of bars supported on the frame. A retainer is associated with the frame for holding each of the spacer bars on the frame against movement. Each of the spacer bars includes a plurality of contact elements slidably disposed thereon and a plurality of spacer members disposed on opposite sides of each contact element locating each contact element in a position relative to the frame. The spacer members and the spacer bars are formed from a nonconductive material and the spacer members and the contact elements are movably disposed on the bars. Desirably, the contact elements are radially yieldably supported on the spacer bar.

[0014] The invention further resides in a method of assembling an electrical connector for use in an array type contact grid comprising the steps of providing at least one elongate bar having a given outer diameter; providing a plurality of contact elements each having a hole formed therein defined generally by an inner diameter which is greater than the outer diameter of the spacer bar; providing a plurality of spacer members; placing a contact element onto the bar and spacing one contact element from another on the bar by placing one or more of the spacers therebetween and securing the at least one spacer bar with the contact elements and spacers thereon to the frame to hold the at least one spacer bar in place on the frame.

[0015] The method further comprises providing each of the contact elements as a split ring capable of radially yielding inwardly and inserting the connector into a gap between two spaced apart contact plates and forming the gap such that upon insertion of the connector into the gap the contact elements are compressed.

[0016] The invention further resides in a method of forming a spacer bar useable as a connection between circuit substrates comprising steps of providing a spacer bar made from an elastomeric material; stretching the spacer bar such that the bar becomes elongated and of a reduced diameter; and placing a contact member on the spacer bar. Ideally, the method of forming a spacer bar further includes forming the spacer bar with a plurality of bosses separated from one another by gaps into which gaps, a contact member is placed.

[0017] The invention also resides in a spacer bar made from an elastomeric material wherein the spacer bar can be stretched such that the bar becomes elongated

and of a reduced diameter so that a contact member can be placed on the stretched bar. Desirably, the spacer bar is formed with a plurality of bosses separated from one another by gaps into which gaps, a contact member is placed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

Figure 1 is a perspective view of the array connector of the present invention.

Figures 2A, 2B, 2C, 2D and 2E respectively show a perspective view, side view, a plan view, other side view, and an end view of the frame used in the connector of Figure 1.

Figure 3 is a perspective view showing a connector shown apart from the frame of Figures 2A-2E.

Figures 3a, 3b show, respectively, side and front elevation views of a second embodiment of the contact element.

Figures 3c and 3d show, respectively, side and front elevation views of a third embodiment of the contact element.

Figures 3e and 3f show, respectively, side and front elevation views of a third embodiment of the contact element.

Figures 3g and 3h show, respectively, side and front elevation views of a fourth embodiment of the contact element.

Figure 4 is a partially fragmentary enlarged view of the end of the bar shown in Figure 3.

Figures 5A, 5B, 5C and 5D show, respectively, a perspective view of the spring ring contact, and end view, a side view and an elevation view of the contact element.

Figures 6A, 6B and 6C show respectively a perspective view, a side view and an end view of a spacer usable in the present invention.

Figures 7A, 7B and 7C show, respectively, a perspective view, a side view and an end view of another spacer usable in the present invention.

Figure 8a, 8b and 8c show respectively a perspective, top plan view and an end view of the spacer bar of the invention

Figure 9 shows a perspective view of an alternative embodiment of the spacer bar of the invention absent the contact elements.

Figure 10 shows a perspective view of an alternative embodiment of the spacer bar of the invention with contact elements mounted.

Figures 11A and 11B show, respectively, partially fragmentary views of a connector frame and its use in a right angle connection.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] Referring now to Figure 1, it should be seen that the array connector illustrated generally as 2 embodies the present invention.

[0020] The connector array 2 is comprised of a frame 10, which has a generally closed shape but can incorporate any geometric shape. In the illustrated embodiment the frame is shown as a square, but could take the form for example, of a rectangle or circle. As shown in Fig. 1, the array connector 2 could be inserted between two spaced apart electrical components 5, 5 having a plurality of conductive elements 7, 7' disposed on surfaces 9, 9' thereof for contact engagement with the contact elements on the connector 2. Conductive elements 7, 7' could be lands on a circuit substrate, solder masses on a BGA package or any other suitable arrangement.

[0021] As seen in Figs. 3 and 4, the connector array 2 further includes a plurality of contact elements 12, 12 which are disposed along an elongated spacer bar 14, 14 which at each end thereof is secured to the frame. Contacts 12, 12 are preferably stamped and formed from a sheet of suitably conductive material, such as cooper alloy. Disposed between each of the contact elements 12, 12 is one or more of a plurality of spacers 16, 16 which are made from an insulative material interposed between contact elements 12, 12 to position each of the contact elements 12, 12 in alignment with a juxtaposed one the surface contacts 7, 7' disposed on corresponding ones of the contact plates 5, 5'. The components 5, 5' engage opposite sides of connector 2. Any known clamping mechanism (not shown) can retain components 5, 5' in suitable electrical connection with connector 2.

[0022] As illustrated in Figures 2A-2D, the frame 10 has a plurality of aligned holes 20, 20' which are aligned with each other along opposite frame members so as to be able to receive one of the plurality of connecting rods 16, 16 therein. As such, each spacer bar 14, 14 is of a length such that each end thereof is journaled within one of the openings 20, 20' to hold it in alignment within the frame 10 so that registration between the contact elements 12, 12 of the connector 2 and the corresponding surface contacts 7, 7' can be effected.

[0023] Referring for the moment to Fig. 8A-8C, it should be seen that each spacer bar 14, 14 is made from a non-conductive material, such as, plastic or an anodized metal. These spacer bars can be generally of a uniform circular diameter and are rigid in character. A typical spacer bar of the invention is seen in Figures 8A-8C.

