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ELECTRICAL CONNECTOR ASSEMBLY

5 The present invention relates to an electrical connector, more specifically to a high density electrical connector such as PC card connector that uses a flexible circuit for interconnecting the contact of the PC connector to another connector mounted on a circuit board.

10 Advances in electronic devices including microprocessors have created a large market for compact electronic apparatus using memory or PC cards, hard disk drives (HDDs), etc. A docking connector or a memory card connector is used in such electronic apparatus. The
15 docking connector issued to interconnect another similar electronic apparatus for creating a network, and also to connect peripheral equipment such as a submemory apparatus. A memory card connector receives one or more memory card or an HDD for electrical connection thereto.

20 Recently, there are needs for card type devices known a PC cards for expansion or additional performance of compact electronic equipment such as notebook personal computers. Such PC cards are normally received in a PC card connector installed in a compact electronic
25 equipment to provide added memory capacity or interfacing with external devices such as peripheral equipment. Typically, PC card connectors have dual stacked connector mating portions to permit reception of three types of PC cards, i.e., Type I, Type II and Type
30 III.

 These docking connectors and PC or memory card connectors include a plurality of contacts often more than one hundred disposed in a matrix having a plurality of rows. Such contacts are bent at right angles or in
35 an L-shape with respect to the connector and are soldered to respective conductive paths or traces on a main PC board. One example of such memory card connector is disclosed in US Patent No. 5,324,204. In

this particular example, four rows of contacts are bent in a staggered relationship to be connected to the main PC board in eight rows.

Typical examples of such connectors also are disclosed in Japanese Patent Publication No. 33257/94 and Japanese UM Publication No. 56992/94. The former connector has contacts aligned in a connector housing and bent at substantially right angles at the rear position to be connected to a main circuit board. In the latter connector, contacts of dual stacked connectors extend at their rear positions toward each other, i.e., toward the center position to be connected to an auxiliary circuit board at the center position, thereby interconnecting the auxiliary and main circuit boards by the board-to-board connector.

Unfortunately, as the electronic equipment becomes more compact a higher density of contacts is required. The individual contacts, therefore, have smaller dimensions and pitch, which makes it difficult to form reliable connections with a main circuit board using a connector having relatively long solder tines of the contacts of the former connector. Although the latter connector is effective to realize relatively fine pitch connections, the connector requires a larger number of components, thus making more difficult to manufacture and more expensive.

Moreover, a standard to form signal and ground (SG) of PC card connectors has been added recently. One object is to isolate signals to be transmitted through one connector from those transmitted through another connector, thereby preventing noise due to cross talk. Unfortunately, however, such noise protection is not always sufficient in conventional connectors.

Additionally, in the above conventional connectors, the connection or mounting location of the connector or its contacts on a main circuit board is required to be predetermined; thereby restricting the design of the

main circuit board and precise manufacture of conductive through hole patterns, etc. with small tolerance. It is, therefore, desired to provide flexibility in connection or mounting.

5 It is known in the art to use a flexible circuit (FC) for interconnecting circuits on a substrate such as a small-size printed circuit board (PCB) and high-density-mounted electronic equipment. Such an electrical connector for FC generally comprises a
10 plurality of contacts to be engaged with conductive pads formed on the FC, a housing for disposing and holding the contacts, and a movable plastic cover or other member for pushing the conductive pads formed on the FC inserted in the housing, into positive engagement with
15 the contacts in the housing. Examples of conventional electrical connectors for FC are disclosed in a Japanese Patent Publication No. 61-131382, a Japanese U.M. Publication No. 2-120780, and a Japanese Patent Publication No. 5-251140.

20 As the electronic equipment becomes smaller with a high density of contacts, e.g., the pitch of the contacts is less than 0.5mm, the dimensions of the contacts to be used therein will also become smaller and therefore, be more easy to deform. It is very difficult
25 to accurately position the contacts, especially their solder-terminating portions, to the desired location and to maintain them so as not to deform the contacts upon handing and mounting the connector to on the substrate.

30 Also, for the electrical connector utilizing the FC, it is difficult to precisely and firmly urge the movable plastic cover to engage over the full width of the FC with the plurality of contacts without having some deformation over the full width of the FC. Accordingly, reliability of connection between the conductive pads
35 and the contacts has been decreased.

Therefore, an object of this invention is to provide a small and high density electrical connector assembly,

which utilizes the FC and enables simple structure and easy handling.

It is another object of this invention to provide an electrical connector assembly having ground function and permitting easy handling, in which the plurality of the conductive pads on the FC and the contacts in the housing are interconnected with high reliability.

It is yet another object of this invention to provide an electrical connector assembly for card bus, which enables one or more memory card connector etc., to easily and reliably connect to the PC board.

In order to solve the problems of the prior art electrical connector assembly and to achieve the above mentioned objects, the electrical connector assembly of the present invention comprises a housing having plural rows of contacts, a flexible printed circuit board (FC) to be connected to the contacts of the housing at both ends of the flexible printed circuit board, said printed circuit board having a plurality of conductive traces and pads, and a guide member to be inserted in the FC, the guide member being bent in a generally U- shape to force the FC between rows of contacts of a corresponding connector to interconnect the conductive traces and contacts.

One aspect of the present invention is a FC having two arrays of corresponding conductive pads and conductive traces on one surface with the plurality of conductive pads of the arrays arranged in rows in an opposed relationship. A plurality of openings are disposed between the arrays leaving narrow bridge portions between adjacent openings. Strengthening plates are attached to the reversed surface at the positions corresponding to the conductive pads with portions of the strengthening plates extending into the openings by a predetermined length.

Also, another aspect of the present invention is a flexible circuit (FC) comprising conductive traces on

one surface on a central film, a ground layer on the reverse surface, and cover layers disposed to cover the conductive traces and the ground layer. A plurality of openings are formed in the cover layers substantially in rows at selected locations that avoid the conductive traces.

The FC according to the present invention has openings in the direction of the width at substantially center position between the rows of the conductive pads. The openings define the relatively narrow bridge portions of the FC. The FC has a pair of strengthening plates adhered to both sides of the openings and at least one surface of the FC. The pair of strengthening plates have edges extending into the openings by a desired length from both sides thereof.

Additionally, the FC according to the present invention has a plurality of recesses arranged substantially in rows near the bent portion. The recesses are preferably formed by removing a part of one layer of a multiple-layer FC, thereby allowing the FC to bend smoothly at a desired position.

The FC is bent or folded along the bridge portions before being inserted into a connector along with a guide member, and upon full insertion of the board and guide member, the conductive pads of the FC are electrically connected with contacts in the connector. The edge portions of the strengthening plates then abut against the bottom in the housing for proper positioning of the FC in the connector, thereby assuring reliable electrical connection between the conductive pads and the contacts. Also, it is bent at a desired angle, preferably right angle along the recesses, thereby permitting connection to a connector such as the PC card connector or other device at the edge portion. Since the electrical connector assembly comprises a FC with no individual contacts bent at right angle with respect to a wall or L-shape as seen in the prior art electrical

connector assembly, the connector of the present invention eliminates deformation of the guide between the contacts, and disengagement and short circuit caused therebetween. Accordingly, stable electrical
5 connections and easy handling are achieved. Also, the structure having the FC connected to the contacts on the housing at the both ends thereof enables high density.

According to another aspect of the present invention, the electrical connector comprises a housing
10 having two rows of contacts along an elongate opening, a flexible printed circuit board having a plurality of conductive traces on a surface corresponding to these contacts, and a guide member having a generally planer portion to be inserted into a U-shaped bent portion of
15 the flexible printed circuit board, wherein the conductive traces on the flexible printed circuit board are forced between the rows of the contacts by means of the guide member for establishing electrical
interconnection between the conductive traces and the
20 contacts and also connection between the both ends of the FC and the contacts of the corresponding connector.

According to the electrical connector assembly, it is possible to connect the high frequency signals to the contacts through the conductive traces on the surface of
25 the FC, since the FC is bent in a U-shape to envelope the guide so as to contact the ground conductor of the FC board and is engaged with the contacts of the housing and is also engaged with ground conductive members of the housing. Since the all conductive traces formed on
30 the FC can be signal traces, a high density and high frequency electrical connector is obtained.

The present invention will now be described by way of example with reference to the preferred embodiment in conjunction with the accompanying drawings.

35 FIGURE 1 is an isometric view of an electrical connector assembly according to a preferred embodiment of the present invention.

FIGURE 2A is a side view of the electrical connector assembly shown in Figure 1 prior to mating with the corresponding connector.

5 FIGURE 2B is a side view of the electrical connector assembly shown in Figure 1 at a starting time for mating with the corresponding connector.

FIGURE 2C is a side view of the electrical connector assembly fully coupled with the corresponding connector.

10 FIGURE 3 is a cross-sectional side view where the electrical connector assembly according to the present invention is adapted to a stacked memory card connector.

FIGURE 4 is a partial model view of another embodiment of the electrical connector assembly according to the present invention.

15 FIGURE 5 is an isometric view of the electrical connector assembly of another embodiment according to the present invention.

20 FIGURE 6 is an isometric view showing a situation where the guide member in the electrical connector assembly shown in Figure 5 is mounted in a flexible printed circuit board connected to the memory card connector.

FIGURE 7A shows a front view of the housing of the electrical connector assembly of Figure 5.

25 FIGURE 7B shows a side view of the housing of the electrical connector assembly of Figure 5.

FIGURE 7C shows a cross-sectional view taken along the line 7C-7C of Figure 7A.

30 FIGURE 8A is a plan view of the housing of Figure 7A.

FIGURE 8B is a bottom view of the housing of Figure 7A.

FIGURE 9A is a front view of a guide member of the electrical connector assembly shown in Figure 5.

35 FIGURE 9B is a plan view of a guide member of the electrical connector assembly shown in Figure 5.

FIGURE 9C is a rear view of a guide member of the electrical connector assembly shown in Figure 5.

FIGURE 10A is a cross-sectional view of the guide member of Figure 9 taken along the line 10A-10A of Figure 9A.

FIGURE 10B is an end view of the guide member of Figure 9A-C.

FIGURE 11A is a front view of a flexible circuit inserted in an electrical connector assembly.

FIGURE 11B is a side view of the flexible circuit inserted in the electrical connector assembly of Figure 11A.

FIGURE 12A is a cross-sectional view showing a guide member of the electrical connector assembly disposed between the U-shaped flexible circuit prior to inserting the flexible circuit into a connector housing.

FIGURE 12B is a cross-sectional view showing a guide member of the electrical connector assembly disposed between the U-shaped flexible circuit with the U-shaped end of the flexible printed circuit board inserted into the connector housing.

FIGURE 12B is a cross-sectional view showing the flexible circuit secured by the guide member in the connector housing.

FIGURE 13 is a plan view at one surface of the FC according to the present invention.

FIGURE 14 is a bottom view of the reverse surface of the FC in Figure 13.

FIGURE 15 is a view similar to Figure 14 prior to adhering the strengthening plates.

FIGURE 16 is a magnified cross-sectional view of the FC in Figure 1.

FIGURE 17 is a simplified cross-sectional view of the FC in Figure 1 as inserted into a connector.

FIGURE 18 is an isometric view of the FC in Figure 13 showing how it is folded or bent when inserted into a connector.

Figure 1 is an isometric view showing a major part of an embodiment of the present invention adapted to an electrical connector assembly, such as a memory card connector 10. Figures 2A through 2C show a process for inserting and connecting the memory card connector 10 of Figure 1 to a mating connector 40 disposed on and connected to a main substrate 100. That is, Figure 2A shows a situation where the memory card connector 10 and the mating connector 40 are separated from each other. Figure 2B shows the memory card connector 10 partially inserted in the mating connector 40. Figure 2C shows the memory card connector 10 fully mated with the mating connector 40.

As appreciated from Figures 1 and 2, the memory card connector 10 of the specific embodiment comprises overlapped two connector housings 11,12. Plural rows of contacts 13,14 project from wall surfaces 11a,12a of these housings 11,12. In these Figures, the plurality of contacts 13,14 are two rows of signal contacts 13a,14a and one row of ground contacts 13b,14b. As appreciated from the above mentioned U.S. Patent No. 5,324,204, these housings 11,12 comprise, at front surfaces thereof, a memory card, or a plastic or a metallic plate holder for receiving the HDD (not shown in the Figures 1, and 2), respectively.

An FC 20 having sufficient length is connected to each contact 13,14 of the connector housings 11,12 at both ends 21,22 of the conductive traces of the FC 20 by means of solder etc., to conventional pads with through holes to form a card bus. A plurality of conductive traces 23 having contact pads 24 are formed on an outer surface of the FC 20.

A guide member 30 is inserted into a middle portion of the FC 20 to bend it in a U-shape. The guide member 30 is preferably formed by traditionally stamping and bending a conductive metal plate. As best seen in Figure 2A-2C, the guide member 30 has an insertion

portion 31 formed by folding the metal plate to be inserted between rows of contacts 50 of a mating connector 40 as hereinafter explained, and an actuating portion 32 generally perpendicular to the insertion portion and having a generally planer surface. The actuation portion 32 is provided with a slot 33, having a width corresponding to the FC 20, for receiving side edges thereof. The FC 20 is inserted in the slot 33 with a generally U-shape along an outer surface of the insertion portion 31.

The receptacle type mating connector 40 has an elongate box-shaped housing 41 to be mounted on the main substrate 100. The housing 41 has an opening 42 at an upper surface thereof, and has a plurality of surface mounted type (SMT) contacts 50 disposed and secured at both sides of the opening 42. The housing 41 has mounting metal fixtures 43 at both ends in the longitudinal direction of the housing 41, and preferably the connector housing 41 is soldered and secured on a conductive layer (not shown) on the main substrate 100.

Each of the contacts 50 of the connector 40 includes a resilient contact beam 52 having a contact surface 51 near the front end thereof, a mounting portion 53 to be inserted and secured in a contact receiving opening of the housing 41, and a connecting portion 54 to be surface mounted to conductive areas 102 on the main substrate 100. Preferably, a length of the resilient contact beam 52 is selected in various different values, and disposed in staggered relationship to achieve high density disposition. As seen from Figures 2A, the contact surface 51 of the contact 50 projects in the opening 42 of the housing 41.

In a condition where the memory card connector 10 is not mated or connected to the corresponding connector 40, that is, in the situation shown in Figure 2A, the contact pad portion of the FC 20 is bent in a generally U-shape. Accordingly, as shown in Figure 2B, the U-

shaped FC 20 can be easily inserted into the housing 41 with low insertion force and without essentially engaging the contacts 50. Finally, as shown in Figure 2C, when the insertion portion 31 of the guide member 30 is inserted into the opening 42 of the corresponding connector 40 the U-shaped portion of the FC 20 formed with contact pads 24 is forced outwardly from inside to urge and expand outwardly the contact beams 52 of the contacts 50. Therefore, the contact pads 24 of the FC 20 of the conductive traces 23 are forced and engaged with the contact points 51 of the contacts 50, thereby interconnecting the contacts 13,14 of the memory card conductor 10 to the contacts 50 of the mating connector 40, further interconnecting between pads 102 on the main substrate 100.

If the FC 20 is formed with a ground conductive layer on an inner surface thereof, the insertion portion 31 of the guide member 30 engages the conductive layer. Although it is not shown, the guide member 30 is preferably engaged with the mounting metal fixture 43 of the housing 41 at the both ends in the longitudinal direction of the guide member 30 to groundingly engage the ground conductive layer of the FC 20.

As is readily appreciated from a comparison between the connectors 10,40 of the Figures 2A through 2C and the conventional memory card connector disclosed in the above described U.S. Patent No. 5,324,204, the electrical connector assembly of the present invention replaces the plurality of L-shaped contacts disposed in staggered relationship of the prior art connector with the FC 20 and the corresponding connector 40. In accordance with the connector of the present invention an easy handling and high density arrangement corresponding to the conductive traces of the FC 20 are achieved because of elimination of plural rows of the deformable and high density L-shaped contacts. Further, an important matter is that length of the signal traces

from contacts 13,14 of the housings 11,12 to the contacts 50 of the mating connector 40 can be formed such that the length is essentially constant.

Accordingly, since even in high speed data signals it is possible to make signal transmission time or signal delay constant, the present connector is suitable for card bus for transmitting high speed and high frequency signals. Further, since the memory card connector 10 is detachably connected to the connector 40 mounted on the main substrate, it should be noted that the termination, assembly of the connector and serviceability are substantially improved.

Figure 3 is a cross-sectional view showing entire memory card connector 10, of the present invention, including a memory card retention portion 15. The memory card retention portion 15 of the memory card connector 10 is formed by bending a thin metal sheet. In the preferred embodiment of the electrical connector assembly shown in Figure 3, the contacts of the connector comprises a plurality of contacts 13,14 in the connector housings 11,12 overlapped with each other. However, the present invention should not be limited to such embodiment, for example, the present invention can be applied to a card bus for interconnecting contacts on wall surfaces of a pair of housings disposed in opposite relationship.

Another such embodiment of an electrical connector 60 is shown in Figure 4. Electrical connector assembly 60 comprises a pair of separate docking connectors or memory card connectors 61,62. Each of the connectors 61,62 opposes each other at a wall surface thereof, and preferably includes plural rows of multiple number of contacts 63,64, including signal contacts 63a,64a and ground contacts 63a,64b. Between both connectors 61,62 is a mating connector 40' soldered on a main substrate 200. The mating connector 40' can be essentially similar to the mating connector 40 shown in Figures 1 through 3.

A FC 70 is connected to the contacts 63,64 at one end of the conductive traces thereof, on the walls of the both connectors 61,62 by means of a prior art technique. A middle portion of the FC 70 is inserted into a slot of a guide member 80. Contact pads (not shown) at the middle portion of the FC 70 is forced by the guide member 80 into an opening of the connector 40' to engage contacts 50' disposed at both sides of the opening to establish interconnection.

With reference to Figures 5 through 12, another embodiment of an electrical connector of the present invention will be described. Figure 5 is an isometric view of the electrical connector of the another embodiment. Figure 6 is an isometric view where the guide member to be used for the electrical connector is set to the FC connected to the memory card connector. Figures 7A-C and 8A-B show a housing of the electrical connector shown in Figure 5. Figures 9A-C and 10A-B show the guide member of the electrical connector shown in Figure 5.

An electrical connector 110 is provided with a housing 120 for receiving an FC 160, a plurality of contacts 122 oppositely disposed in two rows in the housing 120, and a guide member 140 for forcing and securing the FC 160 inserted into the housing 120. Plate-like ground conductive members 124 are provided on both end surfaces 120a of the housing 120 by pressing side portions 124a into slots 120b in the housings 120 to engage projections (not shown) formed at side portions 124a with the housing 120 as shown in Figure 8B. When the guide member 140 is moved along an arrow 141, as will be described hereinafter, to be inserted into the housing 120 a ground portion 142 of the guide member 140 engages the projections 124b of the conductive ground members 124. As the conductive ground member 124 is mounted and connected on the substrate (not shown) mounting strength of the housing 120 to the

substrate is enhanced. A plurality of contacts 122 disposed in the housing 120 are engaged, respectively, with the conductive pads 164 of the signal traces 162 formed on the FC 160.

5 As shown in Figure 6, the FC 160 is bent at a middle portion 165 and end portions 166, 168 of the FC 160 are connected to corresponding contacts of a memory card connector 180. A shape of the FC 160 is schematically shown in Figures 11A-B and 12A-C. The FC 160 is
10 continuously bent at the middle portion 165 thereof to form two wiring portions or arrays 170,172. The wiring portions or arrays 170,172 are formed with signal traces 162 shown in Figure 6 and conductive pads 164 on both surfaces 170a,172a of the wiring portions 170,172.
15 Also, the wiring portions 170,172 are formed with a ground conductor or ground wiring at back surfaces 170b,172b, respectively such as described below with reference to Figures 13-18. The ground wiring or conductor preferably is formed on entire back surfaces
20 170b,172b, or alternatively may be formed only on a portion thereof.

The guide member 140 as shown in Figures 9A-C and 10 A-B is, for example, integrally formed by stamping and bending a sheet of metal made by copper alloy such as
25 phosphorous copper, and is formed with the above described ground portions 142 at both end portions of the guide member 140. Upon forming the guide member 140, the stamped metallic sheet is bent at the middle portion 140a, and is outwardly bent at end portions, and
30 the end, portions corresponding to the ground portions 142 are downwardly bent to form the ground portions 142. The ground portions 142 have resiliency, thereby holding the housing 120 from both sides when assembled thereto. The guide member 140 is disposed between the wiring
35 portions or arrays 170,172. Until the guide member 140 is inserted into the housing 120, the guide member 140

is preengaged with projections 191 (see Figure 11) formed on the FC 160.

Now, with reference to Figures 11A-B and 12 A-C, a sequence will be described in which the FC 160 is inserted into the housing 120 and is secured by means of the guide member 140. In order to secure the FC 160 in the housing 120 by the guide member 140, first, as shown in Figure 12A, the guide member 140 is disposed at a position spaced apart from the middle portion 165 of the FC 160. Then, as shown in Figures 11A-B and 12B, the middle portion 165 of the FC 160 is inserted into the housing 120. After inserting the middle portion 165 of the FC 160 into the housing 120, as shown in Figure 12C, the guide member 140 rides over the projections 160a of the FC 160 to be inserted into the housing 120, and the middle portion 165 of the FC 160 inserted into the housing 120 is forced by the guide member 140. Accordingly, the ground wiring formed on the back surfaces 170b, 172b of the FC 160 are positively engaged with the guide member 140, and also the ground portions 142 of the guide member 140 engage the projections 124b of the ground conductive member 124, as above described.

The guide member 140 is made of metal, thereby eliminating deformation or breaking of the guide member when the guide member 140 is inserted into the housing 120. Accordingly, the conductive pads 164 (see Figure 6) can be readily and firmly engaged with the contacts 122 more easily than can a plastic cover or guide member, thus enabling excellent reliability and easy operation. Further, in the situation where the metallic guide member 140 is inserted into the housing 120, since the guide member 140 engages both the ground conductive members 124 secured in the housing 120 and the ground conductor or wiring (not shown) on the FC 160, the guide member 140 also functions as a ground member.

Illustrated in Figure 13 through 16 is a preferred embodiment of the FC 160 in accordance with the present

invention. Figure 13 shows one surface 160a of the FC 160 while Figure 14 shows the reverse surface 160b thereof. Also shown in Figure 15 is the surface 150b before adhering strengthening plates 190,196 which will be described hereinafter. Furthermore, Figure 16 shows an enlarged cross-sectional view in the thickness direction from the slot to the edge portion.

As shown in Figure 16, the FC 160 is formed as a multi-layer structure. A central film 182 of polyamide or the like separates one side structure 182a to form the surface 160 and a reverse side structure 182b to form the surface 160b. Each structure 182a,182b, is made by an electrically conductive film of copper or the like and a cover layer 185 of polyamide or the like adhered on the surface of the central film 182 by adhesive material 183a,183b,. The electrically conductive film is further etched to form conductive patterns 162 and a ground layer 176 which will be described hereinafter.

As shown in Figures 13 and 16, the structure 160a on one side of the FC comprises conductive arrays 170,172, conductive pads 164 including conductive traces 162, connection portions 167 connected to conductive traces 162 and having through-holes 169 extending to the other surface 160b. Each conductive trace 162 interconnects the respective conductive pads 164 and connection portion 167. As best shown in Figure 16, the conductive pads 164 having gold or solder plating layer 163. The pads 164 are arranged in corresponding positions to the connector contacts, such as in connector 110 shown in Figures 5-12, to receive the FC 160 and are staggered in the particular embodiment shown in Figure 13. Note that ground contact pads 174 are mixed in the rows of the conductive pads 164 as shown in Figure 13. The ground contact pads 174 are disposed at locations to engage with desired contacts in the connector. Also, the ground contact pads 174 are electrically connected to a

ground layer 176 to be described hereinafter by way of via holes 173 extending in the direction of the thickness of the FC. The connection portions 167 formed at the edge portions of the FC 160 are in a ring form to
5 be soldered to the contacts of a PC card connector and are formed with through-holes 169 as mentioned above.

The structure 182a also includes a plurality of recesses 184 which extend into the cover layer 185 and are formed by partly removing the cover layer 185 and
10 are arranged substantially in rows, as seen in Figure 18.

