(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 158 619 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
28.11.2001 Bulletin 2001/48

(51) Int Cl.[7]: **H01R 13/115**

(21) Application number: **01111933.6**

(22) Date of filing: **18.05.2001**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **25.05.2000 US 578648**

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(54) Electrical connector capable of exerting a selectively variable contact force

(57) An electrical connector (11) for mating with a male contact of a mating connector is capable of exerting a selectively variable contact force. The electrical connector (11) includes a conducting member (20) having a lead (26) and a contact beam (24a, 24b) electrically coupled to the lead (26). The contact beam (24a, 24b) is adapted to resiliently engage the male contact. The electrical connector (11) further comprises a contact housing (15). At least a portion of the lead (26) is disposed within the contact housing (15). At least a portion of the contact beam (24a, 24b) is disposed within the contact housing (15) so that the contact beam (24a, 24b) is urged into and restrained by the contact housing (15) when the contact beam (24a, 24b) resiliently engages the male contact. A contact force is thereby generated between the contact beam (24a, 24b) and the contact pin (28). The contact housing (15) is capable of being selectively positioned in relation to the contact beam (24a, 24b) so that a point of restraint on the contact beam (24a, 24b) is selectively variable. The contact force between the contact beam (24a, 24b) and the male contact can thereby be varied on a selective basis.

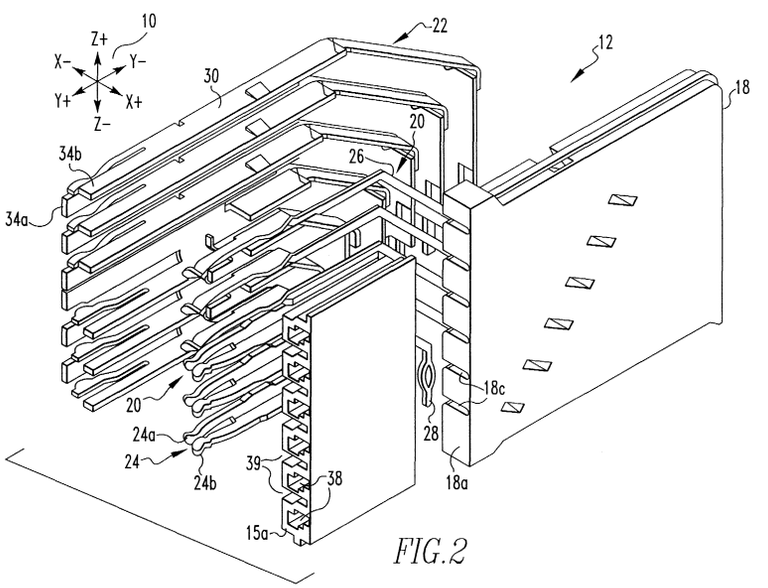

FIG.2

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Description

[0001] The present invention relates generally to electrical connectors. More particularly, the invention relates to an electrical connector that is capable of exerting a contact force that can be selectively varied.

[0002] Electrical connectors typically incorporate one or more conductive contacts. The contacts are typically mated to the contacts of another connector to establish an electrical path between the connectors. For example, a common receptacle-type connector may incorporate one or more contact beams that slidably engage a male contact of a mating connector, thereby forming a conductive path between the connectors.

[0003] Mating first and second electrical contact gives rise to a contact force between the respective contacts. Establishing an appropriate contact force between the contact pair is critical to the proper operation of the connectors. For example, the contact force must be large enough to ensure that the contacts tightly engage. Insufficient engagement can result in poor electrical conductivity (and high signal losses). Excessive contact force, however, can lead to several problems. For example, high contact forces can make it difficult to mate the connectors, and can damage the contacts. High contact forces can also inhibit the removal of the male contact from the mating connector. This problem is particularly troublesome in unmating connectors that incorporate large numbers of contacts, as the contact forces associated with each individual contact can combine to generate excessive insertion and removal forces.

[0004] Furthermore, high contact forces can produce excessive wiping action during insertion and removal of the male contact. Excessive wiping action can result in premature wear of the contacts. Excessive wiping action can also erode the various coatings that are commonly applied to contacts, e.g., gold plating.

[0005] Hence, the contact force generated by a given connector pair must be considered when deciding whether the connector pair is appropriate for a particular application. For example, certain applications may require very low signal losses. A connector pair that generates a relatively large contact force may be appropriate for such applications, particularly where frequent insertion and removal of the male contact is not anticipated. Conversely, a connector pair that generates a relatively low contact force may be appropriate where frequent insertion and removal of the male contact will occur, and where minimal signal losses are not an absolute necessity.

[0006] Conventional connectors produce a fixed, i.e., non-variable, contact force. Hence, different types of connectors must be utilized in applications that require different contact forces. A connector manufacturer must therefore produce a different type of connector for each application that requires a different contact force. This is true even where all of the other requirements for the connector are identical, e.g., overall size, number and type of individual contacts, etc.