[0024] Referring back to Figures 3, 4, 5 and 6, the spacer bar 14, one or more of the spacers 16, 16 disposed on it, and one or more of the conductive contacts elements 12, 12 located over the spacer bar and being of uniform outer diameter form an assembly 25. As seen

in Figures 3, 4 and particularly in 5, each contact element 12 has a generally annular shape which is capable of compressing radially about the spacer bar 14. As best seen in Figures 5A-5C, the spacer bar contact elements 12, 12 are metal spring rings with an interior opening 30 having a diameter D1 which can be somewhat greater in diameter than the outer diameter OD (see Fig. 4) of the spacer bar 14. The spring contact elements 12, 12 can take many different designs, but in the preferred embodiments they are split lock washers.

[0025] For example, in Figures 3a and 3b, the contact element 12' has no offset, yet has an interrupted perimeter 19 making it radially yieldable. In the embodiment of Figures 3c and 3d, the contact element 12'' has a continuous annulus, yet is wider and has a thinner gauge thereby making it yieldable. In the embodiment of Figures 3e and 3f, the contact element 12''' has a pleat 23 formed in its perimeter thereby allowing it to be yieldable. In the embodiment of Figures 3e and 3f, the contact element 12'''' is a standard rigid washer and the diameter of its inner opening is such that the washer can tilt on the bar 14, e.g. yield, between fixed spacers 27, 27 secured to the bar 14 from an unloaded condition (Fig. 3g) to a loaded condition (Fig. 3h).

[0026] As best seen in Figures 5A-5D, each contact element 12, 12 has open ends 32, 34, which are disposed in a side-by-side manner so as to be offset from one another in a non-engaging manner. Since the outer diameter OD of the spacer bar 14 is preferably smaller than the inner diameter D1 of the opening 30 of the contact element 12, the lateral offset OF between the ends 32 and 34 of the contact spring allows each contact spring when engaged by the parallel spaced apart contact plates 5, 5' to be compressed radially about the corresponding one of the spacer bars 14, 14 to which it is mounted to effect positive contact between one contact element 7 on one plate 5 and the corresponding contact element 7 on the opposite plate 5'.

[0027] Referring now to the spacer elements 16, 16' used in the invention, and particularly as shown in Fig. 4 and in Figures 6A-6C and 7A-7C, it should be seen that the spacer elements can take many different forms. Regardless of form, each spacer element is preferably made from an insulative material so as to electrically isolate adjacent contact elements from one another on the common spacer bar. Spacer 16 could be made, for example, from plastic or an elastomer. Since each spacer bar 14, 14 is also made from a non-conductive material, each contact element 12, 12 is positioned on each spacer bar 14 such that each is electrically isolated from the other contact elements 12 on the same bar.

[0028] Referring to Figures 3 and 4, some spacer elements 16, 16' as shown in the embodiment of these figures, have a longitudinally extending slit 36 enabling it to be snap fitted over bar 14 and to be more versatile to adapt to varying and different diameters of the spacer bars and to accommodate manufacturing variation.

However, it should be understood that it is wholly within the purview of the invention to provide spacer elements as shown in Figures 6 and 7 which have a complete and uninterrupted annulus, and thus have no such longitudinal slot formed therein.

[0029] The spacers of Figures 6 and 7 have lengths L1 and L2, respectively, which could be different. Such differing lengths allow almost infinite combinations of spacings to be made between connector contact elements 12,12 to position each connector contact element 12 in registration with the corresponding pair (upper and lower ones of the conductive elements 7,7) on each of the oppositely disposed components 5,5'. Thus, by varying combinations of the spacers 16 and 16' positioning of the connector contact elements 12 can be infinitely effected. It should be further understood that each of the spacers 16,16' can be freely slidable along the spacer bar 14 about which it is disposed.

[0030] Each opposed pair of openings 20,20 formed in the frame 10 of the array 2 slidably receives a spacer bar 14 therein. Each spacer bar 14 has a length L which is longer than the width dimension W of the frame 10 defined between opposed inner side faces of the frame 10. In one method of assembling connector 2, each spacer bar 14,14 can be inserted through one of the openings 20,20 in each opposed opening pair, and thereafter fed through the interior confine 13 of the frame. While each spacer bar is being pushed into the interior confine 13 of the frame, alternating contact elements 12,12 and spacers 16,16' are inserted over the fed length of the spacer bar in accordance with the specifications of the job. Once this is complete, the spacer bar assembly 25 provides the ends of the spacer bar 14 with a small uncovered length. The uncovered length remains within the corresponding one of the openings pairs in the frame. Thereafter, the outer faces 40,40 of the frame 10 in which the openings 20,20 are formed are capped by dowels or other like structure so as to secure the spacer rod against movement relative to the frame and within the confines 13. Alternatively, retention structure, such as a cotter pin, could secure rod 16 in frame 10 as a suitable retainer. In another alternative, frame 10 could be formed from several components that are built up around rods 16.

[0031] Referring now to Figures 9 and 10, and to an alternative embodiment of the spacer bar assembly 25', it should be seen that the assembly illustrated includes a spacer bar referenced generally as 50 and is formed from an elastomeric material, such as rubber. Each such spacer bar 50 has integrally formed with it a plurality of spacer bosses 42,42 located along the length thereof. In the relaxed state of the bar 50, these bosses are of an outer diameter which is slightly larger than the inner diameters D1 of the contact elements 12,12, yet are smaller in diameter than the outer diameter circumference of each of the contact elements 12,12. Thus, in the relaxed state of the bar 50 shown in this embodiment, the bosses 42,42 act to capture the contact ele-

ment 12 disposed therebetween from unwanted axial movement within the gap between each boss. The assembly is fabricated by pulling the free ends 60,62 of the bar in the directions shown by the arrows to elongate it, and thereby reduce the outer diameter of the bosses. In so doing, one or more contact elements can be slid over the bosses until located in the designated gap defined by two consecutively spaced boss elements. Thereafter, the ends of the spacer bar can be released and the contact rims will be held in place thereon.