The FC 160 is preferably formed with openings or slots 186 extending therethrough and at substantially center position between the rows of the conductive pads
15 164. The openings 186 provide the FC 160 with relatively narrow bridge or belt-like portions 188 therebetween.

As best shown in Figures 14 through 16, the reverse structure 182b includes the ground layer 176 and
20 connection portions 178. The ground layer 176 includes a plate portion 175 and mesh portions 177. The plate portion 175 comprises an electrically conductive film of copper or the like extending in two dimension while the mesh portions 177 are formed by etching the electrically
25 conductive film in a slanted mesh as shown in Figure 14 through 15. Also, the ground layer 176 extends from the edges of the meshed portions 177 to the edges of the FC 160 for connection to the connection portions 178 which are substantially similar configuration as the above
30 mentioned connection portions 167. The connection portions 178 receive ground connection terminals of the PC card connector at the through-holes 179 extending to the surface 160a for making solder connections to
35 comprises first and second plastic strengthening plates 190, 196 made from glass-filled epoxy resin 183a or the like which are adhered on the surface 160b as shown in

Figure 14. The first strengthening plates 190 are positioned at both sides of the openings 186 as a pair and at the immediate reverse side of the conductive pads 164. Note that the first strengthening plates 190 include an edge 192 having projecting portions 191 which extend into the openings 186 when the first strengthening plates 190 are adhered. The edges 192 are parallel with the openings 186. As shown in Figures 14 and 15 the first strengthening plates 190 substantially cover the plate portion 175. Also, at least one of the pair of the first strengthening plates 190 is formed with engaging slots 194 or projections 191 to be preliminary retaining the FC 10 with a guide member 140 when it is inserted into the connector, as previously described with reference to Figure 11.

On the other hand, the second strengthening plate 196 is adhesively secured at the locations of the connection portions 167, 178 using adhesive material 183b such as a liquid solder resist. This makes it easy to solder the connector to the PC card connector. The second strengthening plate 196 has through-holes at location corresponding to the connection portions 167, 178.

Shown in Figure 17 is a cross-sectional view of the FC 160 according to the present invention as inserted into the connector 110 having a FC receiving slot 121. The FC 160 is folded at the bridge portions 188 with the conductive pads 164 facing outwardly.

A guide member or guide member 140 is used to insert the FC 160 into the FC receiving slot 121. As shown in Figure 18, the FC 160 is bent at a substantially right angle along the recesses 184 the reverse surface 160a near the edges 193 of the first strengthening plates 190. In the inserted portion the edges 193 of the first strengthening plates 190 abut against the bottom surface 123 of the FC receiving slot 121. This provides precise alignment of the conductive pads 164 with contact points

of contacts (not shown) in the connector 110, thereby assuring reliable interconnection therebetween.

It is to be understood that the FPC shown in Figures 1 through 4 may be modified to include the support
5 plates 190 and 193 as shown in Figure 18. The support of reinforcing plates 190 protects the inner surface of the FC.

While a plurality of exemplary embodiments of the electrical connector assembly according to the present
10 invention has been described herein, it is apparently not intended that this invention be limited to the embodiments. It will be appreciated by those skilled in the art that various modifications can be made for specific applications without departing from the scope
15 and spirit of the invention. For example, the recesses 184 may not be limited to the particular shape but may have a constricted portion along the outer periphery or may have wider portions. The strengthening plates 190 may not be limited to plastic material but may be
20 replaced by metal plates.

The electrical connector assembly according to the present invention, as appreciated from the above description, provides following various excellent advantages. It is suitable for an application where an
25 high density electrical connector such as an memory card connector having a plurality of contacts is interconnected to corresponding conductive areas on the printed circuit board. By using the flexible substrate the right angle contact legs can be eliminated, thus
30 enabling the high density contacts of the connector to be reliably and easily interconnected to the PC board conductive areas without having the problems associated with deformation of the contact legs.

A high density electrical connector is achieved,
35 since the conductive traces or the conductive pads formed at the middle portion of the FC are engaged with

a plurality of contacts, with a conventional FC connector is engaged thereto at one end of the FC.

5 The electrical connection between the conductive pads and the contacts are established by inserting the guide member into the FC bent in a generally U-shape. Since the guide member is forced between the rows of the contacts, which provide steady interconnection even for the FC having sufficiently large width. Further, if a conductive metal guide member is used for the FC having
10 ground conductor on the reverse side thereof to ground contact to ground conductive members at both ends of the housing, minimized and high density connector assembly for high frequency signals is obtained.

15 The flexible circuit according to the present invention assures highly reliable electrical connection while maintaining a relatively narrow pitch between contacts by folding it along the relatively narrow bridge portions and by the provision of the strengthening plates abutting against the housing for
20 accurate alignment or registration between the conductive pads and the contacts. Especially, the bridge portions are relatively narrow to permit smooth folding of the FC, thus avoiding undesirable force to be applied to the arrays of the conductors thereon.

25 Furthermore, the provision of the ground layer on the inner surface of the FC and the conductive patterns for transmitting signals on the outer surface effectively reduces crosstalk noise between the conductive patterns.

30 Additionally, the recesses formed by removing a part of layers near the bending positions of the FC permit bending of the FC at desired position and angle.

CLAIMS

1. An electrical connector comprising:
 - a housing having plural rows of contacts;
 - a flexible substrate connected to the contacts of
 - 5 the housing at both ends of the flexible substrate and
 - having a plurality of conductive traces thereon; and
 - a guide member adapted to be inserted into the
 - flexible substrate that has been bent into a U-shape,
 - and to cause the flexible substrate to be inserted in
 - 10 the mating contact rows to engage the conductive traces
 - with the contacts.
2. The electrical connector of claim 1 wherein said
- guide member is a conductive member adapted to further
- provide a connection to ground for the assembly.
- 15 3. An electrical connector assembly comprising:
 - a housing having two rows of contacts along an
 - elongate opening;
 - a flexible substrate formed with a plurality of
 - conductive traces thereon corresponding to the contacts;
 - 20 and
 - a guide member having a generally flat portion to
 - be inserted in a U-shaped bent portion of the flexible
 - substrate, and to be inserted, with the substrate,
 - between the contact rows of the housing to establish
 - 25 electrical engagement between the contacts and the
 - conductive traces;
 - whereby both ends of the flexible substrate are
 - connected to contacts of a corresponding connector.
4. The electrical connector of claim 3 wherein said
- 30 guide member is a conductive member adapted to further
- provide a connection to ground for the assembly.
5. An electrical connector assembly comprising:
 - a housing having a plurality of contacts disposed
 - along an elongate opening and having ground conductive
 - 35 member at both ends of the housing;
 - a flexible substrate having a width corresponding
 - to the opening of the housing, and having conductive



traces corresponding to the contacts on one surface thereof and formed with ground conductor on the other surface; and

5 a conductive guide member having a plate portion to be disposed in a flexible substrate bent in a generally U-shape with the one surface outside, and to be inserted into the opening of the housing;

whereby the contacts and the conductive traces are electrically connected by the guide member and the
10 ground conductor is connected to the ground conductive member by the guide member.

4. A flexible circuit including a plurality of conductive pads and conductive traces formed on one surface of a flexible substrate, the flexible circuit
15 being characterized in that:

said plurality of conductive pads and traces are disposed in two arrays in opposed relationship;

a plurality of openings are formed between the arrays of said conductive pads to define relatively
20 narrow bridge portions; and

strengthening plates are disposed on the other surface of said flexible substrate at the locations corresponding to said conductive pads with parts of said strengthening plates extending into said openings by
25 predetermined length.

5. A flexible circuit comprising:

a flexible film having conductive arrays of conductive traces and conductive pads formed on one surface thereof, a ground layer disposed on the other
30 surface of said flexible film, and cover layers disposed to cover both of said conductive arrays and said ground layer; wherein a plurality of openings are formed substantially in a line on said cover layer covering said conductive arrays but at locations where said
35 conductive traces and conductive pads are not formed.



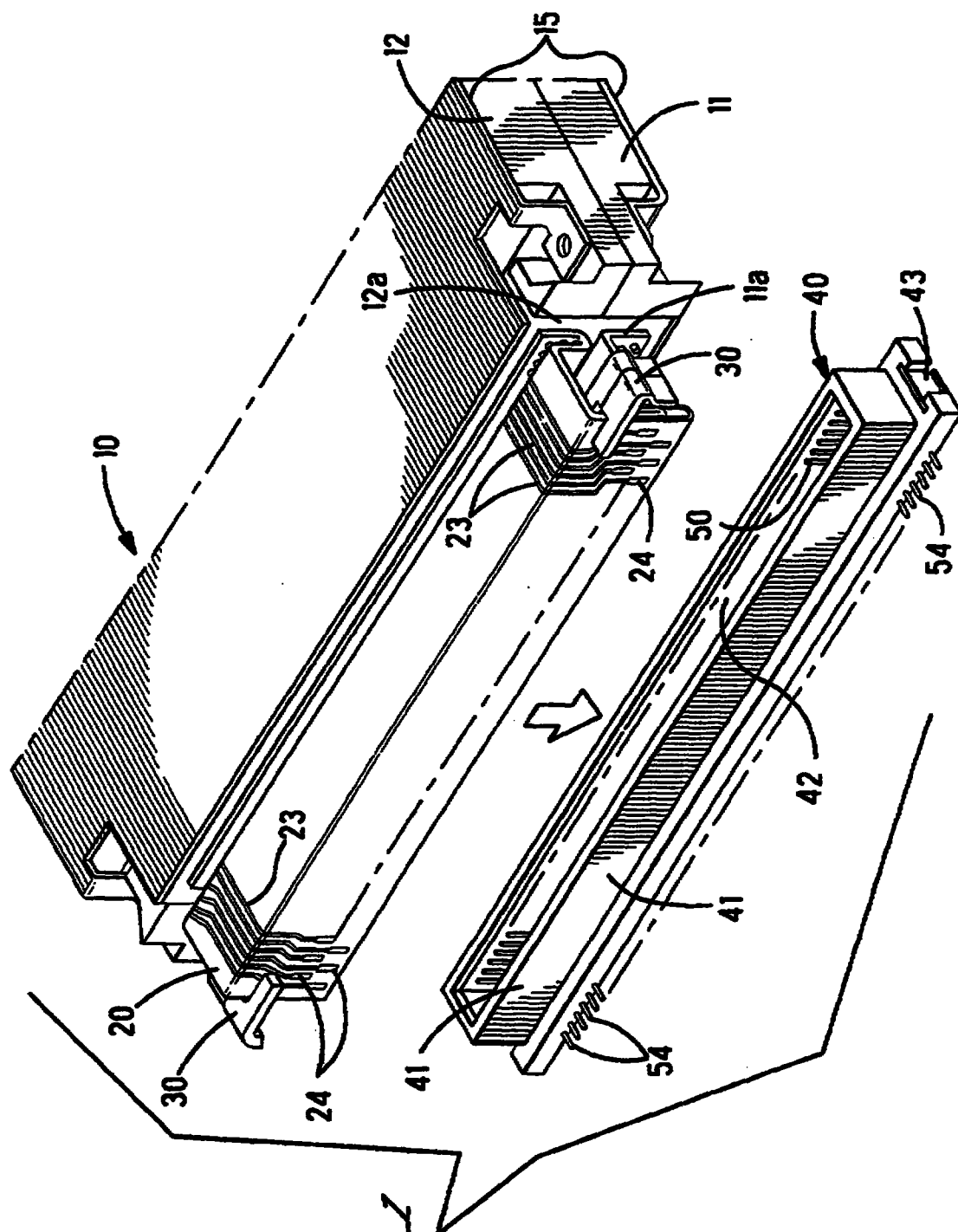
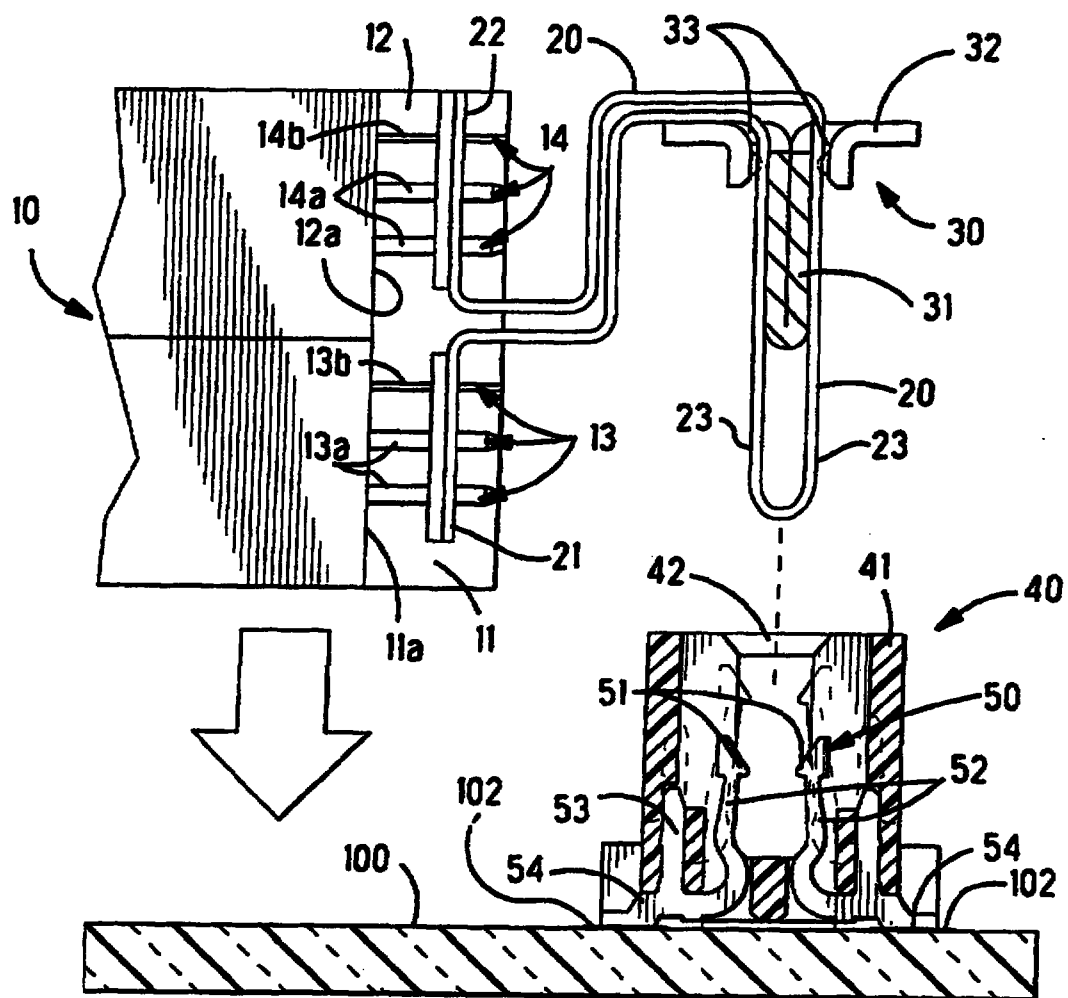