[0032] Figure 11 displays an alternative arrangement of the present invention. Here, the frame 10 is used as a connection between two perpendicularly oriented circuit boards, namely, board PCB1 and PCB2. That is, the frame 10 is located relative to boards PCB1 and PCB2 such that PCB2 is received within gap 70 disposed between opposed rows of contact elements 12,12, while simultaneously, these contact elements are also in contact with corresponding contact surfaces 74 and 76 on board PCB1.

[0033] By the foregoing, an improved electrical connector for an array type contact scheme has been disclosed by way of the preferred invention. However, numerous modifications and substitutions may be had without departing from the spirit of the invention. For example, while the frame of the assembly has been shown in square shape, it is well within the purview of the invention to use any closed shape, preferably a parallelogram for mounting the spacer rods thereon.

[0034] Accordingly, the invention has been described by way of illustration rather than limitation.

Claims

1. An electrical connector (2) for connecting conductive elements on circuit substrates comprising:
 - a frame (10) having at least two opposed portions to define a space therebetween;
 - at least one spacer bar (14; 50) supported on said frame (10) within said space; and
 - said spacer bar (14; 50) having at least one separate contact element (12, 12', 12'') disposed in spatial arrangement therealong and having at least two non-conductive spacer elements (16, 16') disposed on either side of said contact element (12, 12', 12'') for positioning said at least one contact element (12, 12', 12'') in a given location along said spacer bar (14; 50).
2. A connector (2) as defined in claim 1 further characterized by said at least one spacer bar (14; 50) having a non conductive surface.
3. A connector (2) as defined in claim 2 further characterized said spacers (16, 16') being separate ele-

ments mountable on said spacer bar (14; 50).

4. A connector (2) as defined in claim 2 further characterized by said spacer bar (14; 50) being an elongated length of elastomeric material having portions of narrowed diameter followed by larger diameter portions to define a series of bosses (42) and gaps thereon; and wherein said contact elements (12, 12', 12'') are disposed on said spacer bar (50) between said bosses (42). 5 10
5. A connector (2) as defined in claim 2 further characterized by said contact elements (12, 12', 12'') having an inner opening having a diameter which is slightly greater than the outer diameter of said spacer bar (14). 15
6. A connector (2) as defined in claim 5 further characterized by said contact elements (12, 12', 12'') being formed as split spiral rings each having a first and second free end which are laterally offset from one another allowing said rings to be radially compliant. 20
7. A connector (2) as defined in claim 3 characterized by said rings having an inner opening (30) having a diameter (D1) which is slightly greater than the outer diameter (OD) of said spacer bar (14). 25
8. A connector (2) as defined in claim 7 further characterized by said contact elements (12, 12', 12'') being formed as split spiral rings each having a first and second free end (32, 34) which is laterally offset (OF) from one another allowing said rings to be radially compliant. 30 35
9. A connector (2) as defined in claim 4 further characterized by said contact elements (12, 12', 12'') being formed as split spiral rings each having a first and second free end (32, 34) which are laterally offset (OF) from one another allowing said rings to be radially compliant. 40
10. A connector (2) as defined in claim 1 further characterized by said frame (10) being a closed shape having opposed pairs of openings formed therein for receiving said at least one spacer bar (14; 50) therein. 45
11. A connector (2) as defined in claim 10 further characterized by a retainer associated with each of said opposed pairs of openings in said frame (10) for securing a corresponding one of said spacer bars (14) within said opening. 50 55
12. A connector (2) as defined in claim 1 further characterized by said connector (2) having a plurality of spacer bars (14) supported on said frame (10).

13. A connector (2) comprising:

- a frame (10);
- a plurality of bars supported on said frame (10);
- a retainer associated with said frame (10) for holding each of said spacer bars (14) on said frame (10) against movement;
- each of said spacer bars (14) including a plurality of contact elements (12, 12', 12'') slidably disposed thereon and a plurality of spacer members disposed on opposite sides of each contact element (12, 12', 12'') locating each of said contact elements (12, 12', 12'') in a position relative to said frame (10); and
- wherein said spacer members and said spacer bars (14) are formed from a nonconductive material and said spacer members and said contact elements (12, 12', 12'') are movably disposed on said bars.

14. A connector (2) as defined in claim 13 further characterized by each of said contact elements (12, 12', 12'') being radially yieldably supported on said spacer bar (14).

15. A method of assembling an electrical connector (2) for use in an array type contact grid comprising:

- providing at least one elongate bar (14; 50) having a given outer diameter (OD);
- providing a plurality of contact elements (12, 12', 12'') each having a hole formed therein defined generally by an inner diameter (D1) which is greater than the outer diameter (OD) of said spacer bar (14; 50);
- providing a plurality of spacer members;
- placing a contact element (12, 12', 12'') onto said bar (14) and spacing one contact element (12, 12', 12'') from another on said bar (14) by placing one or more of said spacers (16, 16') therebetween and securing said at least one spacer bar (14) with said contact elements (12, 12', 12'') and spacers thereon to said frame (10) to hold said at least one spacer bar (14) in place on said frame (10).

16. A method as defined in claim 19 further characterized by providing each of said contact elements (12, 12', 12'') as a split ring capable of radially yielding inwardly and inserting said connector (2) into a gap (70) between two spaced apart contact plates (5, 5') and forming said gap (70) such that upon insertion of said connector (2) into said gap (70) the contact elements (12, 12', 12'') are compressed.

17. A method as defined in claim 15 further characterized by providing each of said spacers (16, 16') and said spacer bars (14) as non-conductive members.

18. A method of forming a spacer bar (14) useable as a connection between circuit substrates comprising steps of:
- providing a spacer bar (14) made from an elastomeric material; 5
 - stretching said spacer bar (14) such that the bar (14) becomes elongated and of a reduced diameter; and
 - placing a contact member on said spacer bar (14). 10
19. A method of forming a spacer bar (14) as claim 18 further characterized by forming said with a plurality of bosses (42) separated from one gaps (70) into which gaps (70), a contact member is placed. 15
20. A spacer bar (50) made from an elastomeric material; wherein said spacer bar (50) can be stretched such that the bar becomes elongated and of a reduced diameter so that a contact member can be placed on said stretched bar (50). 20
21. A spacer bar (50) as defined in claim 20 further characterized by forming said spacer bar (50) with a plurality of bosses (42) separated from one another by gaps (70) into which gaps (70), a contact member is placed. 25

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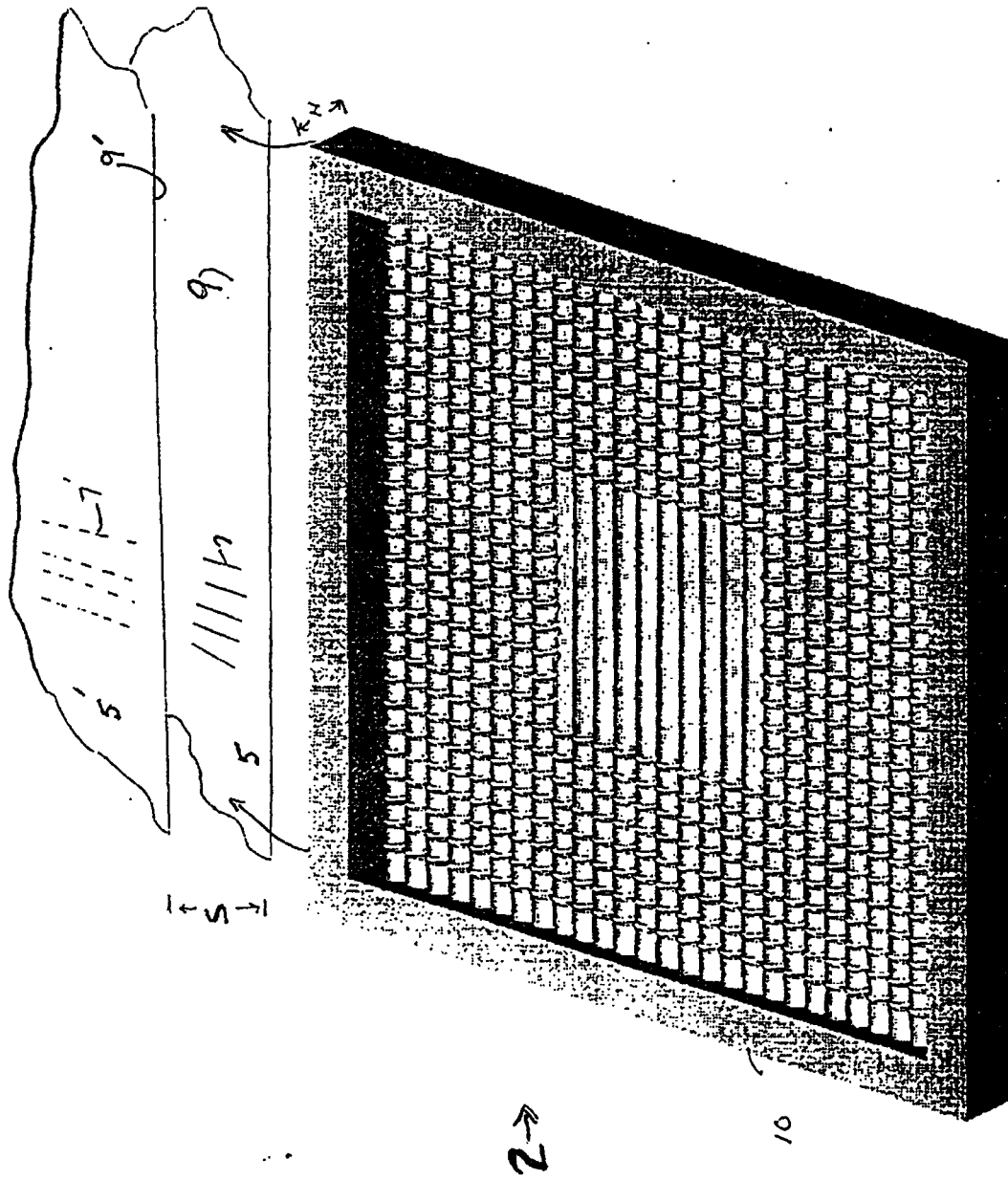