Fig. 1

*Fig. 2A*

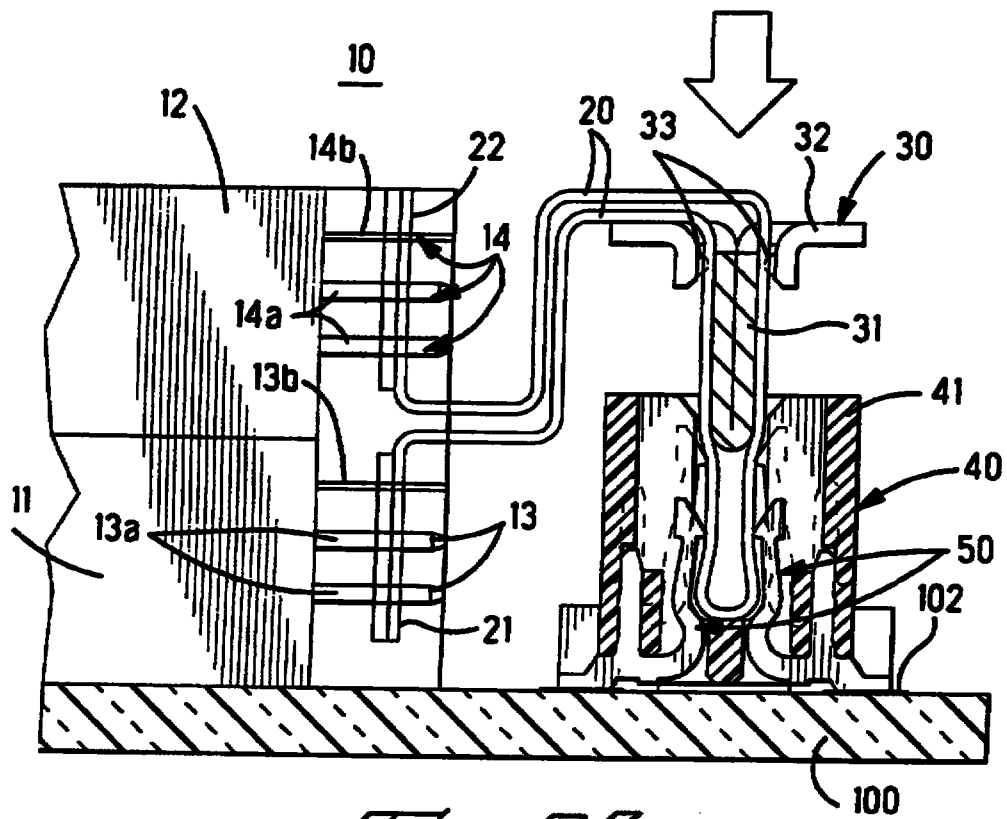


Fig. 2B

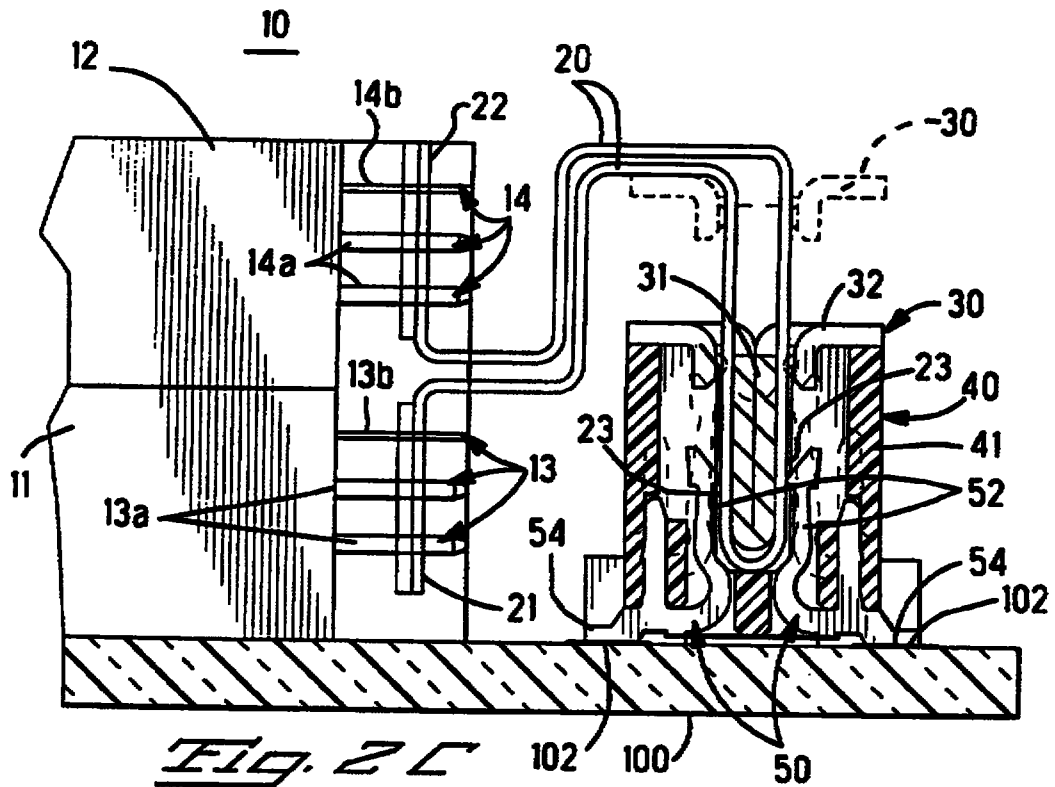
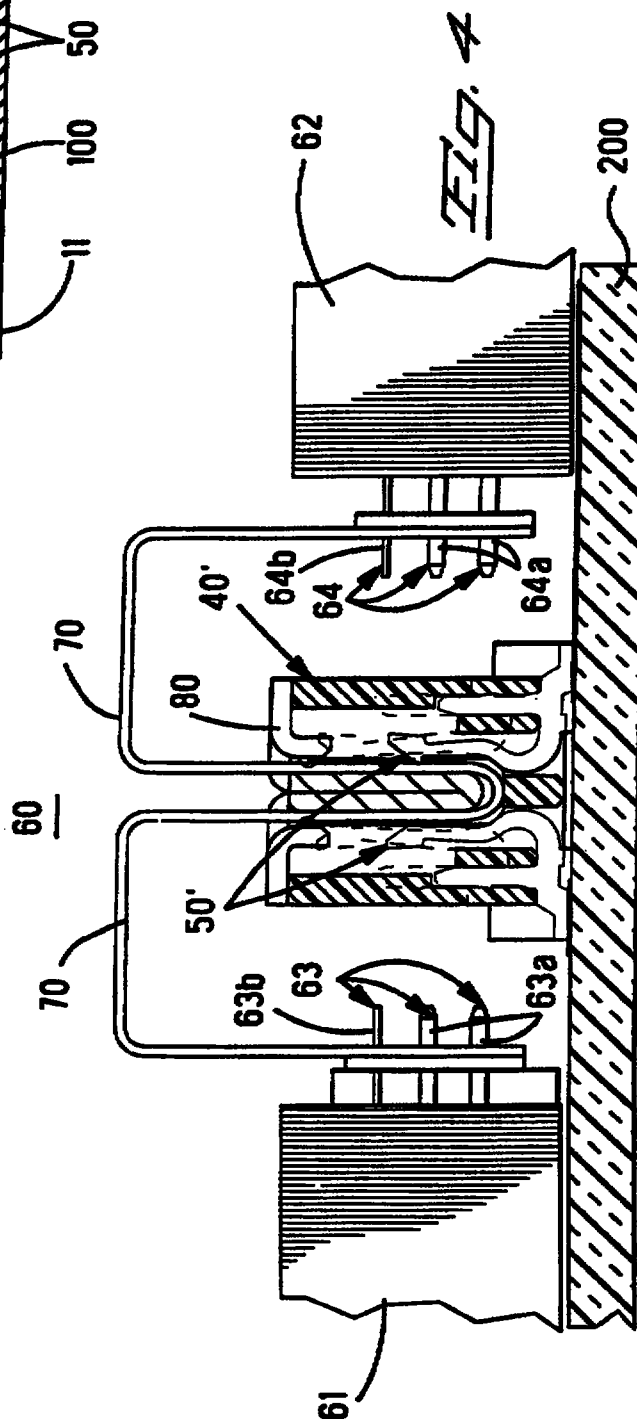
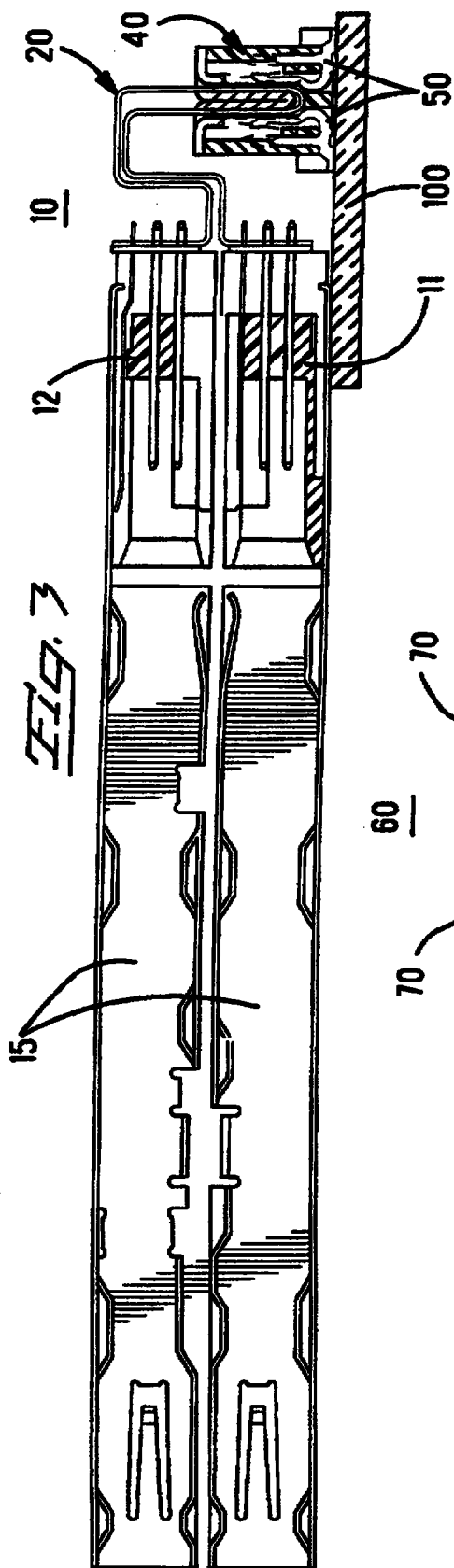
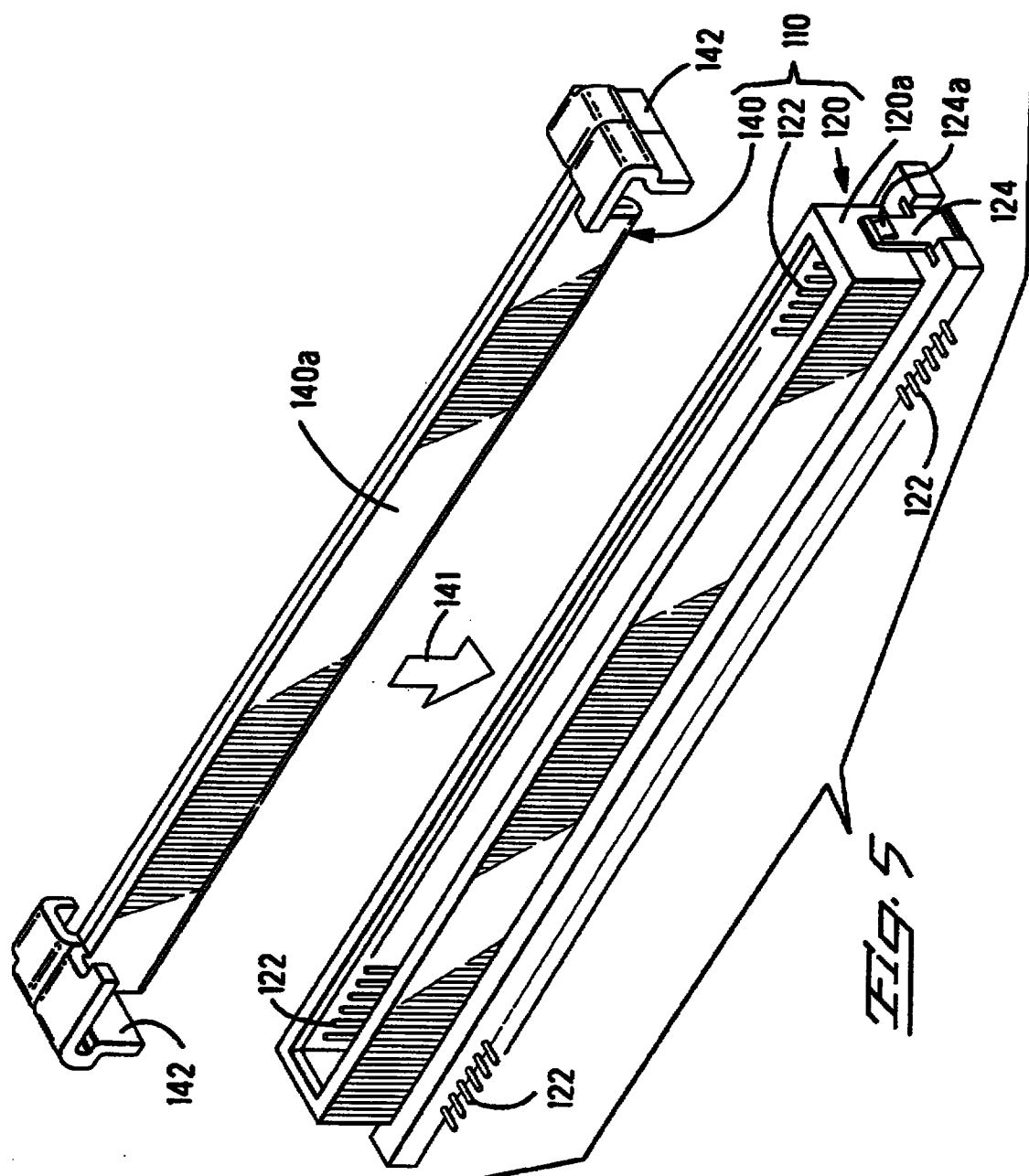
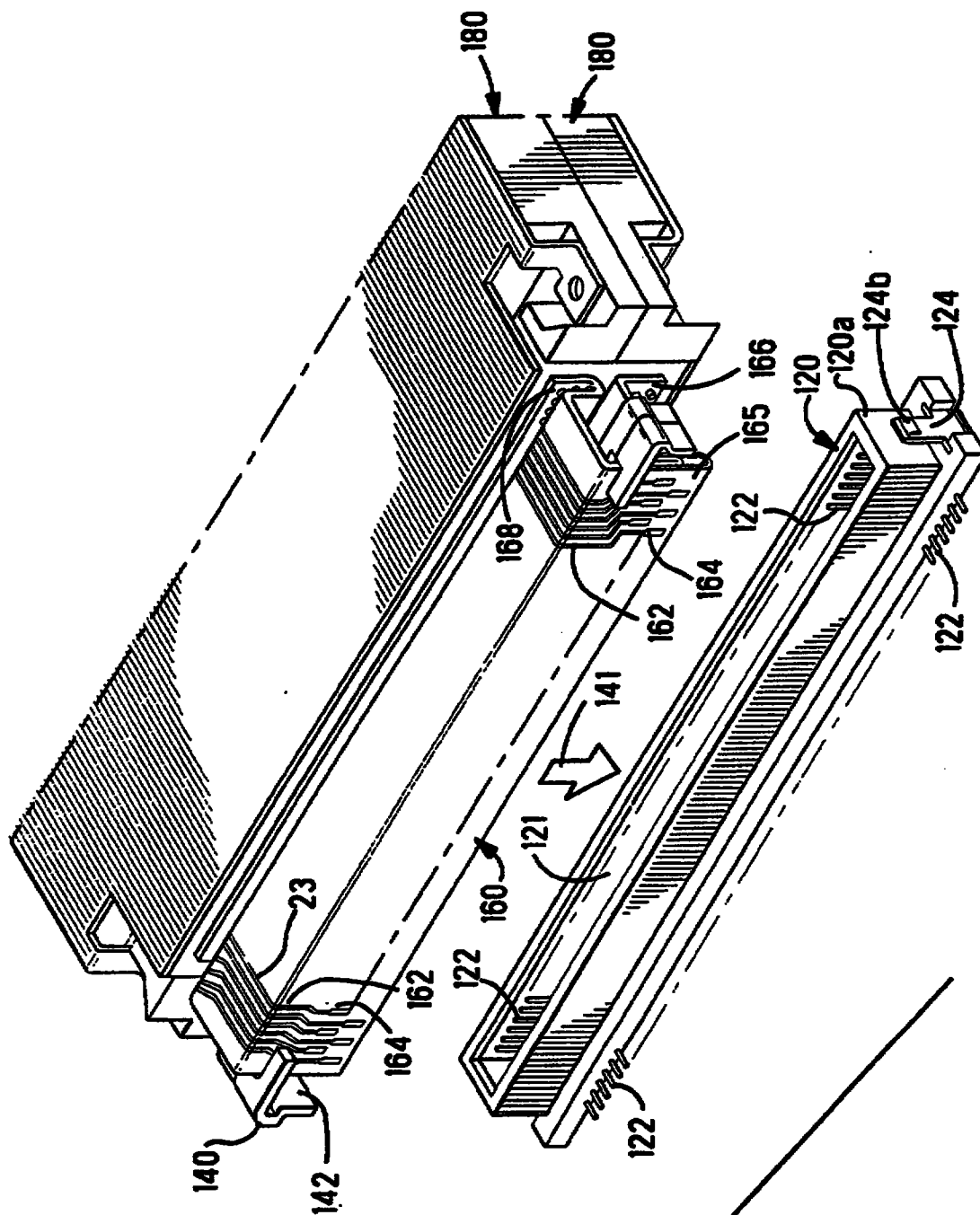
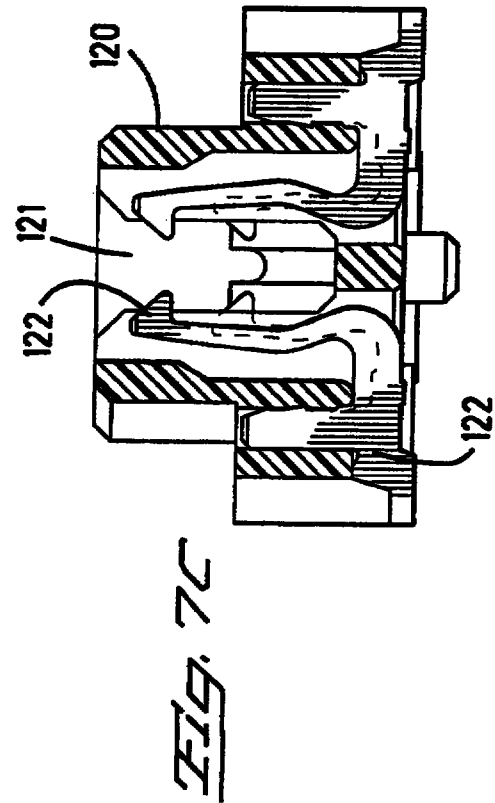
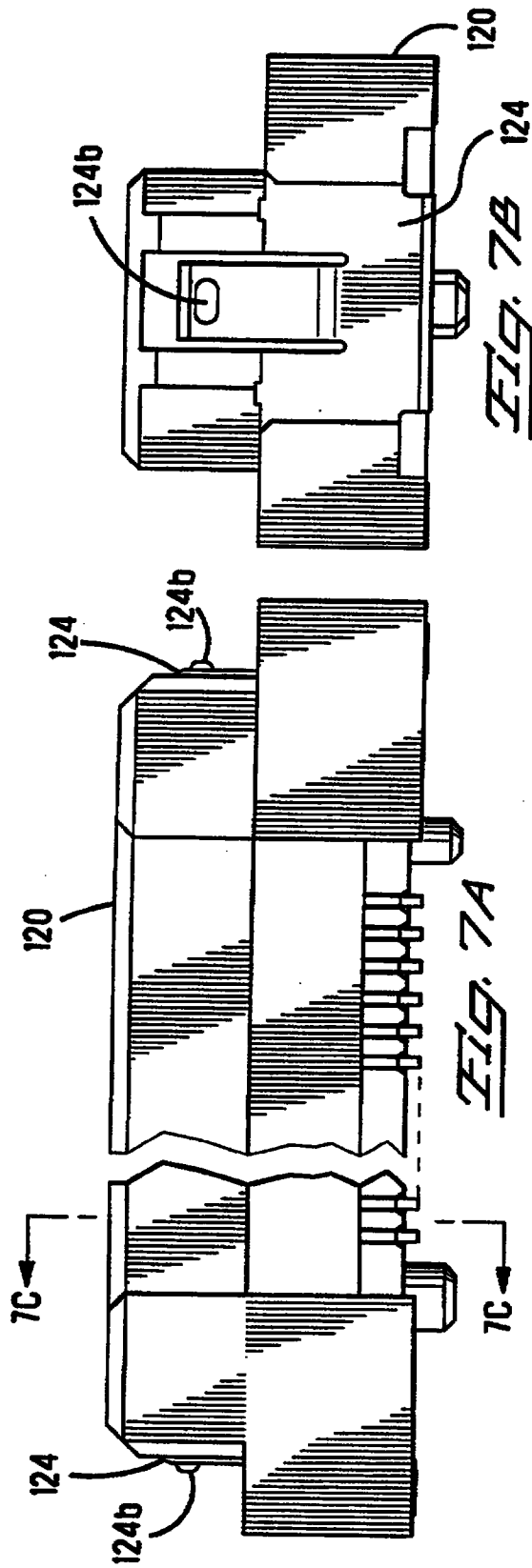


Fig. 2C





**FIG. 6**



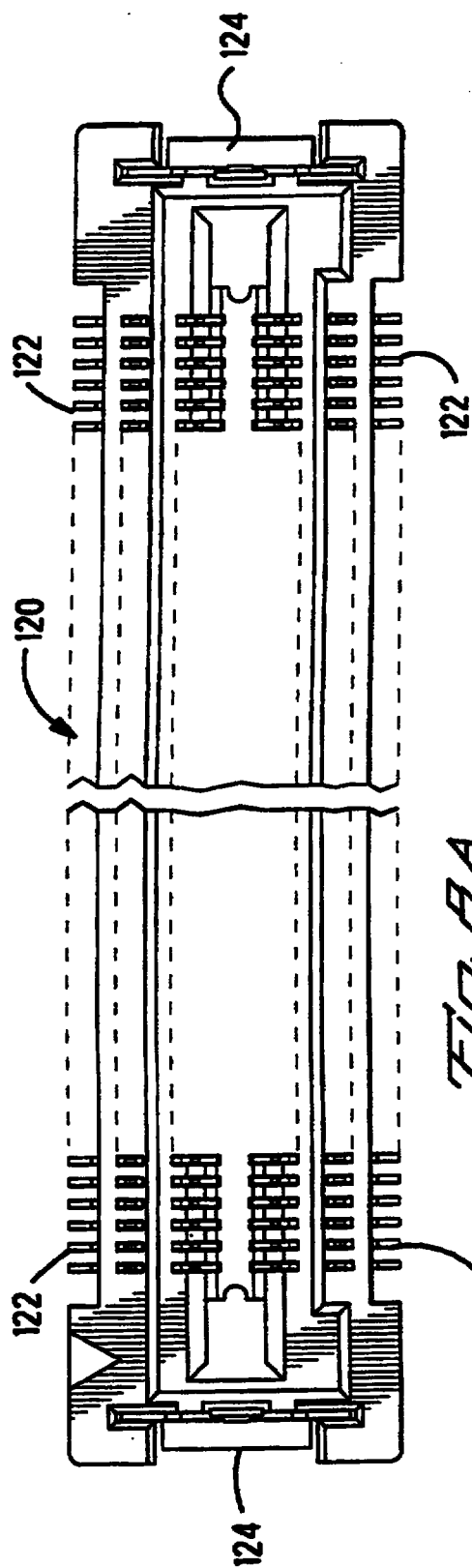


FIG. 8A

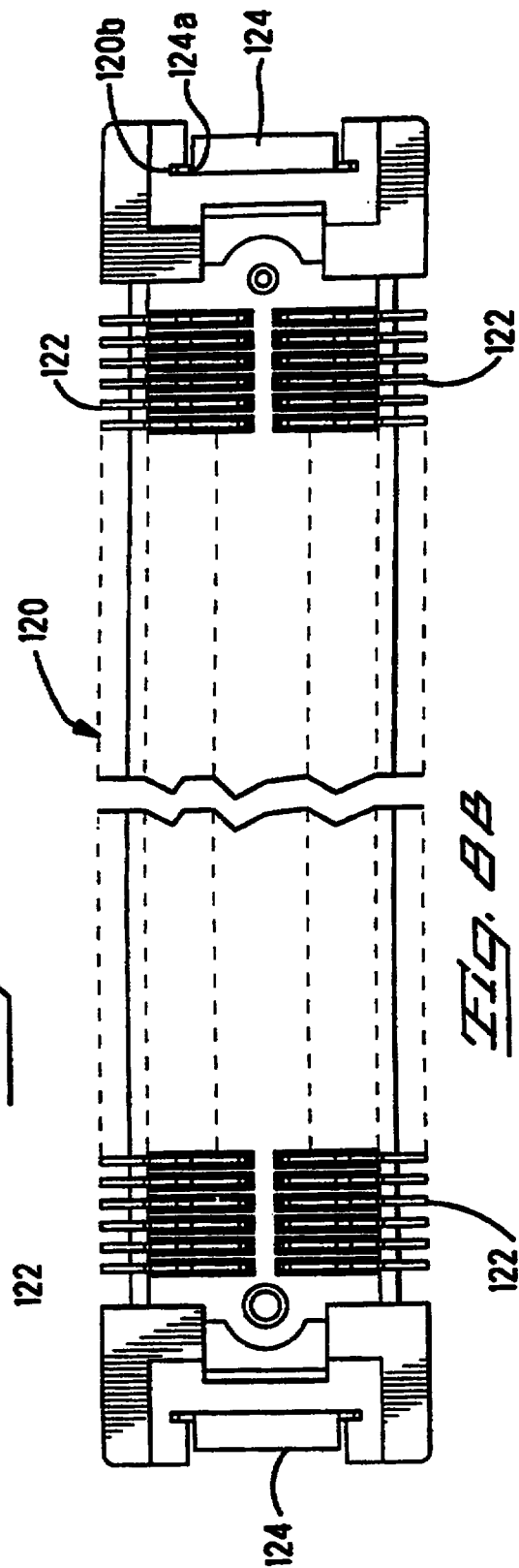
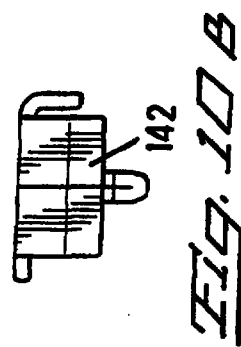
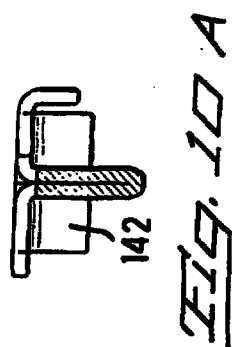
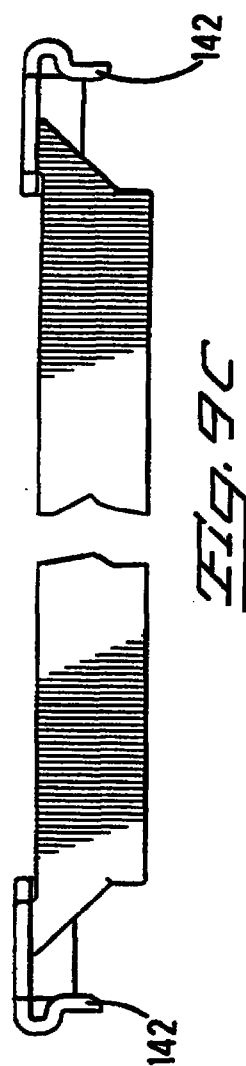
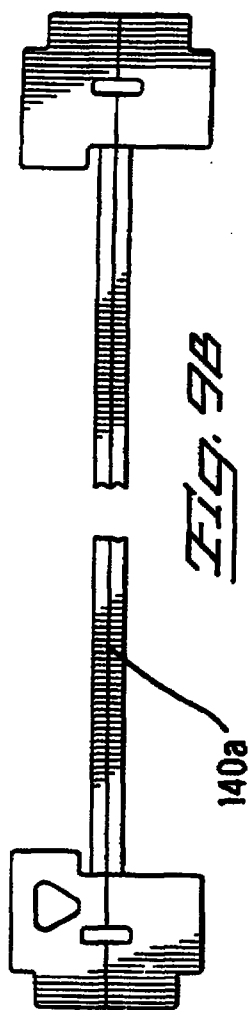
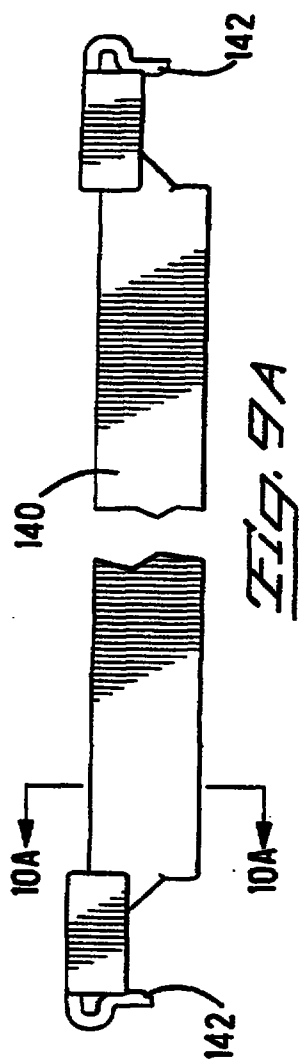
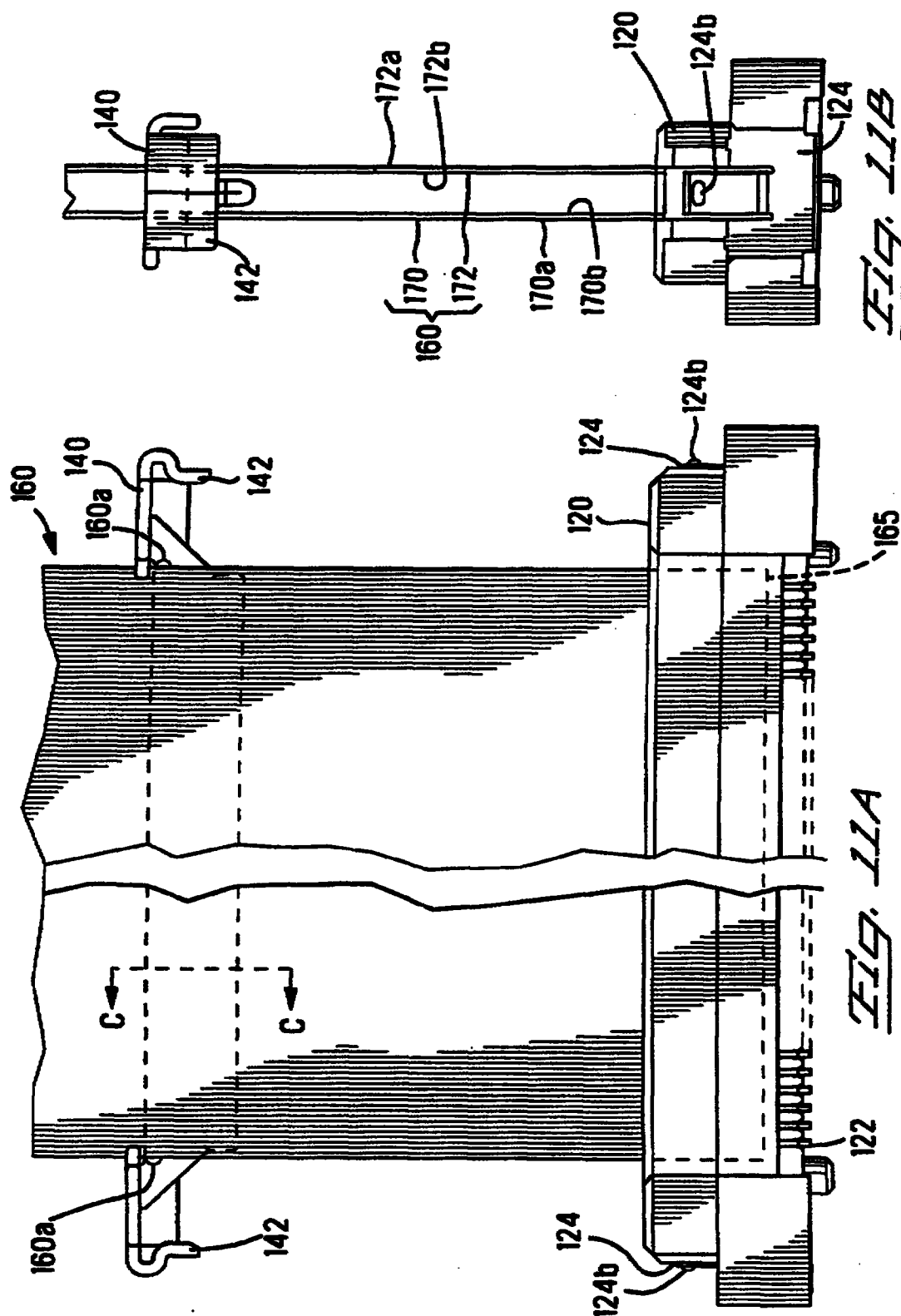
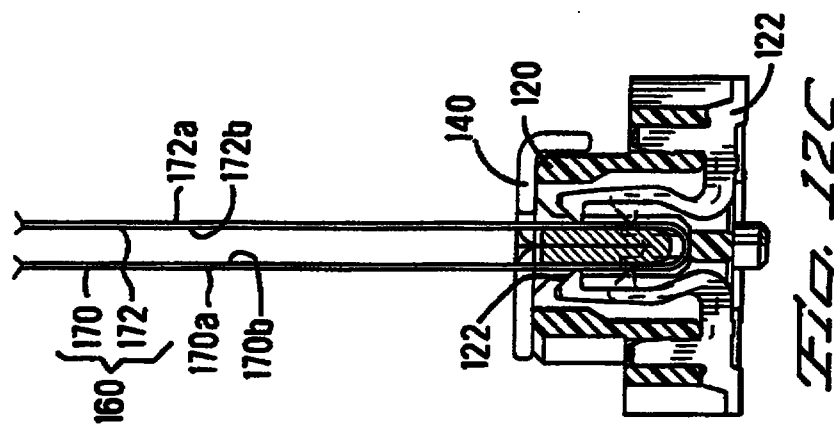
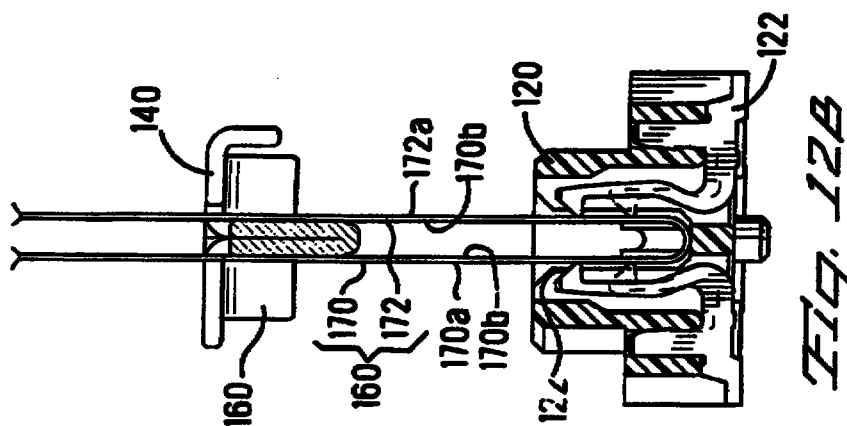
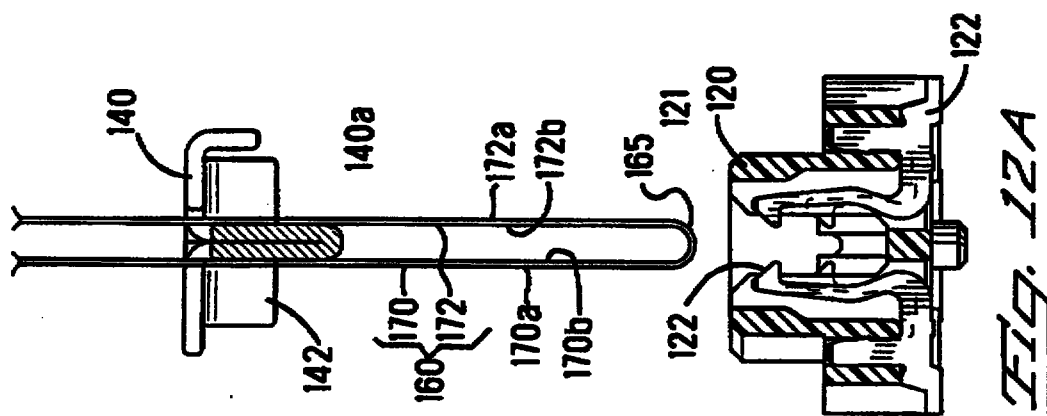


FIG. 8B







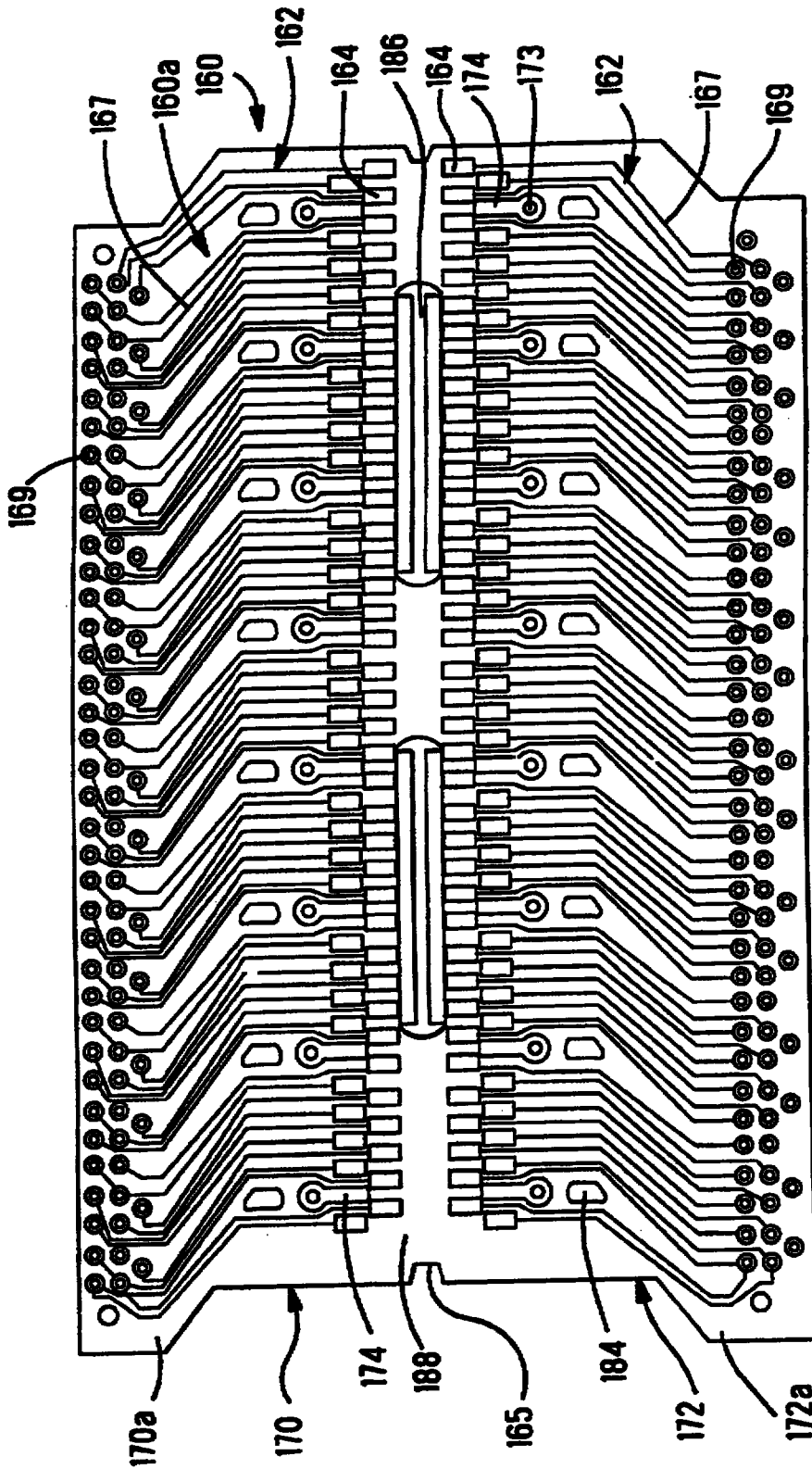


FIG. 13

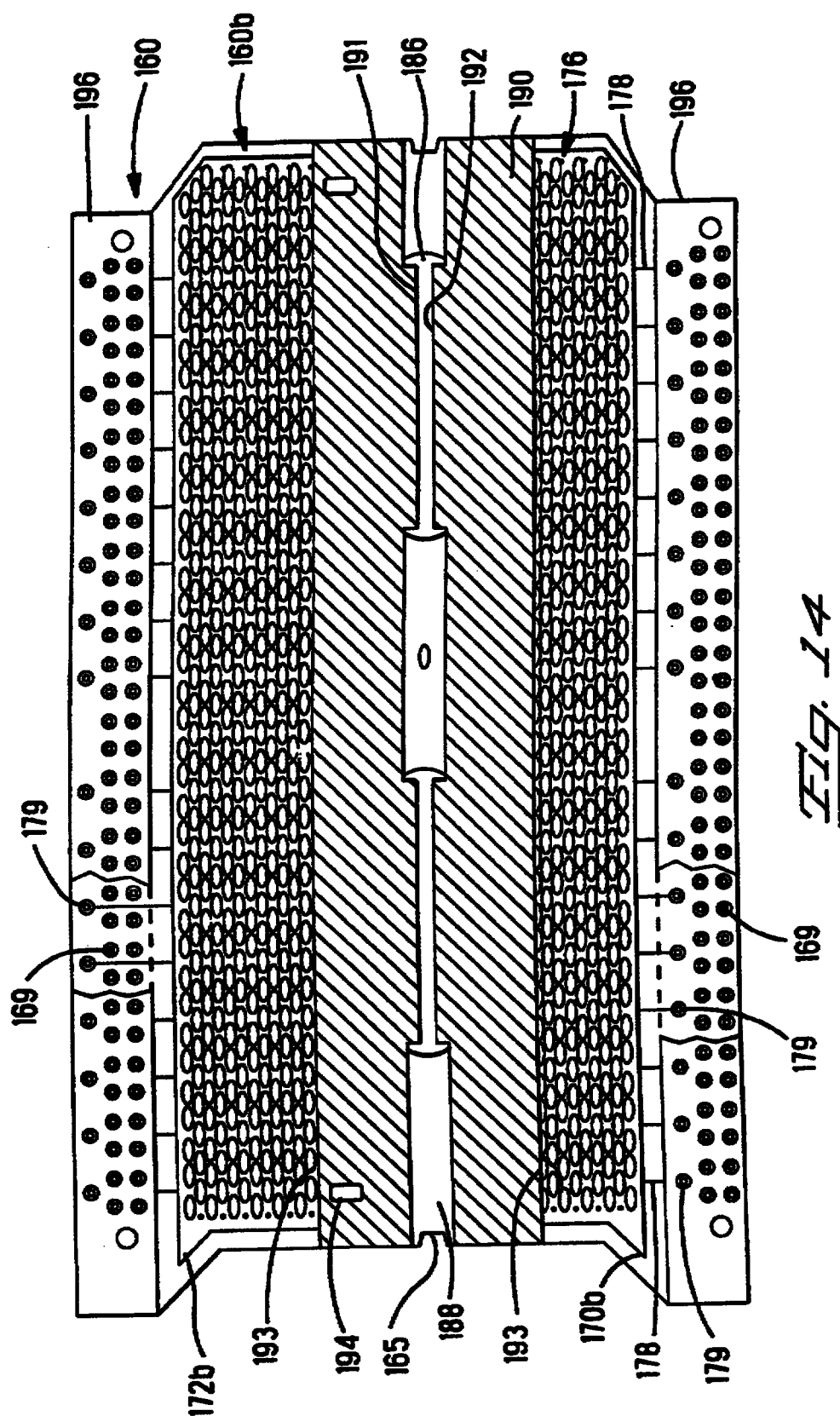


FIG. 14

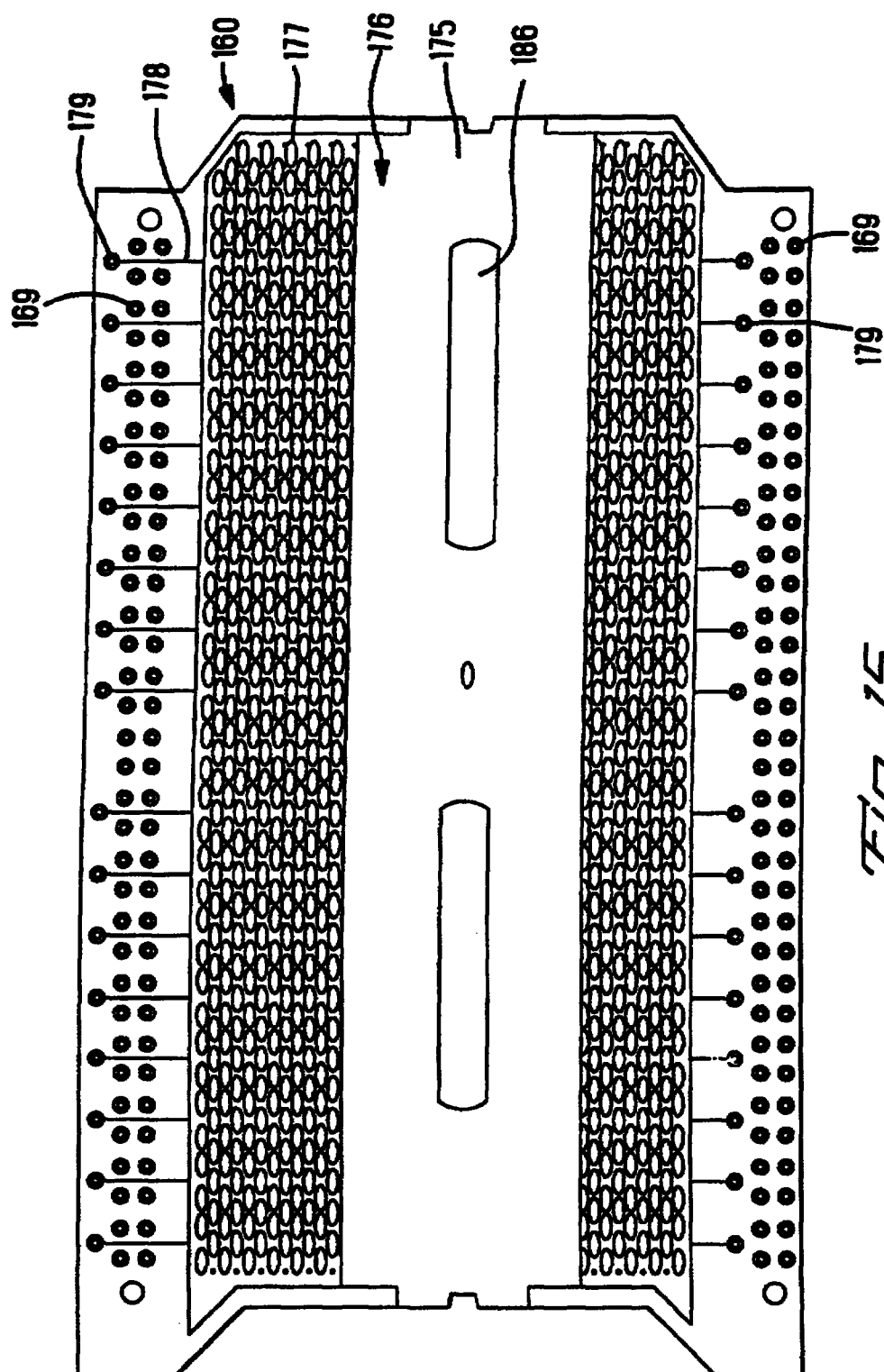


Fig. 15

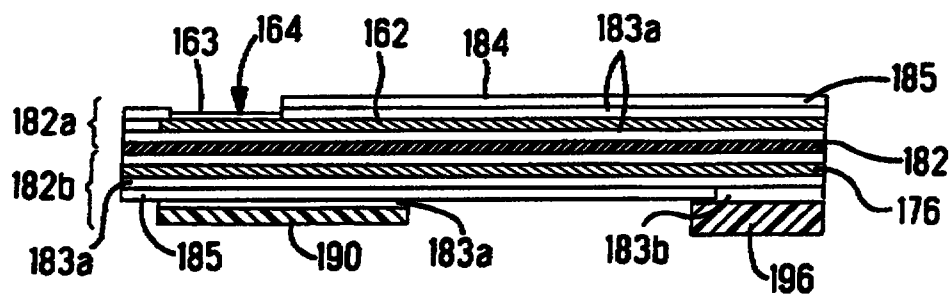


Fig. 16

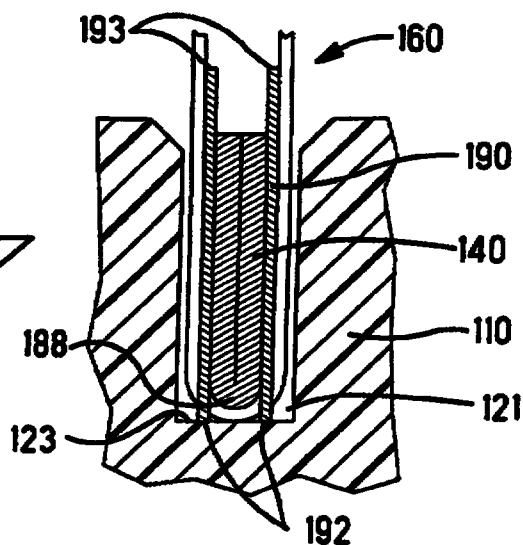


Fig. 17

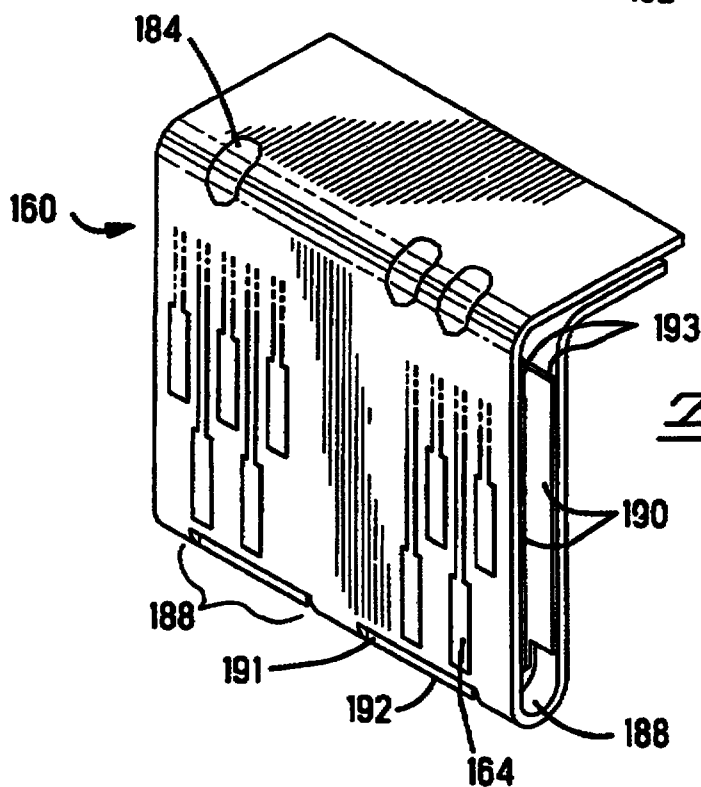


Fig. 18

ELECTRICAL CONNECTOR ASSEMBLY

The present invention relates to an electrical connector, more specifically to a high density electrical connector such as a PC card connector that uses a flexible circuit for interconnecting the contact of the PC connector to another connector mounted on a circuit board.

Advances in electronic devices including microprocessors have created a large market for compact electronic apparatus using memory or PC cards, hard disk drives (HDDs), etc. A docking connector or a memory card connector is used in such electronic apparatus. The docking connector is used to interconnect another similar electronic apparatus for creating a network and also to connect peripheral equipment such as a submemory apparatus. A memory card connector receives one or more memory card or an HDD for electrical connection thereto.

Recently, needs have arisen for card type devices known as PC cards for expansion or additional performance of compact electronic equipment such as notebook personal computers. Such PC cards are normally received in a PC card connector installed in a compact electronic equipment to provide added memory capacity or interfacing with external devices such as peripheral equipment. Typically, PC card connectors have dual stacked connector mating portions to permit reception of three types of PC cards, i.e., Type I, Type II and Type III.

These docking connectors and PC or memory card connectors include a plurality of contacts often more than one hundred disposed in a matrix having a plurality of rows. Such contacts are bent at right angles or in an L-shape with respect to the connector and are soldered to respective conductive paths or traces on a main PC board. One example of such memory card connector is disclosed in US Patent No. 5,324,204. In

this particular example, four rows of contacts are bent in a staggered relationship to be connected to the main PC board in eight rows.

Typical examples of such connectors also are disclosed in Japanese Patent Publication No. 6-332573 and Japanese UM Publication No. 6-56992. The former connector has contacts aligned in a connector housing and bent at substantially right angles at the rear position to be connected to a main circuit board. In the latter connector, contacts of dual stacked connectors extend at their rear positions toward each other, i.e., toward the center position to be connected to an auxiliary circuit board at the center position, thereby interconnecting the auxiliary and main circuit boards by the board-to-board connector.

Unfortunately, as electronic equipment becomes more compact, a higher density of contacts is required. The individual contacts, therefore, have smaller dimensions and pitch, which makes it difficult to form reliable connections with a main circuit board using a connector having relatively long solder tines of the contacts of the former connector. Although the latter connector is effective to realize relatively fine pitch connections, the connector requires a larger number of components, thus making it more difficult to manufacture and more expensive.

Moreover, a standard to form signal and ground (SG) of PC card connectors has been added recently. One object is to isolate signals to be transmitted through one connector from those transmitted through another connector, thereby preventing noise due to cross talk. Unfortunately, however, such noise protection is not always sufficient in conventional connectors.

Additionally, in the above conventional connectors, the connection or mounting location of the connector or its contacts on a main circuit board is required to be predetermined, thereby restricting the design of the

main circuit board and precise manufacture of conductive through hole patterns, etc. with small tolerances. It is, therefore, desirable to provide flexibility in connection or mounting.

5 Using a flexible circuit (FC) for interconnecting circuits on a substrate such as a small-size printed circuit board (PCB) and high-density-mounted electronic equipment is known in the art. Such an electrical connector for an FC generally comprises a plurality of
10 contacts to be engaged with conductive pads formed on the FC, a housing for disposing and holding the contacts, and a movable plastic cover or other member for pushing the FC into the housing and the conductive pads formed thereon into positive engagement with the
15 contacts in the housing. Examples of conventional electrical connectors for FC are disclosed in a Japanese Patent Publication No. 61-131382, a Japanese UM Publication No. 2-120780, and a Japanese Patent Publication No. 5-251140.

20 U.S. Patent No. 3,923,364 discloses an electrical connector assembly including a housing having a plurality of contacts disposed along an elongate opening; a shielded flexible substrate having a width corresponding to the opening of the housing and
25 conductive signal traces and pads and ground conductive pads on one surface thereof corresponding to the contacts in the housing; and a guide member having a plate portion to be disposed in a flexible substrate bent in a generally U-shape with the one surface outside
30 to be inserted into the opening of the housing whereby, upon inserting the guide member and substrate into the housing opening, the signal and ground pads on the one surface of the substrate are electrically engaged to corresponding contacts in the housing.

35 As electronic equipment becomes smaller with a higher density of contacts, e.g., the pitch of the contacts is less than 0.5mm, the dimensions of the

contacts to be used therein will also become smaller and, therefore, be more easy to deform. It is very difficult to accurately position the contacts, especially their solder-terminating portions, in the
5 desired location and to maintain them so as not to deform the contacts upon handling and mounting the connector on to the substrate.

Also, for the electrical connector utilizing the FC, it is difficult to precisely and firmly urge the movable
10 plastic cover to engage over the full width of the FC with the plurality of contacts without having some deformation over the full width of the FC. Accordingly, reliability of connection between the conductive pads and the contacts has been decreased.

15 Therefore, an object of this invention is to provide a small and high density electrical connector assembly, that utilizes the FC and enables simple structure and easy handling.

It is another object of this invention to provide an
20 electrical connector assembly having a ground function and permitting easy handling in which the plurality of the conductive pads on the FC and the contacts in the housing are interconnected with high reliability.

It is yet another object of this invention to
25 provide an electrical connector assembly for card bus, which enables one or more memory card connector etc. to connect easily and reliably to the FC board.