FIG.1

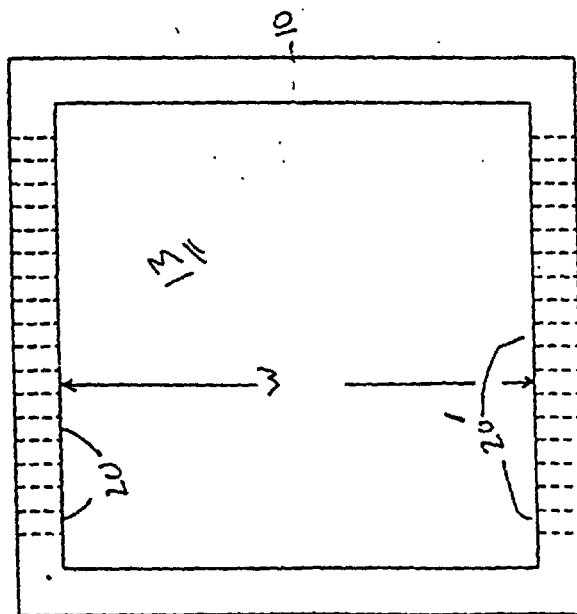
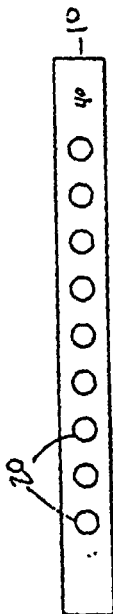
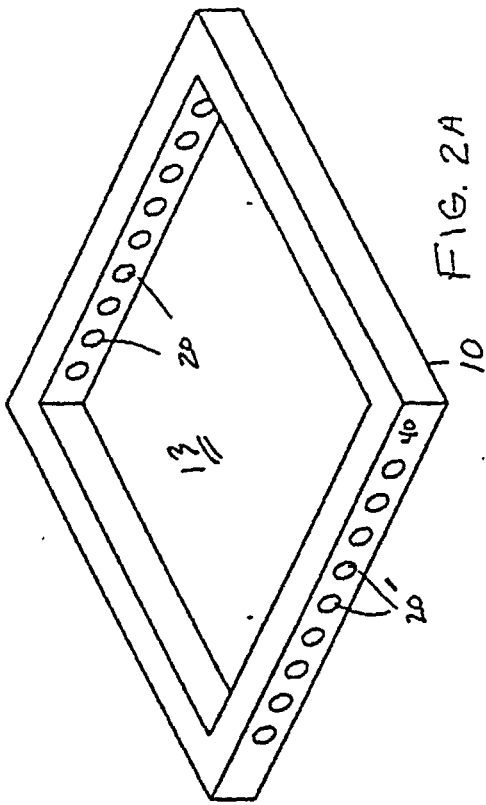
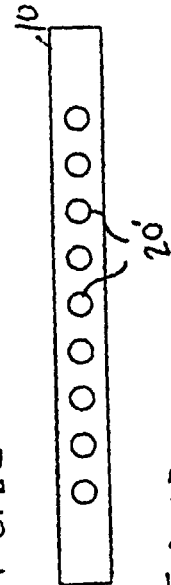
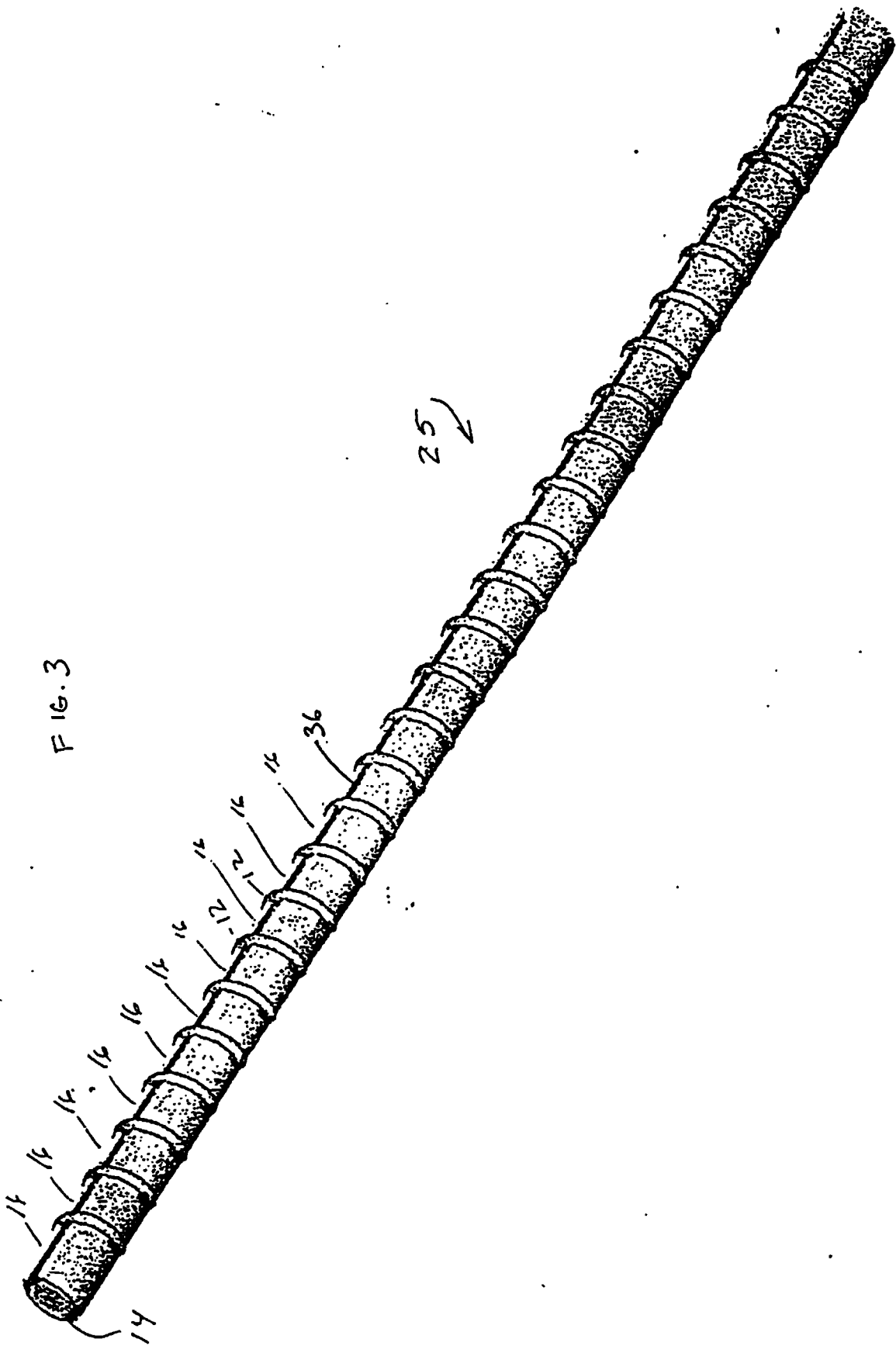