In order to solve the problems of the prior art electrical connector assembly and to achieve the above
30 mentioned objects, the electrical connector assembly of the present invention comprises a housing having plural rows of contacts, a flexible printed circuit board (FC) to be connected to the contacts of the housing at both ends of the flexible printed circuit board, said printed
35 circuit board having a plurality of conductive traces and pads, and a guide member to be inserted in the FC, the guide member being bent in a generally U-shape to



force the FC between rows of contacts of a corresponding connector to interconnect the conductive traces and contacts.

5 In accordance with one aspect of the present invention, the electrical connector assembly includes a housing having a plurality of contacts disposed along an elongate opening; a flexible substrate having a width corresponding to the opening of the housing and conductive traces on one surface thereof corresponding to the contacts in the housing; and a guide member having a plate portion to be disposed in a flexible substrate bent in a generally U-shape with the one surface outside to be inserted into the opening of the housing. The connector assembly is characterized in that: the housing includes a ground conductive member at at least one end thereof; the flexible substrate is formed with a ground conductor on the other surface thereof; and the guide member is a conductive member adapted to further provide a connection to ground for the assembly whereby the contacts and the conductive traces are electrically connected by the force exerted by the guide member on the flexible substrate and the ground conductor of the substrate is connected to the ground conductive member of the housing by the guide member.

In the preferred embodiment, the assembly further includes strengthening plates disposed on the other surface thereof at the locations corresponding to the conductive pads.

30 One aspect of the present invention is an FC having two arrays of corresponding conductive pads and conductive traces on one surface with the plurality of conductive pads of the arrays arranged in rows in an opposed relationship. A plurality of openings are
35 disposed between the arrays leaving narrow bridge portions between adjacent openings. Strengthening plates are attached to the reversed surface at the



positions corresponding to the conductive pads with portions of the strengthening plates extending into the openings by a predetermined length.

Also, another aspect of the present invention is a
5 flexible circuit (FC) comprising conductive traces on one surface of a central film, a ground layer on the reverse surface, and cover layers disposed to cover the conductive traces and the ground layer. A plurality of
10 openings are formed in the cover layers substantially in rows at selected locations that avoid the conductive traces.

The FC according to the present invention has openings in the direction of the width at substantially center position between the rows of the conductive pads.
15 The openings define the relatively narrow bridge portions of the FC. The FC has a pair of strengthening plates adhered to both sides of the openings and at least one surface of the FC. The pair of strengthening plates have edges extending into the openings by a
20 desired length from both sides thereof.

Additionally, the FC according to the present invention has a plurality of recesses arranged substantially in rows near the bent portion. The recesses are preferably formed by removing a part of one
25 layer of a multiple-layer FC, thereby allowing the FC to bend smoothly at a desired position.

The FC is bent or folded along the bridge portions before being inserted into a connector along with a guide member, and upon full insertion of the board and
30 guide member, the conductive pads of the FC are electrically connected with contacts in the connector. The edge portions of the strengthening plates then abut the bottom in the housing for proper positioning of the FC in the connector, thereby assuring reliable
35 electrical connection between the conductive pads and the contacts. Also, it is bent at a desired angle, preferably a right angle along the recesses, thereby



5 permitting connection to a connector such as the PC card
connector or other device at the edge portion. Since
the electrical connector assembly comprises a FC with no
individual contacts bent at right angle with respect to
a wall or L-shape as seen in the prior art electrical
connector assembly, the connector of the present
invention eliminates deformation of the guide between
the contacts and disengagement and short circuit caused
therebetween. Accordingly, stable electrical
10 connections and easy handling are achieved. Also, the
structure having the FC connected to the contacts on the
housing at the both ends thereof enables high density.

According to another aspect of the present
invention, the electrical connector comprises a housing
15 having two rows of contacts along an elongate opening, a
flexible printed circuit board having a plurality of
conductive traces on a surface corresponding to these
contacts, and a guide member having a generally planer
portion to be inserted into a U-shaped bent portion of
20 the flexible printed circuit board, wherein the
conductive traces on the flexible printed circuit board
are forced between the rows of the contacts by means of
the guide member for establishing electrical
interconnection between the conductive traces and the
25 contacts in the housing, thus electrically connecting
the contacts with corresponding contacts of at least one
electrical connector terminated to the ends of the FC.

According to the electrical connector assembly, it
is possible to connect the high frequency signals to the
30 contacts through the conductive traces on the surface of
the FC. The FC is bent in a U-shape to envelope the
guide such that the guide electrically engages the
ground conductor of the FC board and upon inserting the
FC into the housing, the guide electrically engages the
35 ground conductive members of the housing. Since all the
conductive traces formed on the one surface of the FC

can be signal traces, a high density and high frequency electrical connector is obtained.

5 The present invention will now be described by way of example with reference to the preferred embodiment in conjunction with the accompanying drawings.

FIGURE 1 is an isometric view of an electrical connector assembly according to a preferred embodiment of the present invention.

10 FIGURE 2A is a side view of the electrical connector assembly shown in Figure 1 prior to mating with the corresponding connector.

FIGURE 2B is a side view of the electrical connector assembly shown in Figure 1 at a starting time for mating with the corresponding connector.

15 FIGURE 2C is a side view of the electrical connector assembly fully coupled with the corresponding connector.

FIGURE 3 is a cross-sectional side view where the electrical connector assembly according to the present invention is adapted to a stacked memory card connector.

20 FIGURE 4 is a partial model view of another embodiment of the electrical connector assembly according to the present invention.

FIGURE 5 is an isometric view of the electrical connector assembly of another embodiment according to the present invention.

25 FIGURE 6 is an isometric view showing a situation where the guide member in the electrical connector assembly shown in Figure 5 is mounted in a flexible printed circuit board connected to the memory card connector.

30 FIGURE 7A shows a front view of the housing of the electrical connector assembly of Figure 5.

FIGURE 7B shows a side view of the housing of the electrical connector assembly of Figure 5.

35 FIGURE 7C shows a cross-sectional view taken along the line 7C-7C of Figure 7A.

FIGURE 8A is a plan view of the housing of Figure 7A.

FIGURE 8B is a bottom view of the housing of Figure 7A.

5 FIGURE 9A is a front view of a guide member of the electrical connector assembly shown in Figure 5.

FIGURE 9B is a plan view of a guide member of the electrical connector assembly shown in Figure 5.

10 FIGURE 9C is a rear view of a guide member of the electrical connector assembly shown in Figure 5.

FIGURE 10A is a cross-sectional view of the guide member of Figure 9 taken along the line 10A-10A of Figure 9A.

15 FIGURE 10B is an end view of the guide member of Figure 9A-C.

FIGURE 11A is a front view of a flexible circuit inserted in an electrical connector assembly.

20 FIGURE 11B is a side view of the flexible circuit inserted in the electrical connector assembly of Figure 11A.

FIGURE 12A is a cross-sectional view showing a guide member of the electrical connector assembly disposed between the U-shaped flexible circuit prior to inserting the flexible circuit into a connector housing.

25 FIGURE 12B is a cross-sectional view showing a guide member of the electrical connector assembly disposed between the U-shaped flexible circuit with the U-shaped end of the flexible printed circuit board inserted into the connector housing.

30 FIGURE 12B is a cross-sectional view showing the flexible circuit secured by the guide member in the connector housing.

FIGURE 13 is a plan view at one surface of the FC according to the present invention.

35 FIGURE 14 is a bottom view of the reverse surface of the FC in Figure 13.

FIGURE 15 is a view similar to Figure 14 prior to adhering the strengthening plates.

FIGURE 16 is a magnified cross-sectional view of the FC in Figure 1.

5 FIGURE 17 is a simplified cross-sectional view of the FC in Figure 1 as inserted into a connector.

FIGURE 18 is an isometric view of the FC in Figure 13 showing how it is folded or bent when inserted into a connector.

10 Figure 1 is an isometric view showing a major part of an embodiment of the present invention adapted to an electrical connector assembly, such as a memory card connector 10. Figures 2A through 2C show a process for inserting and connecting the memory card connector 10 of
15 Figure 1 to a mating connector 40 disposed on and connected to a main substrate 100. That is, Figure 2A shows a situation where the memory card connector 10 and the mating connector 40 are separated from each other. Figure 2B shows the memory card connector 10 partially
20 inserted in the mating connector 40. Figure 2C shows the memory card connector 10 fully mated with the mating connector 40.

As appreciated from Figures 1 and 2, the memory card connector 10 of the specific embodiment comprises two
25 stacked connector housings 11,12. Plural rows of contacts 13,14 project from wall surfaces 11a,12a of these housings 11,12. In these Figures, the plurality of contacts 13,14 are two rows of signal contacts 13a,14a and one row of ground contacts 13b,14b. As
30 appreciated from the above mentioned U.S. Patent No. 5,324,204, these housings 11,12 comprise, at front surfaces thereof, a memory card, or a plastic or a metallic plate holder for receiving the HDD (not shown in the Figures 1, and 2), respectively.

35 An FC 20 having sufficient length is connected to each contact 13,14 of the connector housings 11,12 at both ends 21,22 of the conductive traces of the FC 20 by

means of solder etc. to conventional pads with through holes to form a card bus. A plurality of conductive traces 23 having contact pads 24 are formed on an outer surface of the FC 20.

5 A guide member 30 is inserted into a middle portion of the FC 20 to bend it in a U-shape. The guide member 30 is preferably formed by stamping and bending a conductive metal plate in a traditional manner. As best
10 seen in Figure 2A-2C, the guide member 30 has an insertion portion 31 formed by folding the metal plate to be inserted between rows of contacts 50 of a mating connector 40 as hereinafter explained, and an actuation
15 portion 32 generally perpendicular to the insertion portion and having a generally planar surface. The actuation portion 32 is provided with a slot 33, having a width corresponding to the FC 20, for receiving side edges thereof. The FC 20 is inserted in the slot 33 with a generally U-shape along an outer surface of the
20 insertion portion 31.

20 The receptacle type mating connector 40 has an elongate box-shaped housing 41 to be mounted on the main substrate 100. The housing 41 has an opening 42 at an upper surface thereof, and has a plurality of surface
25 mounted type (SMT) contacts 50 disposed and secured at both sides of the opening 42. The housing 41 has metal mounting fixtures 43 at both ends in the longitudinal direction of the housing 41, and preferably the
connector housing 41 is soldered and secured on a conductive layer (not shown) on the main substrate 100.

30 Each of the contacts 50 of the connector 40 includes a resilient contact beam 52 having a contact surface 51 near the front end thereof, a mounting portion 53 to be inserted and secured in a contact receiving opening of
35 the housing 41, and a connecting portion 54 to be surface mounted to conductive pads 102 on the main substrate 100. Preferably, a length of the resilient contact beam 52 is selected in various different

lengths, and disposed in staggered relationship to achieve high density disposition. As seen from Figures 2A, the contact surface 51 of each contact 50 projects into the opening 42 of the housing 41.

5 In a condition in which the memory card connector 10 is not mated or connected to the corresponding connector 40, that is, in the situation shown in Figure 2A, the contact pad portion of the FC 20 is bent in a generally U-shape. Accordingly, as shown in Figure 2B, the U-
10 shaped FC 20 can be easily inserted into the housing 41 with low insertion force and essentially without engaging the contacts 50. Finally, as shown in Figure 2C, when the insertion portion 31 of the guide member 30 is inserted into the opening 42 of the corresponding
15 connector 40 the U-shaped portion of the FC 20 formed with contact pads 24 is forced outwardly from inside to urge and expand outwardly the contact beams 52 of the contacts 50. Therefore, the contact pads 24 of the FC
20 of the conductive traces 23 are forced and engaged with the contact surfaces 51 of the contacts 50, thereby interconnecting the contacts 13,14 of the memory card conductor 10 to the contacts 50 of the mating connector 40, further interconnecting between pads 102 on the main substrate 100.

25 If the FC 20 is formed with a ground conductive layer on an inner surface thereof, the insertion portion 31 of the guide member 30 engages the conductive layer. Although it is not shown, the guide member 30 is preferably engaged with the mounting metal fixture 43 of
30 the housing 41 at the both ends in the longitudinal direction of the guide member 30 to electrically engage the ground conductive layer of the FC 20.

As is readily appreciated from a comparison between the connectors 10,40 of the Figures 2A through 2C and
35 the conventional memory card connector disclosed in the above described U.S. Patent No. 5,324,204, the electrical connector assembly of the present invention

replaces the plurality of L-shaped contacts disposed in staggered relationship of the prior art connector with the FC 20 and the corresponding connector 40. In accordance with the connector of the present invention

5 an easily handled and a highly dense arrangement corresponding to the conductive traces of the FC 20 is achieved because of elimination of plural rows of the deformable and high density L-shaped contacts. Further, an important matter is that length of the signal traces

10 from contracts 13,14 of the housings 11,12 to the contacts 50 of the mating connector 40 can be formed such that the length is essentially constant. Accordingly, since even in high speed data signals it is possible to make signal transmission time or signal

15 delay constant, the present connector is suitable for a card bus for transmitting high speed and high frequency signals. Further, since the memory card connector 10 is detachably connected to the connector 40 mounted on the main substrate, it should be noted that the termination

20 assembly of the connector and serviceability are substantially improved.

Figure 3 is a cross-sectional view showing entire memory card connector 10, of the present invention, including a memory card retention portion 15. The

25 memory card retention portion 15 of the memory card connector 10 is formed by bending a thin metal sheet. In the preferred embodiment of the electrical connector assembly shown in Figure 3, the connector housings 11,12 are in a stacked arrangement with the respective

30 contacts 13,14 overlying each other. However, the present invention is not limited to such an embodiment; for example, the present invention can be applied to a card bus for interconnecting contacts on wall surfaces of a pair of housings disposed in opposite relationship.

35 Another such embodiment of an electrical connector 60 is shown in Figure 4. Electrical connector assembly 60 comprises a pair of separate docking connectors or

memory card connectors 61,62. Each of the connectors 61,62 opposes each other at a wall surface thereof and preferably includes plural rows of multiple number of contacts 63,64, including signal contacts 63a,64a and ground contacts 63a,64b. Between both connectors 61,62 is a mating connector 40' soldered on a main substrate 200. The mating connector 40' can be essentially similar to the mating connector 40 shown in Figures 1 through 3. A FC 70 is connected to the contacts 63,64 at one end of the conductive traces thereof on the walls of the both connectors 61,62 by means of a prior art technique. A middle portion of the FC 70 is inserted into a slot of a guide member 80. Contact pads (not shown) at the middle portion of the FC 70 are forced by the guide member 80 into an opening of the connector 40' to engage contacts 50' disposed at both sides of the opening to establish interconnection.

With reference to Figures 5 through 12, another embodiment of an electrical connector of the present invention will be described. Figure 5 is an isometric view of the electrical connector of the another embodiment. Figure 6 is an isometric view in which the guide member to be used for the electrical connector is positioned on the FC that is connected to the memory card connector. Figures 7A-C and 8A-B show a housing of the electrical connector shown in Figure 5. Figures 9A-C and 10A-B show the guide member of the electrical connector shown in Figure 5.

An electrical connector 110 is provided with a housing 120 having an opening 121 for receiving an FC 160, a plurality of contacts 122 oppositely disposed in two rows in the housing 120, and a guide member 140 for forcing and securing the FC 160 inserted into the housing 120. Plate-like ground conductive members 124 are provided on both end surfaces 120a of the housing 120 by pressing side portions 124a into slots 120b in the housings 120 to engage projections (not shown)

formed at side portions 124a with the housing 120 as shown in Figure 8B. When the guide member 140 is moved in the direction of arrow 141, as will be described hereinafter, to be inserted into the housing 120, a
5 ground portion 142 of the guide member 140 engages the projections 124b of the conductive ground members 124. As the conductive ground member 124 is mounted and connected on the substrate (not shown), the mounting strength of the housing 120 to the substrate is
10 enhanced. A plurality of contacts 122 disposed in the housing 120 are engaged, respectively, with the conductive pads 164 of the signal traces 162 formed on the FC 160.

As shown in Figure 6, the FC 160 is bent at a middle
15 portion 165 and end portions 166, 168 of the FC 160 are connected to corresponding contacts of a memory card connector 180. A shape of the FC 160 is schematically shown in Figures 11A-B and 12A-C. The FC 160 is continuously bent at the middle portion 165 thereof to
20 form two wiring portions or arrays 170, 172. The wiring portions or arrays 170, 172 are formed with signal traces 162 shown in Figure 6 and conductive pads 164 on both surfaces 170a, 172a of the wiring portions 170, 172. Also, the wiring portions 170, 172 are formed with a
25 ground conductor or ground wiring at back surfaces 170b, 172b, respectively, such as described below with reference to Figures 13-18. The ground wiring or conductor preferably is formed on entire back surfaces 170b, 172b or, alternatively, may be formed only on a
30 portion thereof.

The guide member 140, as shown in Figures 9A-C and 10 A-B is, for example, integrally formed by stamping and bending a sheet of metal made of copper alloy such as phosphorous copper, and is formed with the above
35 described ground portions 142 at both end portions of the guide member 140. Upon forming the guide member 140, the stamped metallic sheet is bent at the middle

portion 140a and is outwardly bent at the end portions. The end portions are bent downwardly to form the ground portions 142. The ground portions 142 have resiliency, thereby gripping the housing 120 from both sides when assembled thereto. The guide member 140 is disposed between the wiring portions or arrays 170, 172. Until the guide member 140 is inserted into the housing 120, the guide member 140 is preengaged with projections 191 (see Figures 11 and 14) formed on the FC 160.

Now, with reference to Figures 11A-B and 12 A-C, a sequence will be described in which the FC 160 is inserted into the housing 120 and is secured by means of the guide member 140. In order to secure the FC 160 in the housing 120 by the guide member 140, first, as shown in Figure 12A, the guide member 140 is disposed at a position spaced apart from the middle portion 165 of the FC 160. Then, as shown in Figures 11A-B and 12B, the middle portion 165 of the FC 160 is inserted into the housing 120. After inserting the middle portion 165 of the FC 160 into the housing 120, as shown in Figure 12C, the guide member 140 rides over the projections 161 of the FC 160 to be inserted into the housing 120, and the middle portion 165 of the FC 160 is inserted into the housing 120 and is forced into position by the guide member 140. Accordingly, the ground wiring formed on the back surfaces 170b, 172b of the FC 160 are positively engaged with the guide member 140, and, additionally the ground portions 142 of the guide member 140 engage the projections 124b of the ground conductive member 124, as described above. The guide member 140 is made of metal, thereby eliminating deformation or breaking of the guide member when the guide member 140 is inserted into the housing 120. Accordingly, the conductive pads 164 (see Figure 6) can be readily and firmly engaged with the contacts 122 more easily than can a plastic cover or guide member, thus enabling excellent reliability and easy operation. Further, in the situation in which the

metallic guide member 140 is inserted into the housing 120, the guide member 140 engages both the ground conductive members 124 secured in the housing 120 and the ground conductor or wiring (not shown) on the FC 160, the guide member 140 also functions as a ground member.

A preferred embodiment of the FC 160 in accordance with the present invention is illustrated in Figures 13 through 16. Figure 13 shows one surface 160a of the FC 160 while Figure 14 shows the reverse surface 160b thereof. Also shown in Figure 15 is the surface 150b before adhering strengthening plates 190, 196, which will be described hereinafter. Furthermore, Figure 16 shows an enlarged cross-sectional view in the thickness direction from the slot to the edge portion.

As shown in Figure 16, the FC 160 is formed as a multi-layer structure. A central film 182 of polyamide or the like separates one side structure 182a to form the surface 160 and a reverse side structure 182b to form the surface 160b. Each structure 182a, 182b, is made by an electrically conductive film of copper or the like and a cover layer 185 of polyamide or the like adhered on the surface of the central film 182 by adhesive material 183a, 183b. The electrically conductive film is further etched to form conductive patterns 162 and a ground layer 176, which will be described hereinafter.

As shown in Figures 13 and 16, the structure 182a on surface 160a of the FC comprises conductive arrays 170, 172, having conductive pads 164, including conductive traces 162, connection portions 167 connected to conductive traces 162, and through-holes 169 extending to the other surface 160b. Each conductive trace 162 interconnects the respective conductive pads 164 and connection portion 167. As best shown in Figure 16, the conductive pads 164 have a gold or solder plating layer 163. The pads 164 are arranged in

corresponding positions to the connector contacts, such as in connector 110 shown in Figures 5-12, to receive the FC 160 and are staggered in the particular embodiment shown in Figure 13. Note that ground contact pads 174 are mixed in the rows of the conductive pads 164 as shown in Figure 13. The ground contact pads 174 are disposed at locations to engage with desired contacts in the connector. Also, the ground contact pads 174 are electrically connected to a ground layer 176 to be described hereinafter by way of via holes 173 extending in the direction of the thickness of the FC. The connection portions 167 formed at the edge portions of the FC 160 are in a ring form to be soldered to the contacts of a PC card connector and are formed with through-holes 169 as mentioned above.

The structure 182a on surface 160a also includes a plurality of recesses 184 that extend into the cover layer 185 and are formed by partly removing the cover layer 185 and are arranged substantially in rows, as seen in Figures 13 and 18.

The FC 160 is preferably formed with openings or slots 186 extending therethrough and at substantially center position between the rows of the conductive pads 164. The openings 186 provide the FC 160 with relatively narrow bridge or belt-like portions 188 therebetween.

As best shown in Figures 14 through 16, the reverse structure 182b on surface 160b includes the ground layer 176 and connection portions 178. The ground layer 176 includes a plate portion 175 and mesh portions 177. The plate portion 175 comprises an electrically conductive film of copper or the like extending in two dimensions while the mesh portions 177 are formed by etching the electrically conductive film in a slanted mesh as shown in Figure 14 through 15. Also, the ground layer 176 extends from the edges of the meshed portions 177 to the edges of the FC 160 for connection to the connection

portions 178 that are substantially similar configuration as the above mentioned connection portions 167. The connection portions 178 receive ground connection terminals of the PC card connector at the through-holes 179 extending to the surface 160a for making solder connections to contacts of a connector (not shown).

The FC 160 further includes first and second plastic strengthening plates 190, 196 made from glass-filled epoxy resin or the like that are adhered on the surface 160b as shown in Figure 14. The first strengthening plates 190 are positioned at both sides of the openings 186 as a pair and at the immediate reverse side of the conductive pads 164. Note that the first strengthening plates 190 include opposed edges 192, 193 with edge 192 having projections 191 that extend into the openings 186 when the first strengthening plates 190 are adhered. The edges 192 are parallel with the openings 186. As shown in Figures 14 and 15, the first strengthening plates 190 substantially cover the plate portion 175. Also, at least one of the pair of the first strengthening plates 190 is formed with engaging slots 194 or projections 191 to be used preliminary for retaining the FC 160 to guide member 140 when it is inserted into the connector, as previously described with reference to Figure 11.

Additionally, the second strengthening plate 196 is adhesively secured at the locations of the connection portions 167, 178 using adhesive material 183b such as a liquid solder resist. This makes it easy to solder the connector to the PC card connector. The second strengthening plate 196 has through-holes at location corresponding to the connection portions 167, 178.

A cross-sectional view of the FC 160 according to the present invention as inserted into the connector 110 having a FC receiving opening 121 is shown in Figure 17.

The FC 160 is folded at the bridge portions 188 with the conductive pads 164 facing outwardly.

5 A guide member or guide member 140 is used to insert the FC 160 into the FC receiving slot 121. As shown in Figure 18, the FC 160 is bent at a substantially right angle along the recesses 184 and the reverse surface 160b near the edges 193 of the first strengthening plates 190. In the inserted portion, the edges 193 of the first strengthening plates 190 abut against the
10 bottom surface 123 of the FC receiving opening 121. This provides precise alignment of the conductive pads 164 with contact points of contacts (not shown) in the connector 110, thereby assuring reliable interconnection therebetween.

15 It is to be understood that the shown in Figures 1 through 4 may be modified to include the support plates 190, as shown in Figure 18 and additional plates 196 (not shown). The support of reinforcing plates 190 protects the inner surface of the FC.

20 While a plurality of exemplary embodiments of the electrical connector assembly according to the present invention has been described herein, it is not intended that this invention be limited to the embodiments. It will be appreciated by those skilled in the art that
25 various modifications can be made for specific applications without departing from the scope and spirit of the invention. For example, the recesses 184 may not be limited to the particular shape but may have a constricted portion along the outer periphery or may
30 have wider portions. The strengthening plates 190 may not be limited to plastic material but may be replaced by metal plates.

The electrical connector assembly according to the present invention, as appreciated from the above
35 description, provides following various excellent advantages. It is suitable for an application in which an high density electrical connector such as an memory

card connector having a plurality of contacts is interconnected to corresponding conductive areas on the printed circuit board. By using the flexible substrate, the right angle contact legs can be eliminated, thus enabling the high density contacts of the connector to be reliably and easily interconnected to the PC board conductive areas without having the problems associated with deformation of the contact legs.

A high density electrical connector assembly is achieved, since the conductive traces or the conductive pads formed at the middle portion of the FC are engaged with a plurality of contacts in one connector and the other ends of the traces are connected to corresponding contacts of at least one conventional FC connector terminated at the ends of the FC.

The electrical connection between the conductive pads and the contacts are established by inserting the guide member into the FC bent in a generally U-shape. Since the guide member is forced between the rows of the contacts, an assured interconnection is provided even for an the FC having sufficiently large width. Further, if a conductive metal guide member is used for the FC having a ground conductor on the reverse side thereof the guide member can be electrically engaged to ground conductive members at one or both ends of the housing. Thus a high density connector assembly for high frequency signals is obtained.

The flexible circuit according to the present invention assures highly reliable electrical connection while maintaining a relatively narrow pitch between contacts by folding it along the relatively narrow bridge portions and by the provision of the strengthening plates abutting against the housing for accurate alignment or registration between the conductive pads and the contacts. Especially, the bridge portions are relatively narrow to permit smooth

folding of the FC, thus avoiding undesirable force being applied to the arrays of the conductors thereon.

Furthermore, the provision of the ground layer on the inner surface of the FC and the conductive patterns
5 for transmitting signals on the outer surface effectively reduces crosstalk noise between the conductive patterns.

Additionally, the recesses formed by removing a part of the layers near the bending positions of the FC
10 permit bending of the FC at a desired position and angle.

CLAIMS

1. An electrical connector assembly including a housing (41,120) having a plurality of contacts (50,122) disposed along an elongate opening (42,121); a flexible
5 substrate having a width corresponding to the opening (42,121) of the housing (41,120), and having conductive traces (23,162) on one surface thereof corresponding to the contacts (50,122) in the housing; and a guide member (30,140) having a plate portion to be disposed in a
10 flexible substrate bent in a generally U-shape with the one surface outside, and to be inserted into the opening (42,121) of the housing (41,120); the connector assembly being characterized in that:

the housing (41,120) includes a ground conductive
15 member (43,124) at least one end thereof;

the flexible substrate is formed with a ground conductor (176) on the other surface thereof; and

the guide member (30,140) is a conductive member adapted to further provide a connection to ground for
20 the assembly

whereby the contacts (50,122) and the conductive traces (23) are electrically connected by the force exerted by the guide member (30,140) on the flexible substrate and the ground conductor (176) of the
25 substrate is connected to the ground conductive member (43,140) of the housing (41,120) by the guide member (30,140).

2. The electrical connector assembly of claim 1 wherein the flexible substrate further includes
30 strengthening plates (190) disposed on the other surface thereof at the locations corresponding to the conductive pads (164).

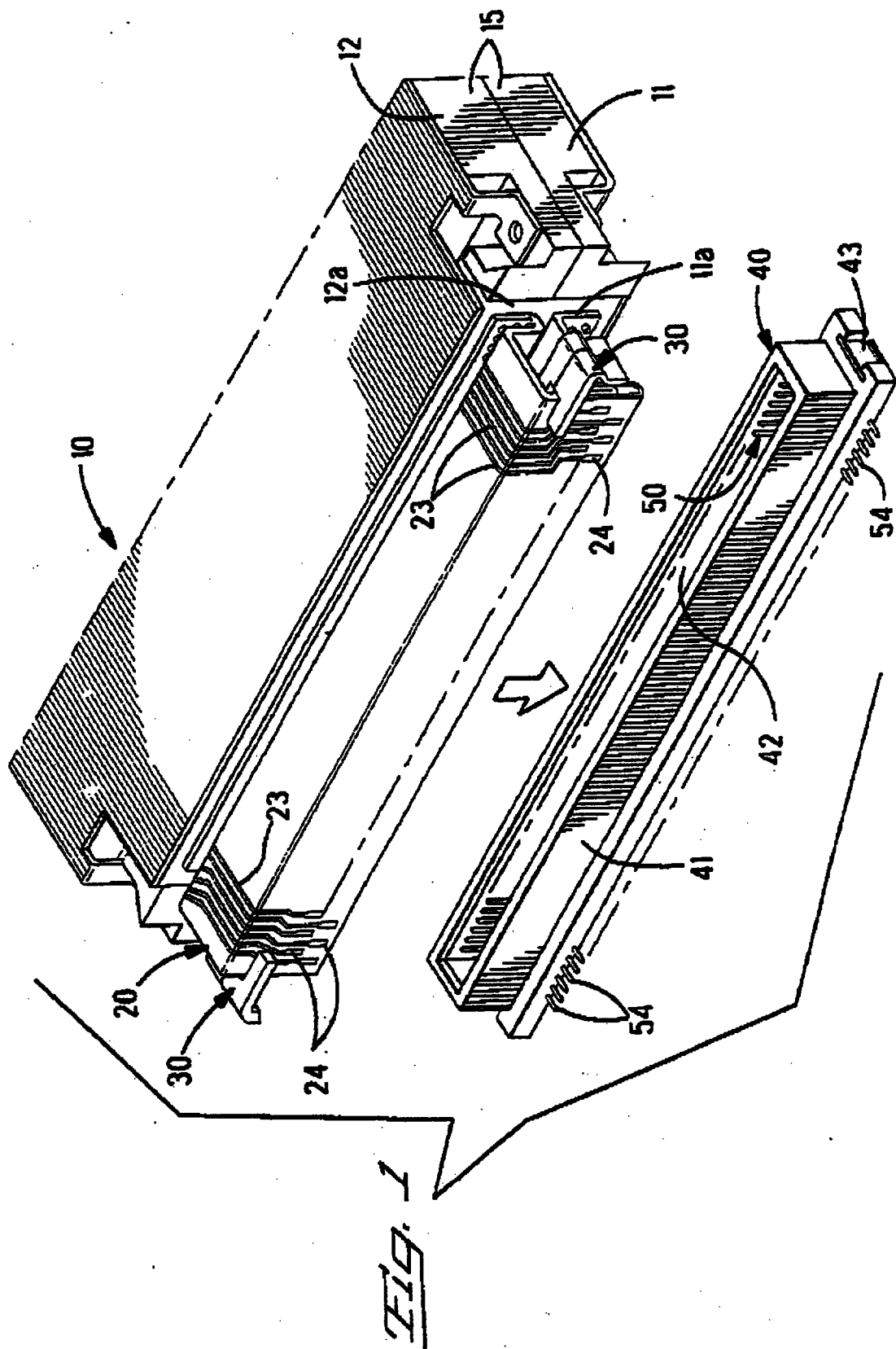
3. The electrical connector assembly of claim 2 wherein the flexible substrate further includes a
35 plurality of openings (186) formed between the arrays of the conductive pads (164) to define relatively narrow bridge portions (188); and parts of the strengthening

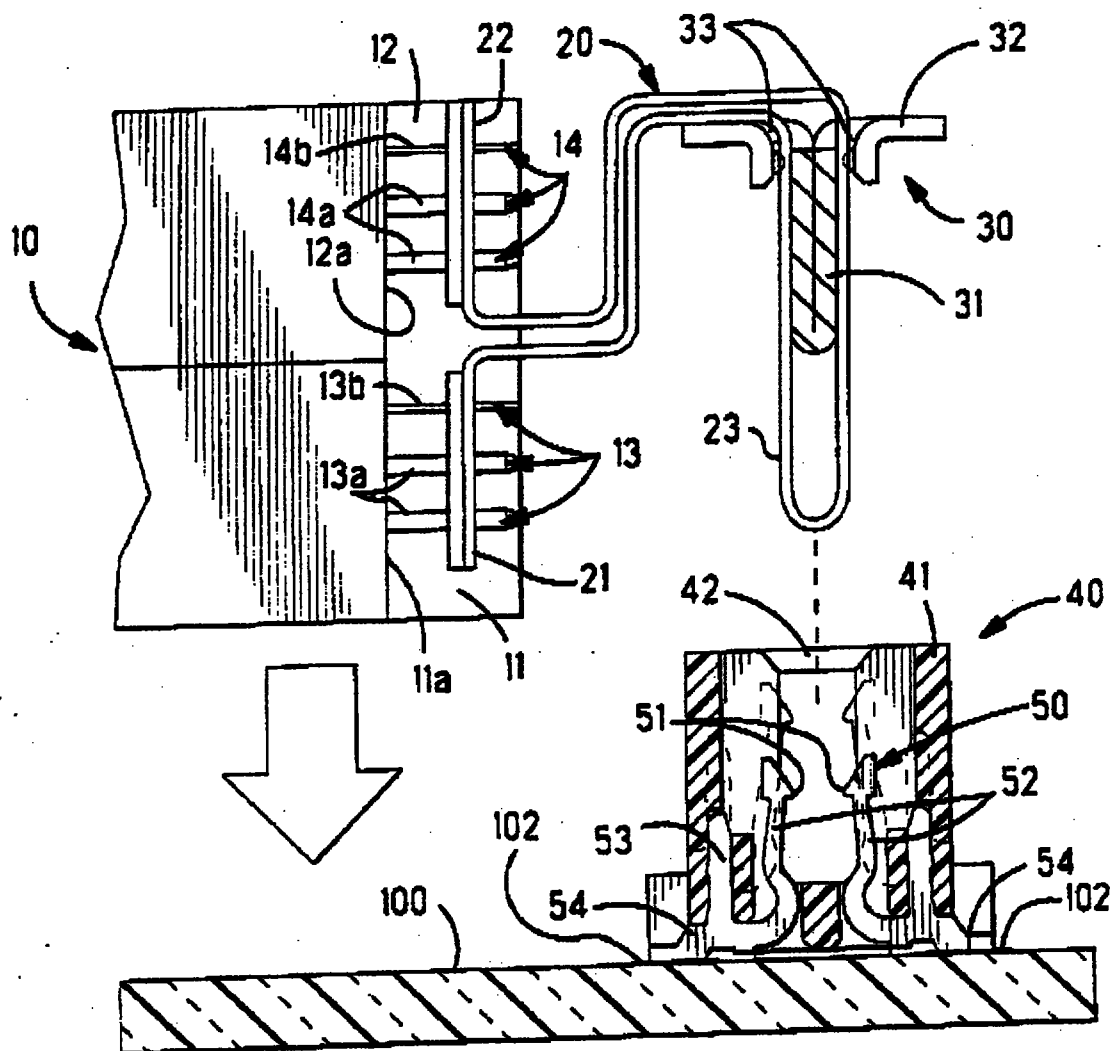


plates (190) extend into the openings (188) by a predetermined length.

4. The electrical connector assembly of claim 1, 2 or 3 wherein the flexible substrate further includes a cover
- 5 layer (185) disposed over the conductive traces with conductive pads (164) of the traces being free of the cover layer (185) to enable electrical connection thereto, the cover including a plurality of recesses (184) formed substantially in a line thereon at
- 10 locations where the conductive traces (162) and conductive pads (164) are not formed to facilitate bending of the flexible circuit (160) at a selected location.





Fig. 2A

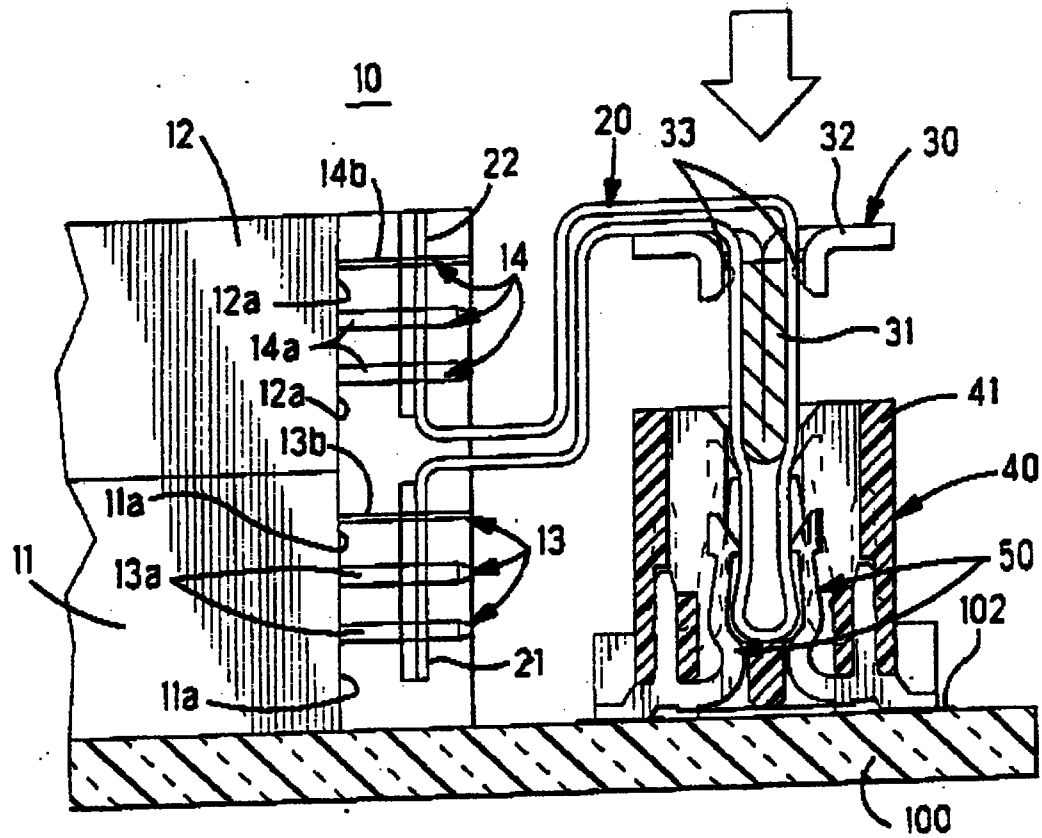


Fig. 2B

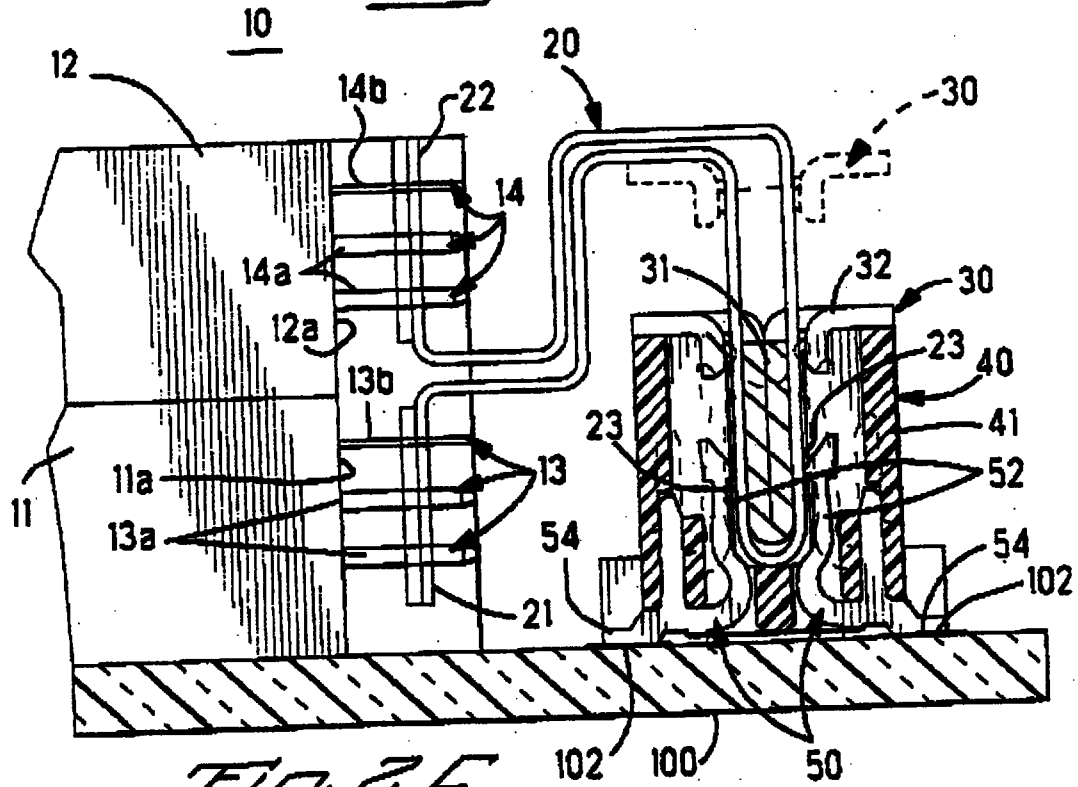
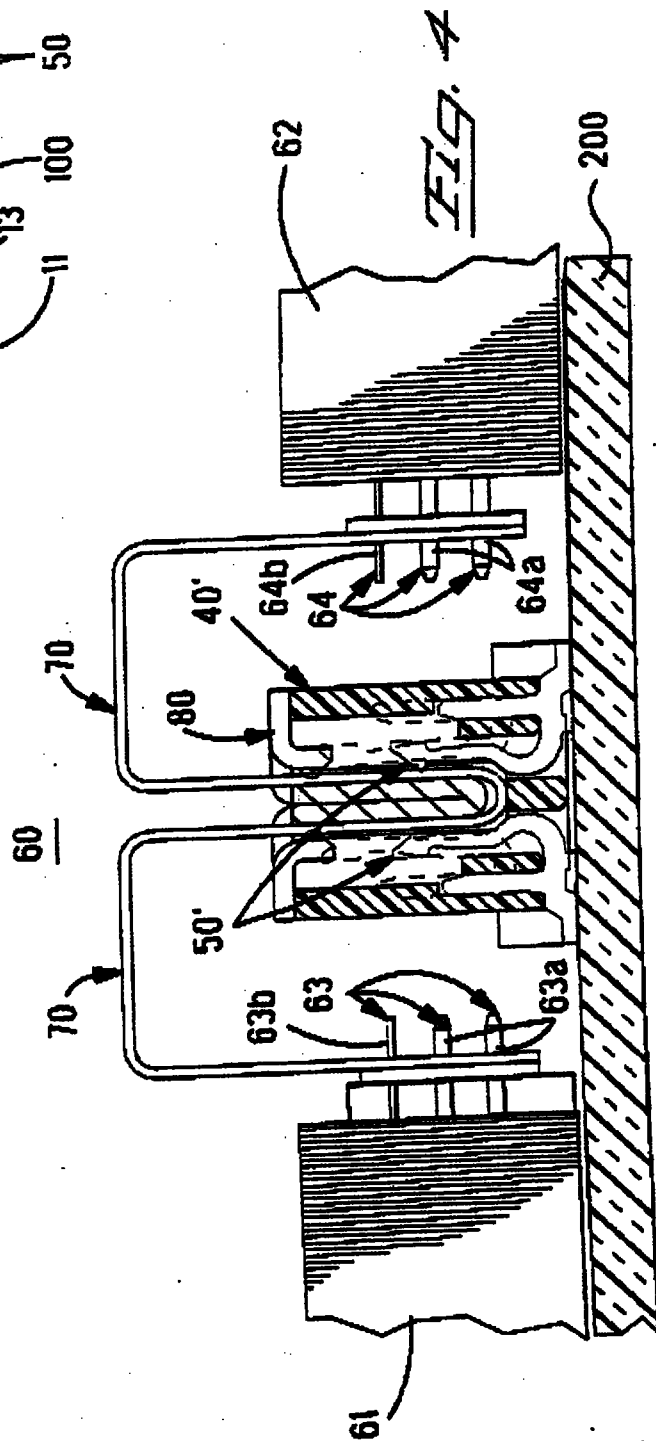
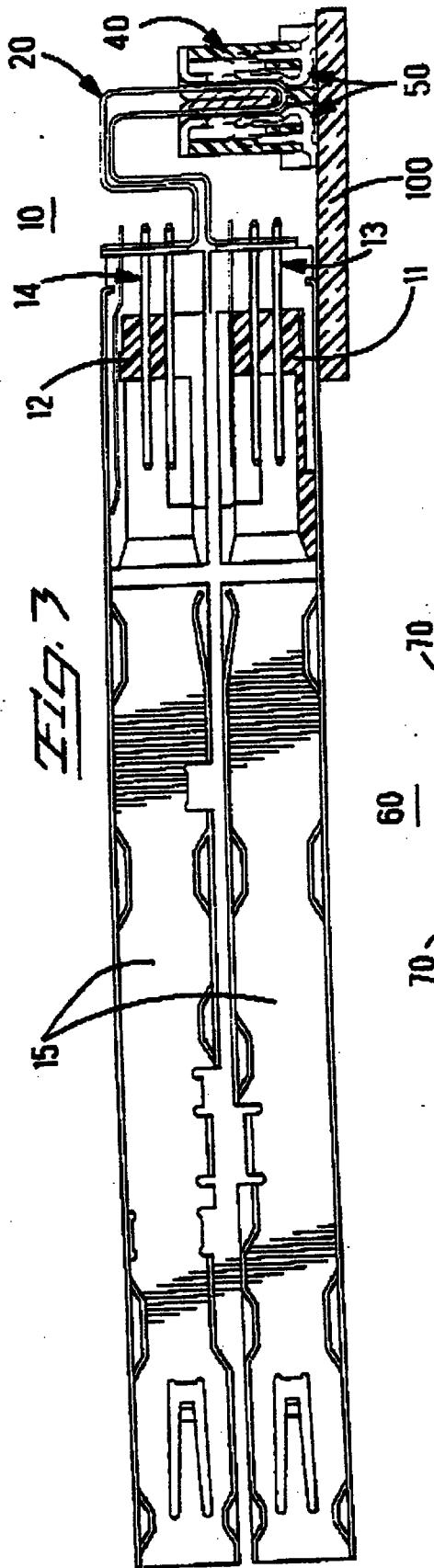
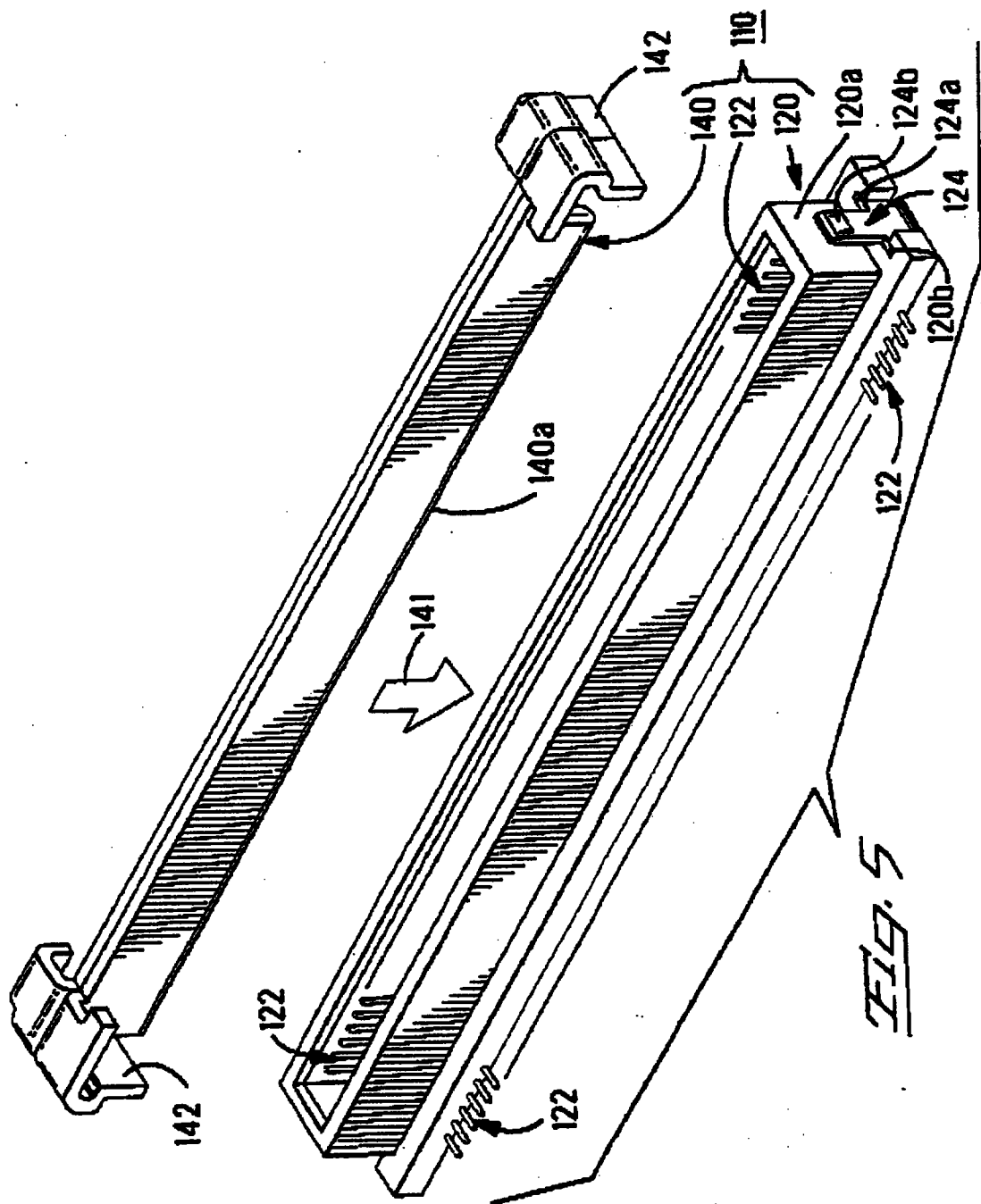