FIG. 2E



H — I



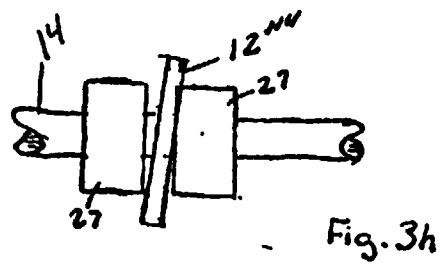
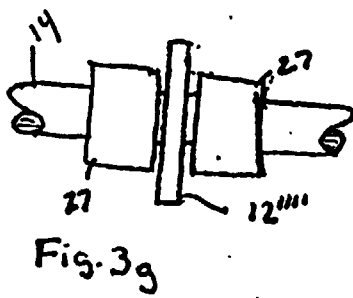
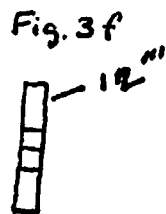
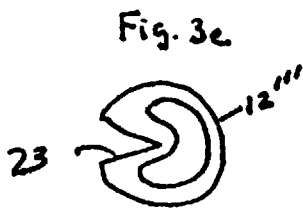
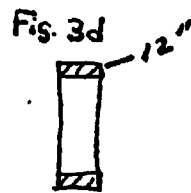
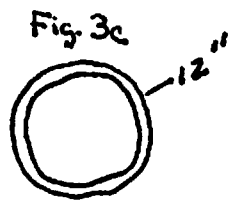
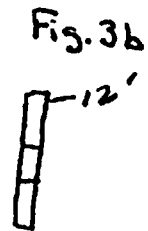
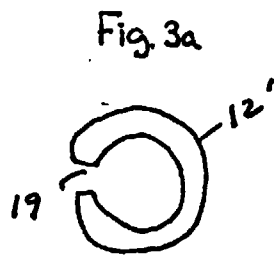
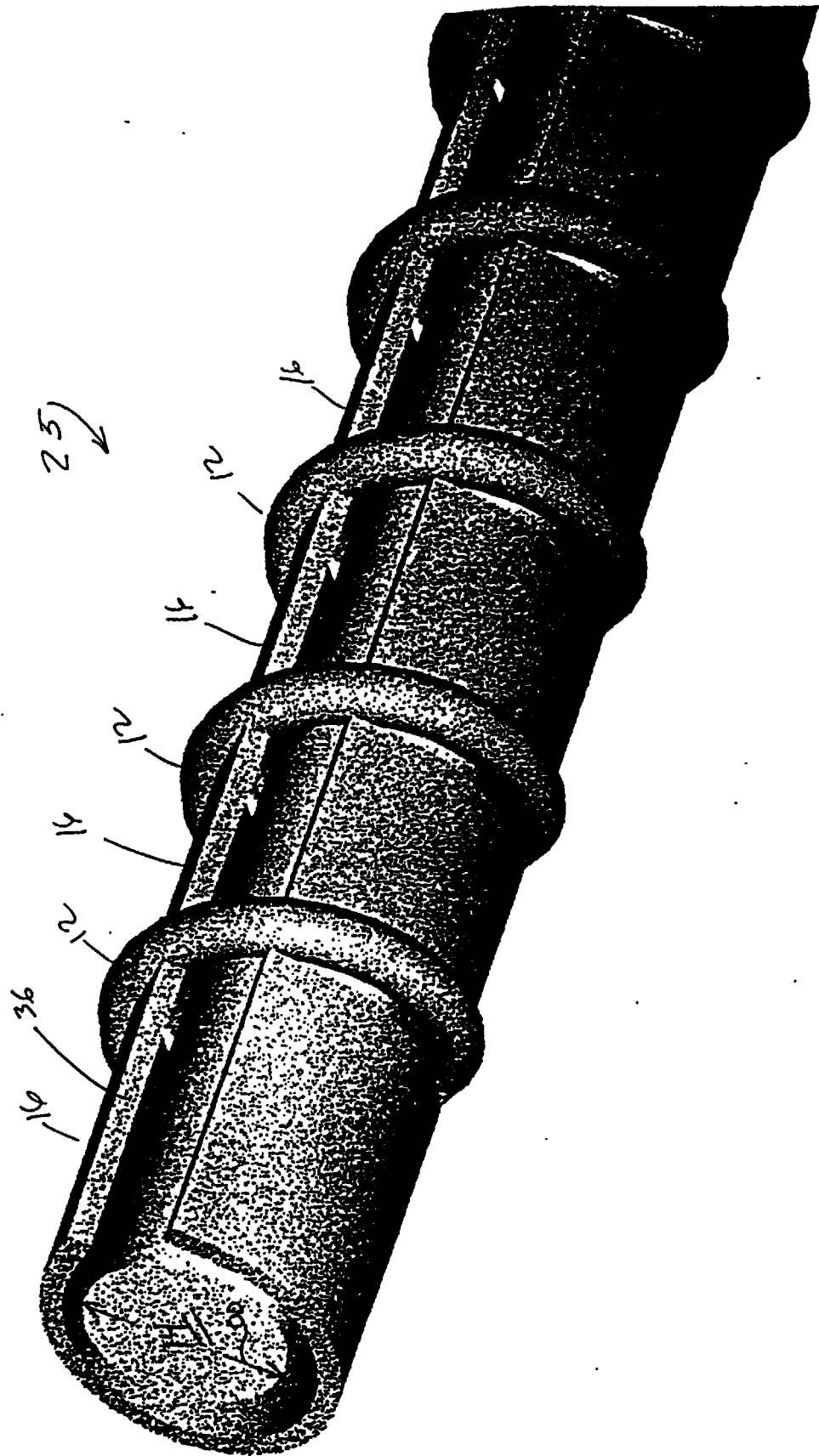