Fig. 2C





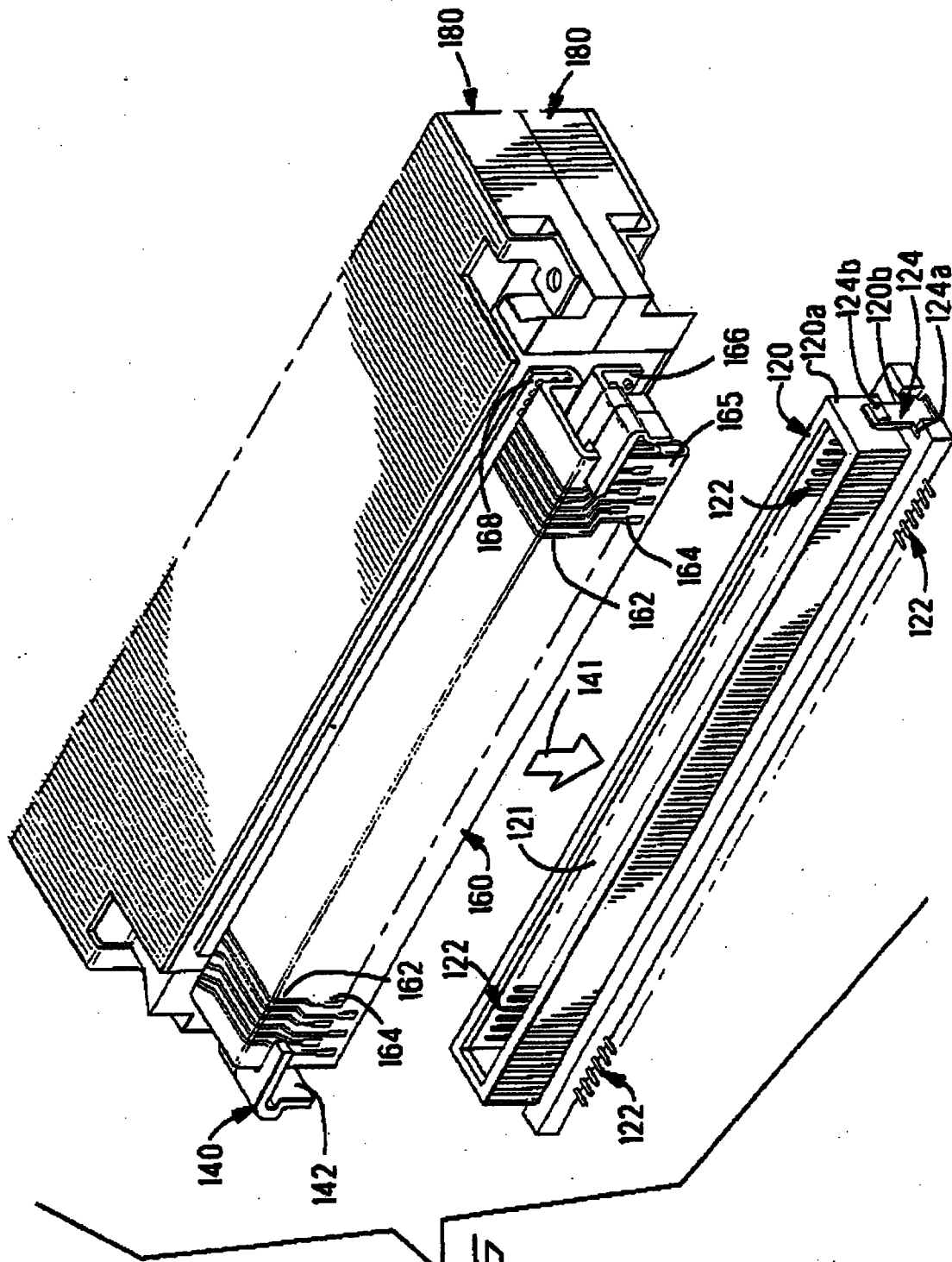
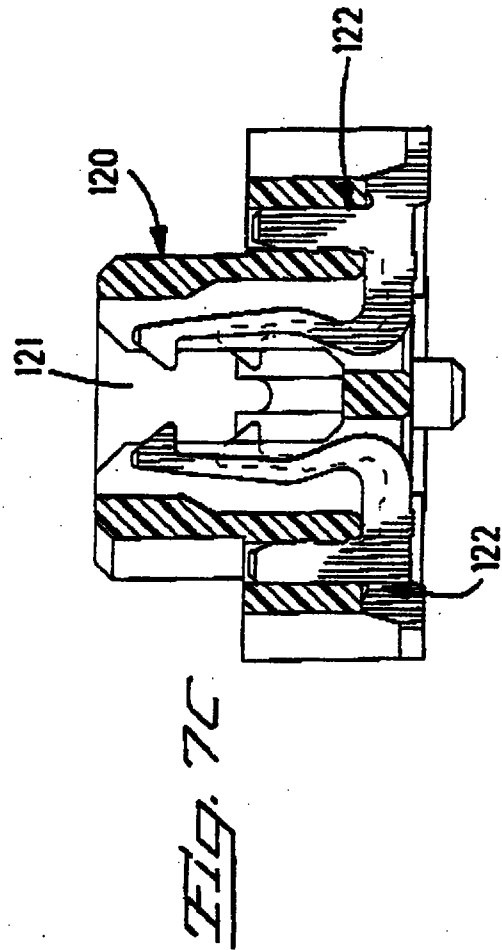
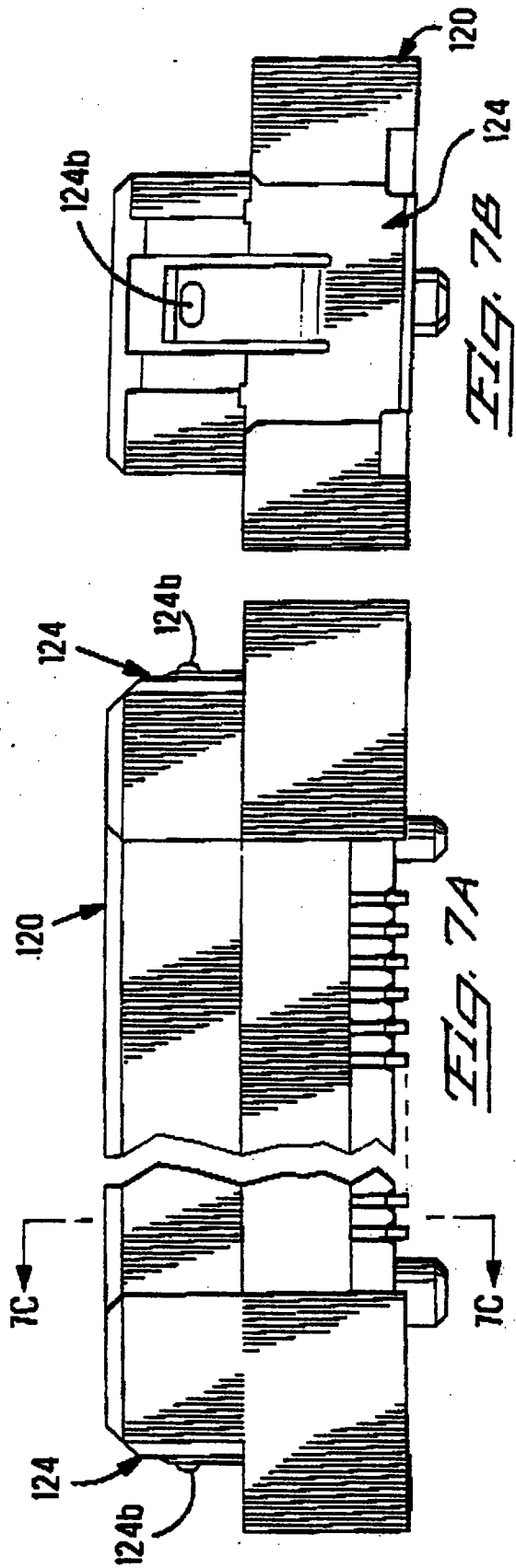
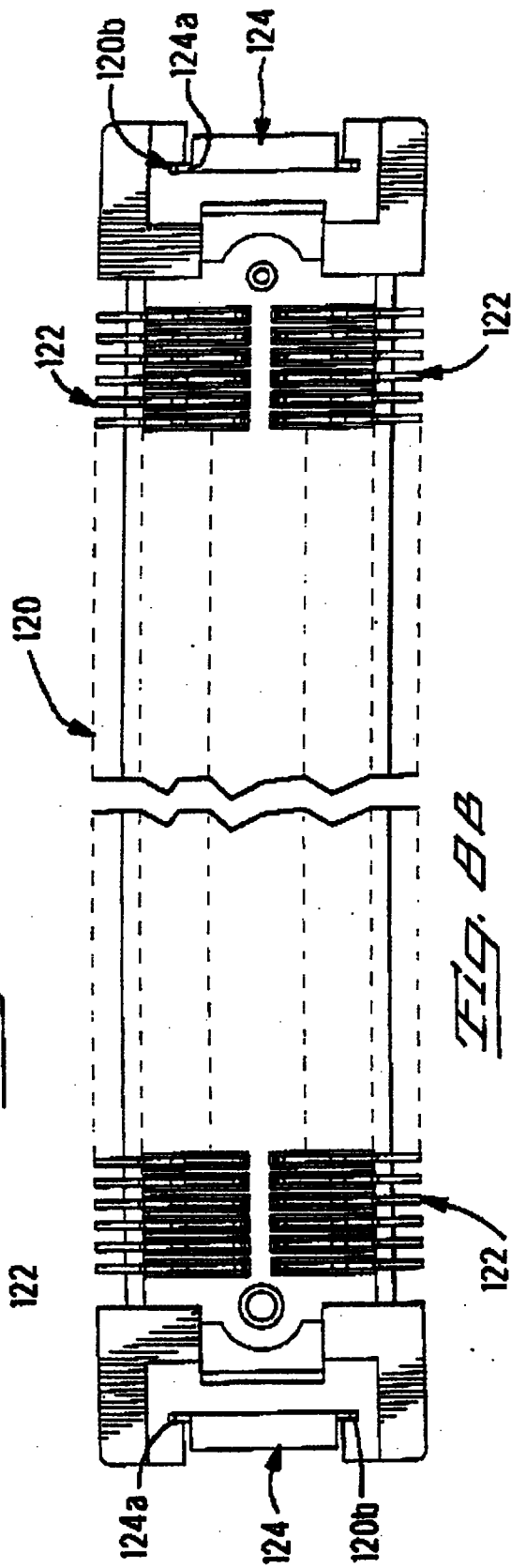
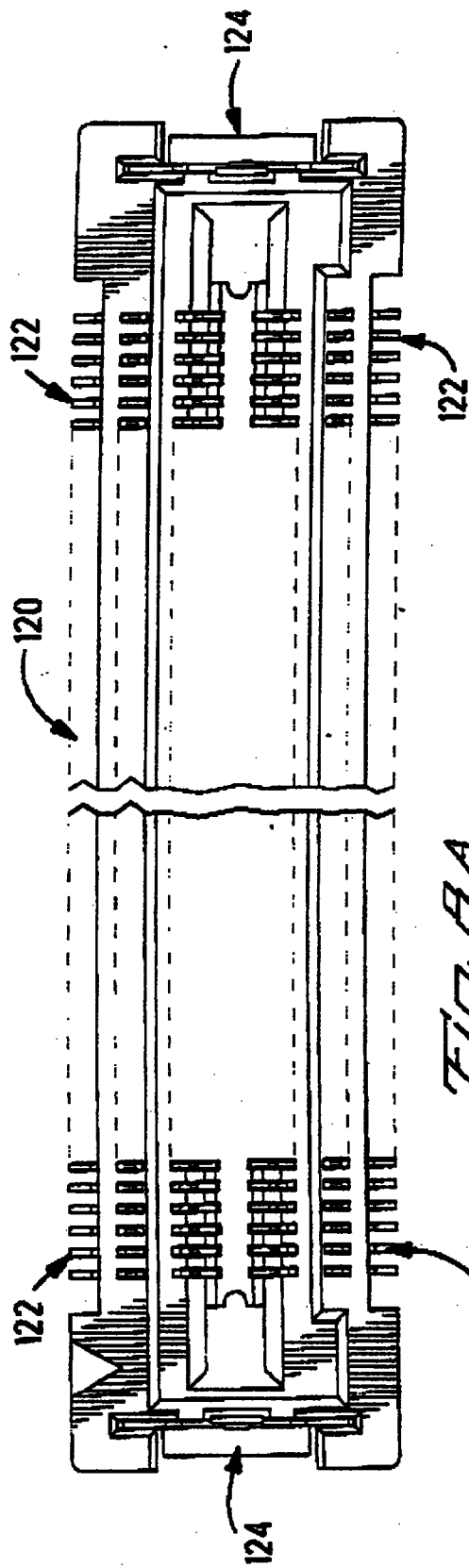
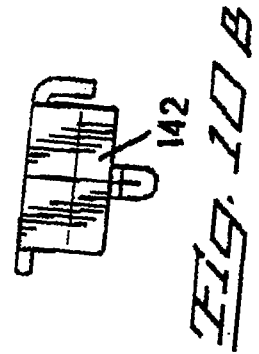
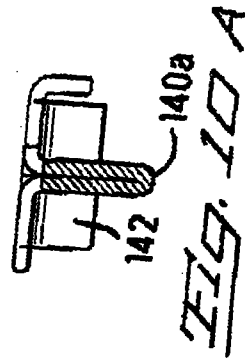
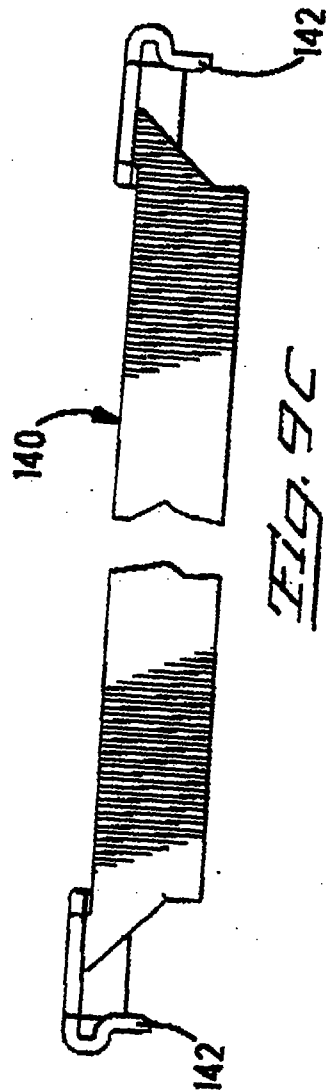
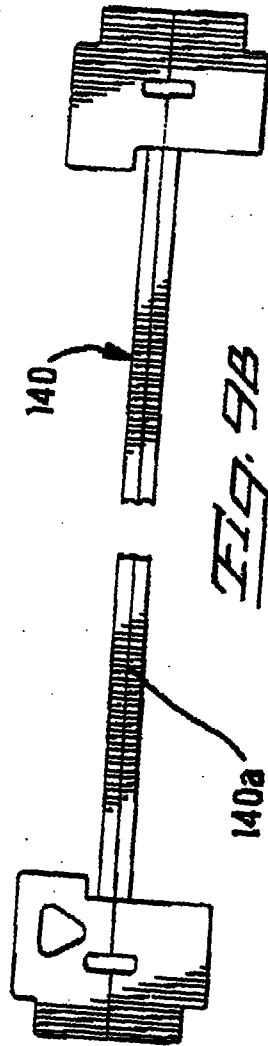
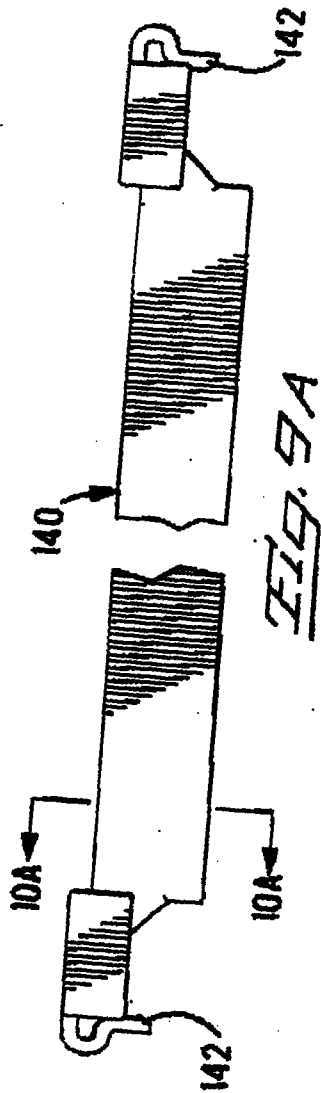
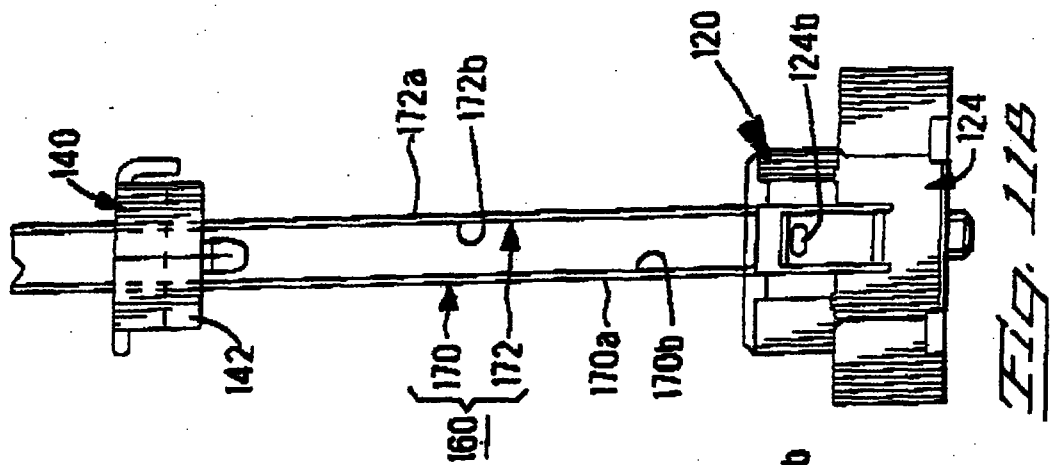
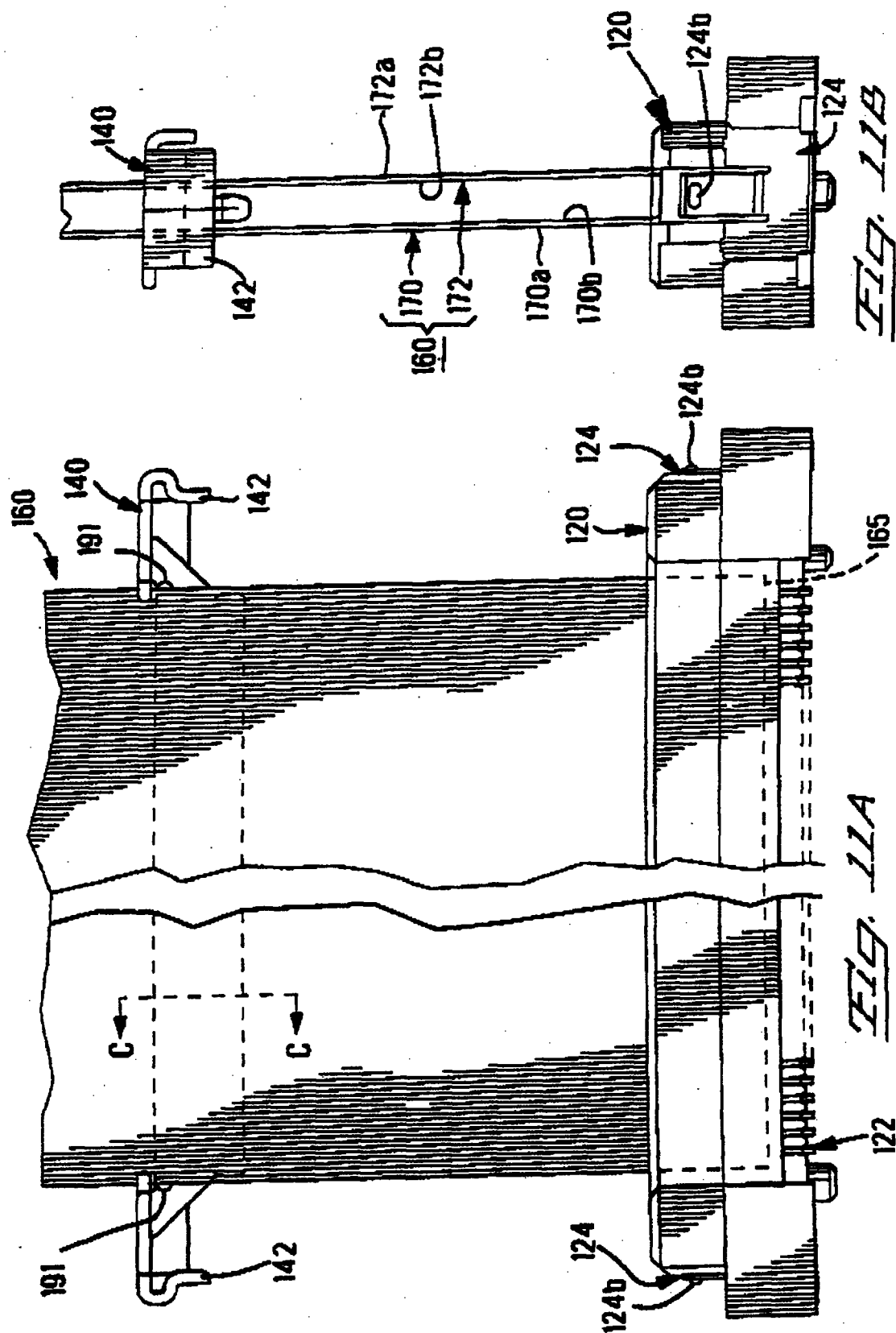


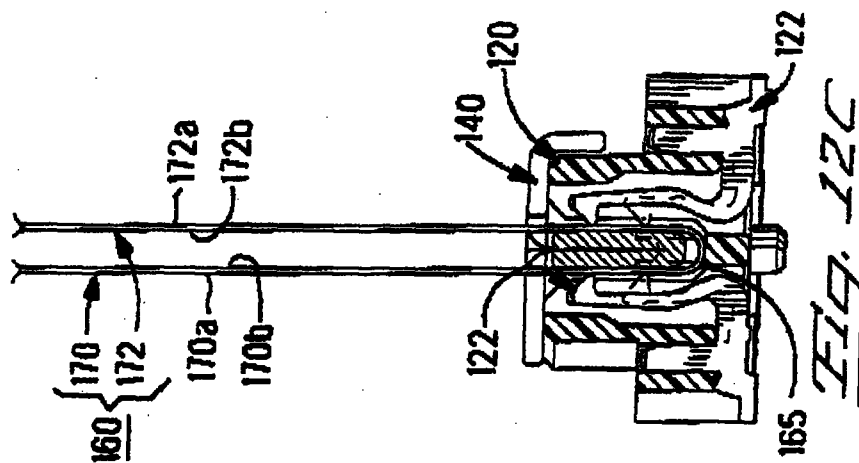
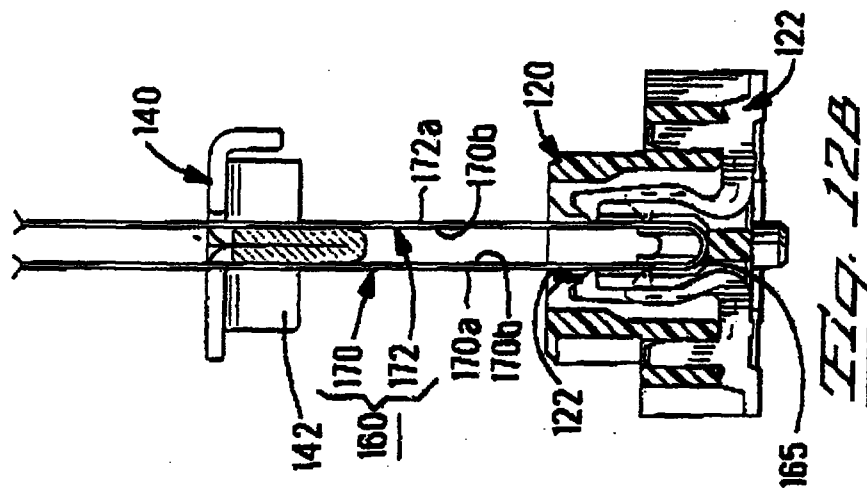
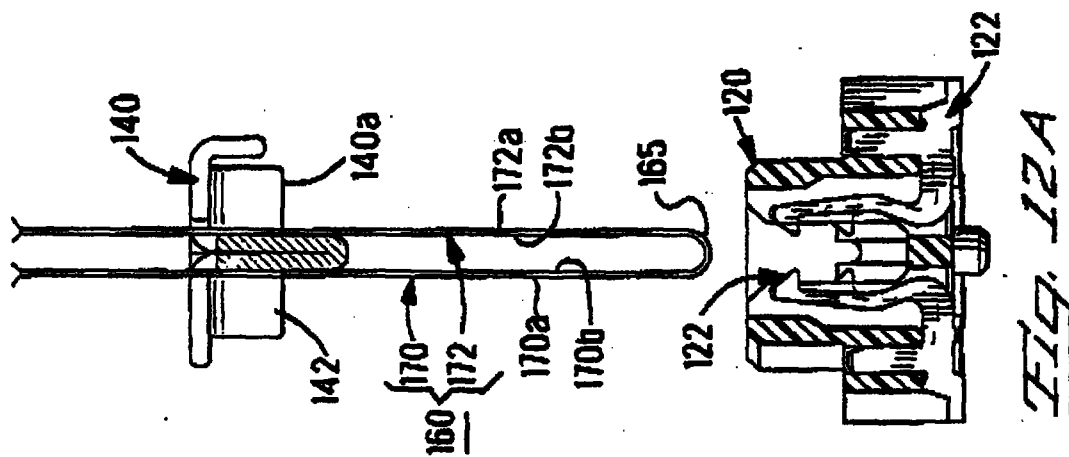
FIG. 6











AMENDED SHEET

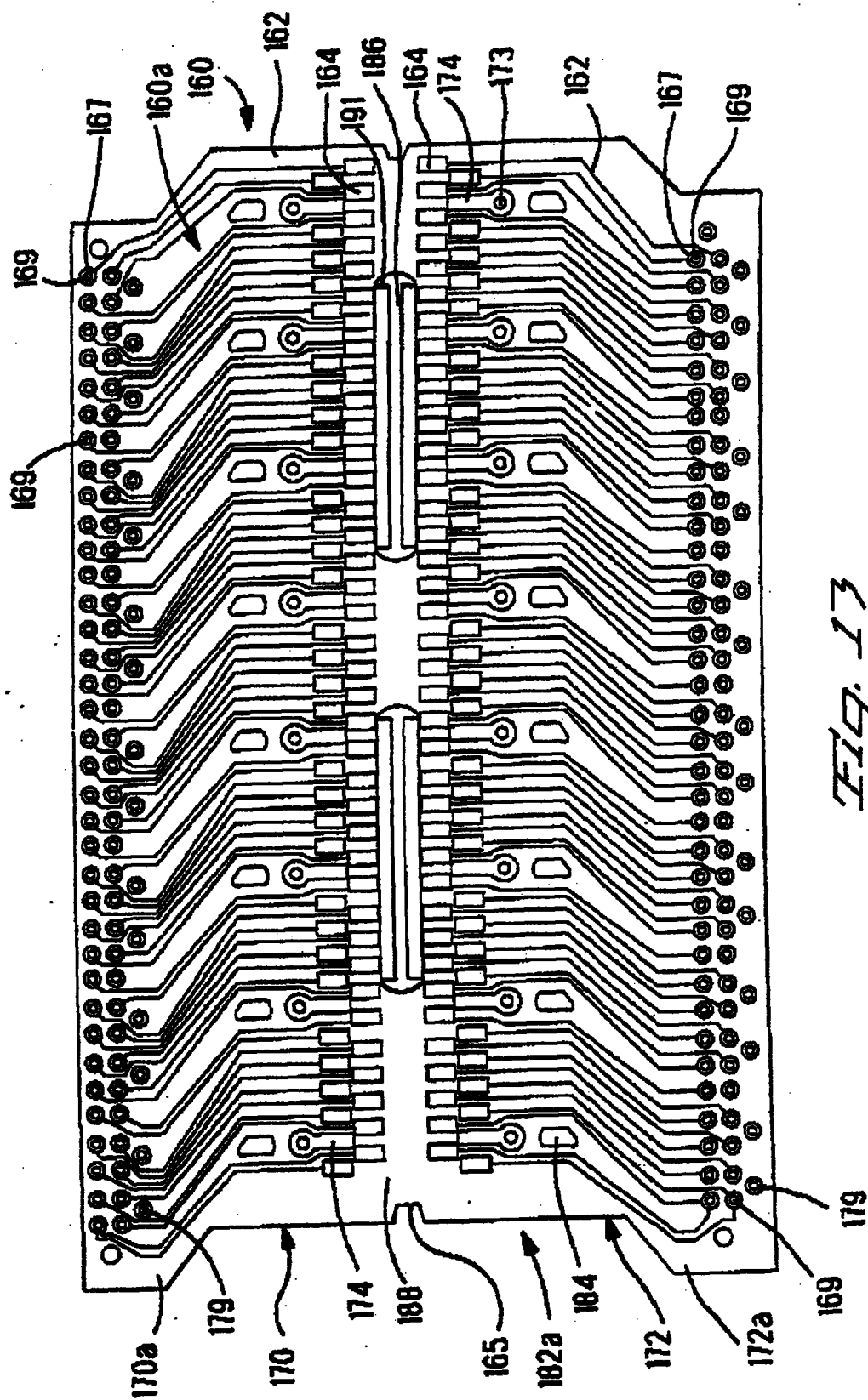
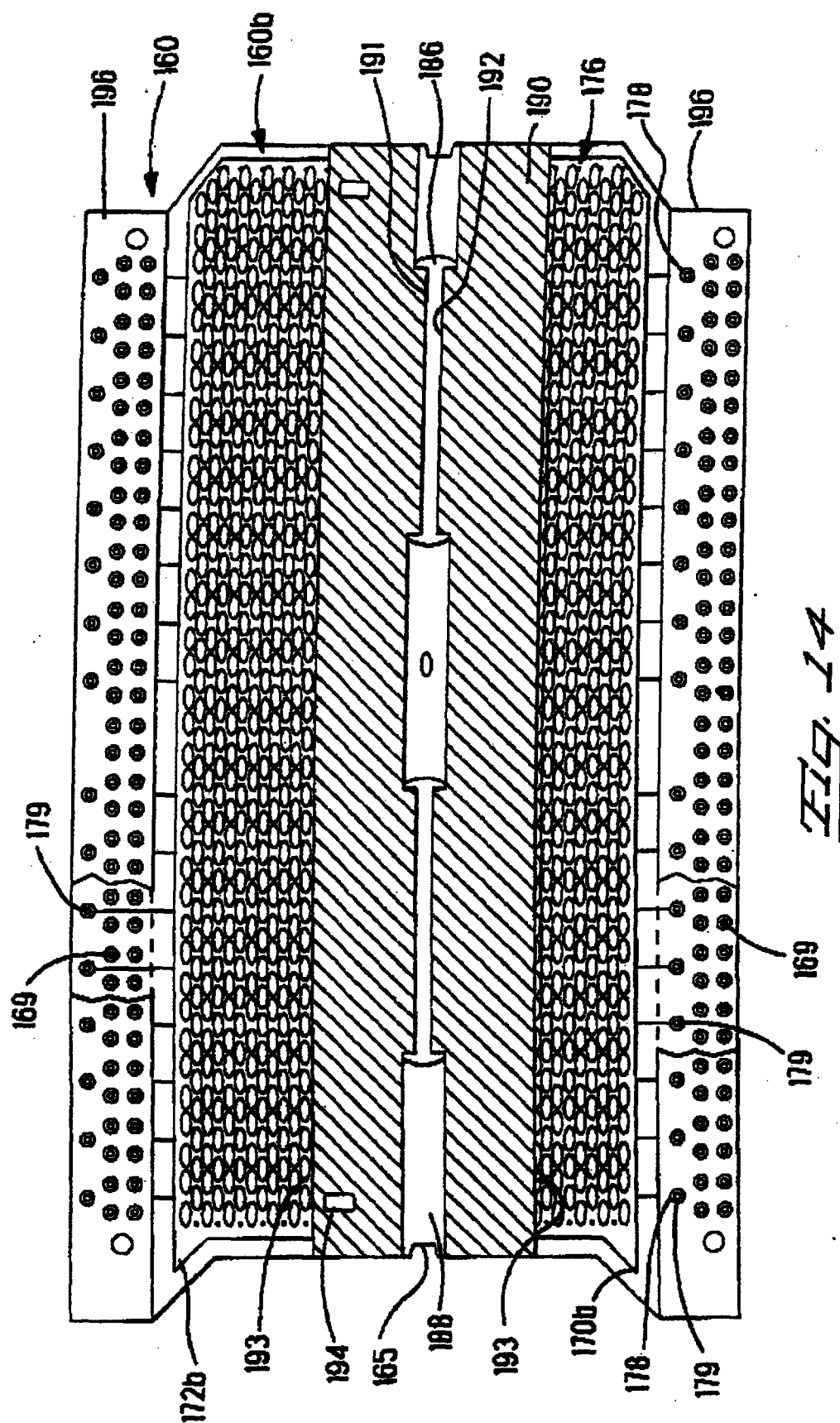


FIG. 13



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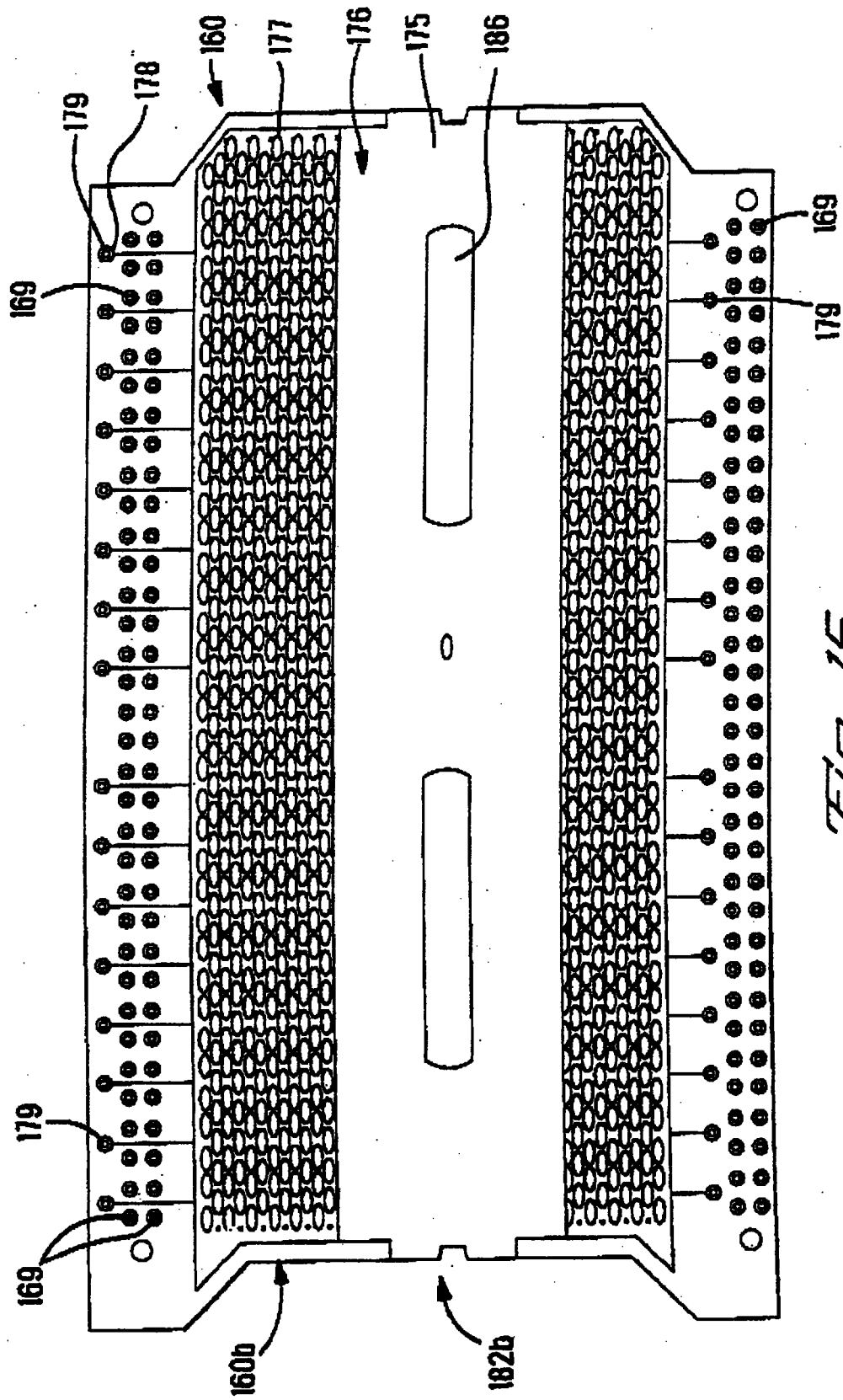


Fig. 15

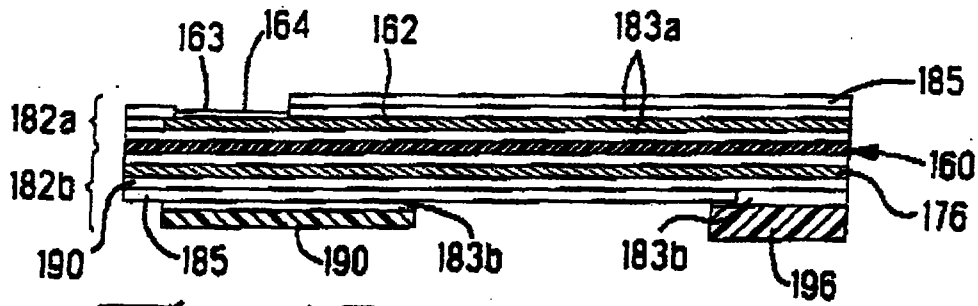


Fig. 16

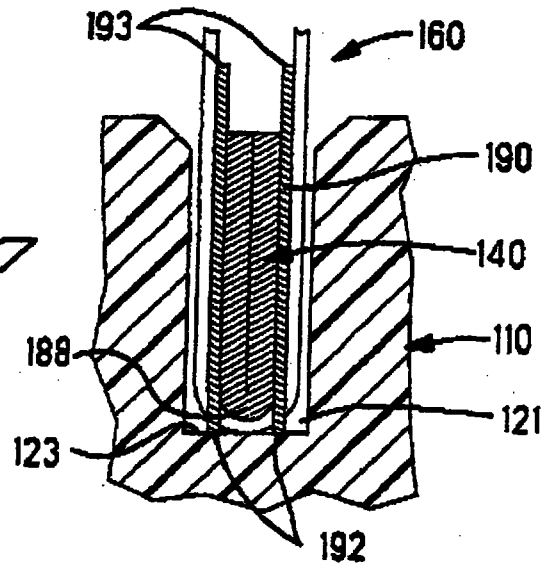


Fig. 17

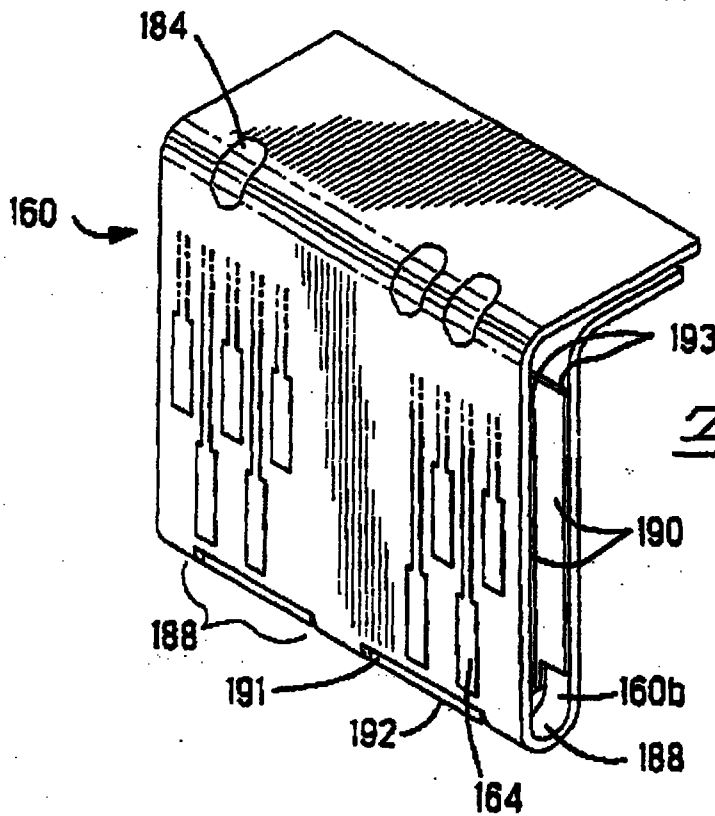


Fig. 18

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contacts to be used therein will also become smaller and, therefore, be more easy to deform. It is very difficult to accurately position the contacts, especially their solder-terminating portions, in the desired location and to maintain them so as not to deform the contacts upon handing and mounting the connector on to the substrate.

Also, for the electrical connector utilizing the FC, it is difficult to precisely and firmly urge the movable plastic cover to engage over the full width of the FC with the plurality of contacts without having some deformation over the full width of the FC. Accordingly, reliability of connection between the conductive pads and the contacts has been decreased.

Therefore, an object of this invention is to provide a small and high density electrical connector assembly, that utilizes the FC and enables simple structure and easy handling.

It is another object of this invention to provide an electrical connector assembly having a ground function and permitting easy handling in which the plurality of the conductive pads on the FC and the contacts in the housing are interconnected with high reliability.

It is yet another object of this invention to provide an electrical connector assembly for card bus, which enables one or more memory card connector etc. to connect easily and reliably to the PC board.

In order to solve the problems of the prior art electrical connector assembly and to achieve the above mentioned objects, the electrical connector assembly includes a housing having a plurality of contacts disposed along an elongate opening; a flexible substrate having a width corresponding to the opening of the housing and conductive traces on one surface thereof corresponding to the contacts in the housing; and a guide member having a plate portion to be disposed in a flexible substrate bent in a generally U-shaped with the one surface outside to be inserted into the opening of the housing. The connector assembly is characterized in that; the housing includes a ground conductive member at at least one end thereof; the flexible substrate

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is formed with a ground conductor on the other surface thereof; and the guide member is a conductive member adapted to further provide a connection to ground for the assembly whereby the contacts and the conductive traces are electrically connected by the force exerted by the guide member on the flexible substrate and the ground conductor of the substrate is connected to the ground conductive member of the housing by the guide member.

In the preferred embodiment, the assembly further includes strengthening plates disposed on the other surface thereof at the locations corresponding to the conductive pads.

One aspect of the present invention is that the FC includes a plurality of openings disposed between the arrays leaving narrow bridge portions between adjacent openings. Portions of the strengthening plates extend into the openings by a predetermined length.

Also, another aspect of the present invention is a flexible circuit (FC) having a cover layers disposed over the conductive traces and the ground layer with the conductive pads being free of the cover layer to enable electrical connection thereto.

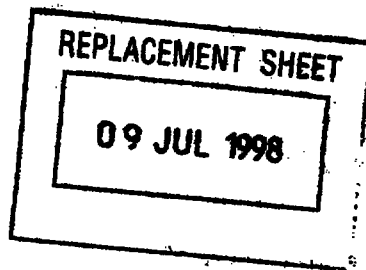
Additionally, the cover of the FC according to the present invention has a plurality of recesses arranged substantially in rows near the bent portion and at locations spaced from the conductive pads and traces.

According to another aspect of the present invention, the electrical connector comprises a housing having two rows of contacts along an elongate opening, a flexible printed circuit board having a plurality of conductive traces on a surface corresponding to these contacts, and a guide member having a generally planer portion to be inserted into a U-shaped bent portion of the flexible printed circuit board, wherein the conductive traces on the flexible printed circuit board are forced between the rows of the contacts by means of the guide member for establishing electrical interconnection between the conductive traces and the contacts in the housing, thus electrically connecting the contacts with corresponding of at least one electrical connector terminated

to the ends of the FC.

5 According to the electrical connector assembly, it is possible to connect the high frequency signals to the contacts through the conductive traces on the surface of the FC. The FC is bent in a U-shape to envelope the guide such that the guide electrically engages the ground conductor of the FC board and upon inserting the FC into the housing, the guide electrically engages the ground conductive members of the housing. Since all the conductive traces formed on the one surface of the FC

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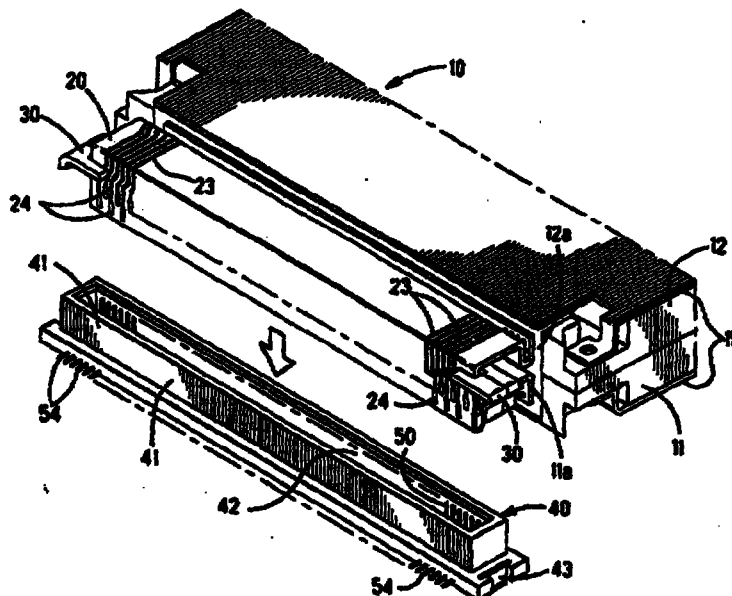
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(57) Abstract

Connector housings (11, 12) to be mounted on a printed circuit board (100) have a plurality of rows of contacts (13, 14) extending from wall surfaces of the housings (11, 12). These contacts (13, 14) are soldered to conductive pads (23) of a flexible circuit (20). The flexible circuit (20), bent in a generally U-shape, is preferably inserted by a metallic guide member (30) between rows of contacts (50) of a mating connector (40) for interconnection therebetween. The guide member (30) preferably causes a ground conductor (176) on the reverse surface of the flexible substrate to groundingly engage conductive members (43, 124) positioned at both ends of the housing. In an alternate embodiment strengthening plates may be adhered to the flexible circuit between the opposed arrays of conductive pads and ground contact pads.