FIG. 4



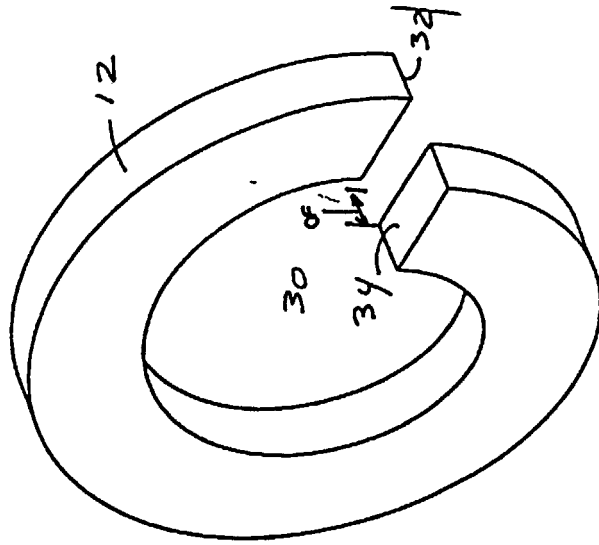


FIG. 5A

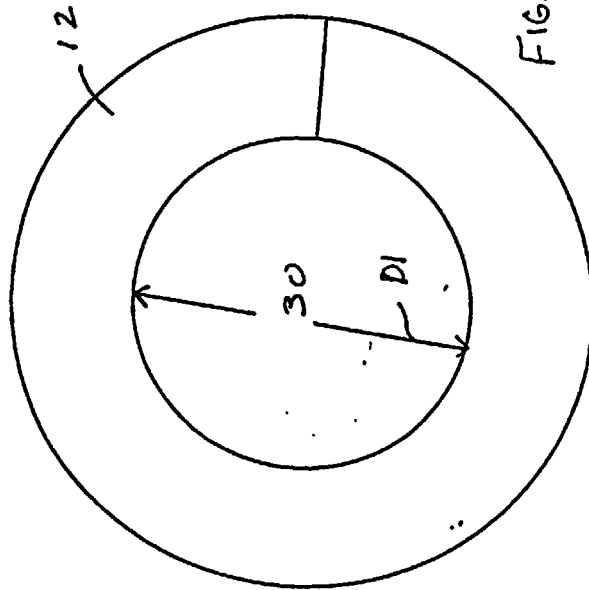


FIG. 5B



FIG. 5C

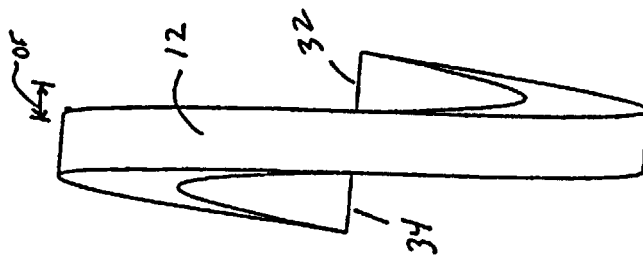


FIG. 5D

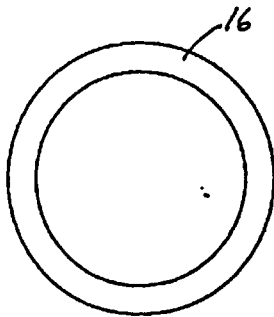


FIG. 6C

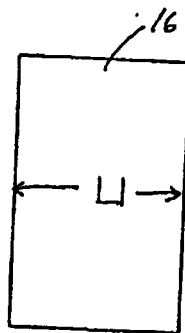


FIG. 6B

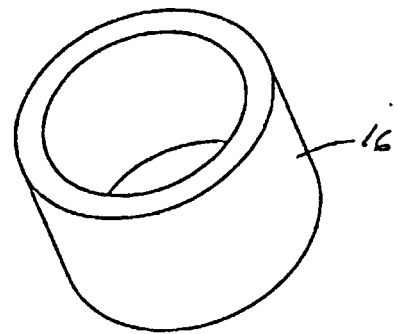


FIG. 6A

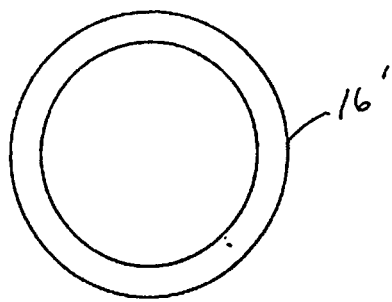


FIG. 7C

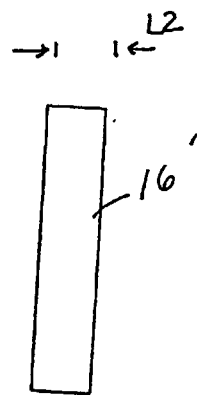


FIG. 7B

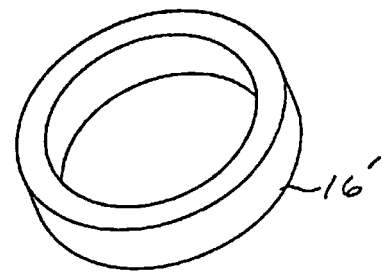


FIG. 7A

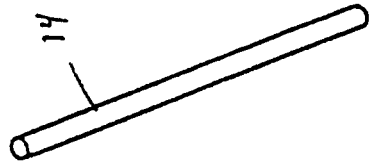


FIG. 8a

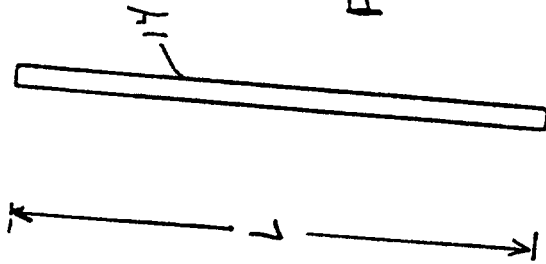


FIG. 9b



FIG. 9c

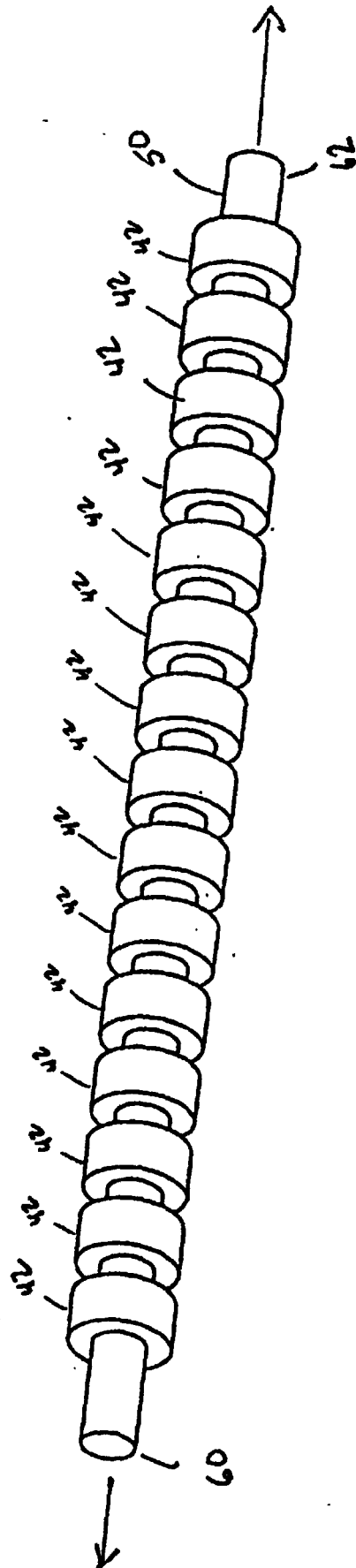


Fig. 9

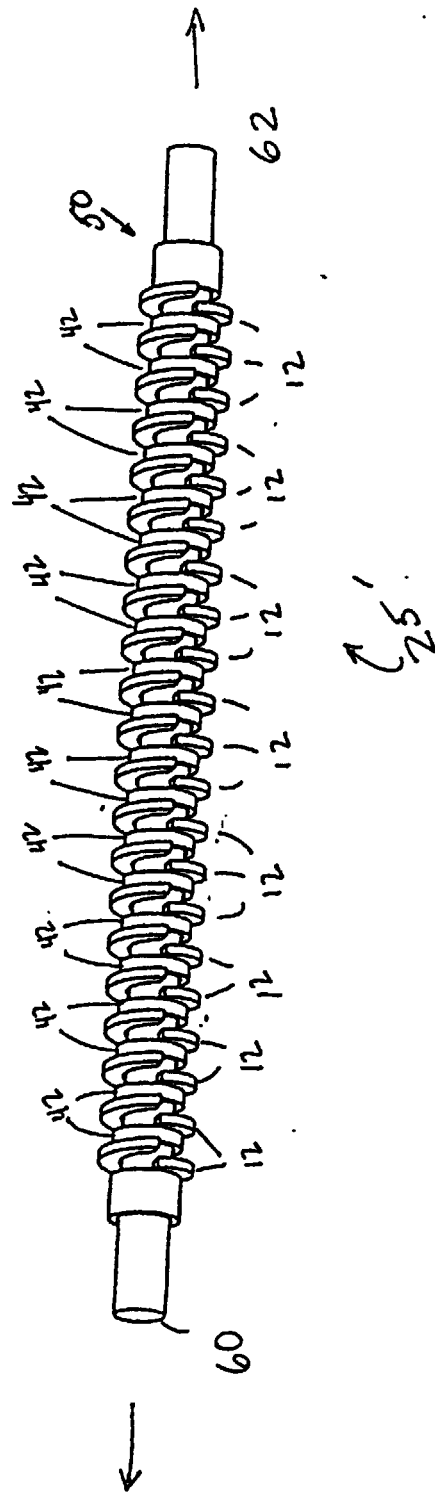


FIG. 10

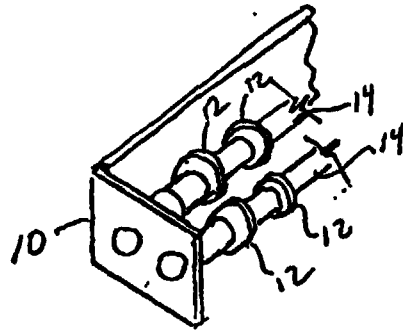


Fig 11A

Fig 11B