[0007] The above discussion illustrates the current need for a connector that is capable of exerting a contact force that can be varied among different values. Such a connector could be used in a variety of different applications that each require different amounts of contact force, thereby eliminating the need to produce different types of connectors for each of the various applications.

[0008] Utilizing a single connector configuration in a variety of different applications can lead to potentially significant cost savings. For example, manufacturing costs can be lowered by reducing the number of different hardware configurations that need to be produced for a given number of applications. Savings in inventory, packaging, and marketing-related expenses can also be realized by using a single type of connector in place of multiple connector types. Also, the use of a connector that is capable of exerting a variable contact force can allow the contact force to be more closely tailored to an optimal value than may otherwise be possible.

[0009] A first object of the present invention is to provide an electrical connector that is capable of exerting a contact force that can be selectively varied.

[0010] A second object of the present invention is to provide a method of adjusting a spring rate of a contact in an electrical connector.

[0011] A third object of the present invention is to provide a kit for making an electrical connector.

[0012] In accordance with the first object, a presently-preferred embodiment of the invention provides an electrical connector for mating with a male contact of a mating connector. The connector module comprises a conducting member including a lead and a contact beam electrically coupled to the lead. The contact beam is adapted to resiliently engage the male contact. The connector module further comprises a contact housing. At least a portion of the lead is disposed within the contact housing. At least a portion of the contact beam is disposed within the contact housing so that the contact beam is urged into and restrained by the contact housing when the contact beam resiliently engages the male contact. A contact force is thereby generated between the contact beam and the contact pin.

[0013] The contact housing in one particular preferred embodiment is capable of being selectively positioned in relation to the contact beam so that a point of restraint on the contact beam is selectively variable. The contact force between the contact beam and the male contact can thereby be varied on a selective basis.

[0014] Further in accordance with the above-noted object, another presently-preferred embodiment of the invention provides an electrical connector for mating with a male contact of a mating connector. The electrical connector comprises a conducting element having a lead. The conducting element also includes a contact beam having a first end that is fixedly coupled to the lead. The contact beam also has a second free-standing end for resiliently engaging the male contact so that the

contact beam deflects when the contact beam engages the male contact.

[0015] The electrical connector further comprises a housing that is adapted to inhibit the deflection of the contact beam by restraining the contact beam at a point of restraint located between the first and the second ends of the contact beam, whereby a contact force is generated between the contact beam and the male contact and the contact force is dependent upon the location of the point of restraint on the contact beam.

[0016] In accordance with the second object, a presently-preferred method of adjusting a spring rate of a contact in an electrical connector before the connector engages a mating connector comprises the step of providing an electrical connector with a housing and a deflectable contact, the housing being positionable relative to the contact at a plurality of positions. The preferred method further comprises the step of positioning the housing at a predetermined one of the plurality of positions, wherein the predetermined position of the housing determines the spring rate of the contact.

[0017] In accordance with the third object, a presently-preferred embodiment of the invention provides a kit for making an electrical connector having a contact with a predetermined spring rate. The kit comprises a plurality of housings and a deflectable contact mountable to any one of the plurality of housings to form an electrical connector, wherein the housings can engage the contact to provide a predetermined spring rate to the contact, and each one of the housings provides a different predetermined spring rate.

[0018] The foregoing summary, as well as the following detailed description of a presently preferred embodiment, is better understood when read in conjunction with the appended drawings. For the purpose of illustrating the invention, the drawings show an embodiment that is presently preferred. The invention is not limited, however, to the specific instrumentalities disclosed in the drawings. In the drawings:

Fig. 1 is a side view of an electrical connector in accordance with the present invention;

Fig. 2 is an exploded perspective view of a connector module of the electrical connector shown in Fig. 1;

Fig. 3 is another exploded perspective view of the connector module shown in Fig. 2;

Fig. 4 is a top perspective view of a contact portion of the connector module shown in Figs. 2 and 3;

Fig. 5 is a top perspective view of a forward portion of a contact housing of the connector module shown in Figs. 2 and 3;

Fig. 6A is a forward-side view of the contact housing shown in Fig. 5 located in a rearward position on the electrical connector shown in Fig. 1;

Fig. 6B is a forward-side view of the contact housing shown in Figs. 5 and 6A with the contact housing located in an intermediate position on the electrical connector shown in Fig. 1;

Fig. 6C is a forward-side view of the contact housing shown in Figs. 5, 6A, and 6B with the contact housing located in a forward position on the electrical connector shown in Fig. 1;

Fig. 7A is a side view of the contact portion shown in Fig. 4 and a cam surface of the contact housing shown in Figs. 5 and 6A-6C, with the contact housing positioned as depicted in Fig. 6A;

Fig. 7B is a side view of the contact portion shown in Figs. 4 and 7A and a cam surface of the contact housing shown in Figs. 5 and 6A-6C, with the contact housing positioned as depicted in Fig. 6B;

Fig. 7C is a side view of the contact portion shown in Figs. 4, 7A, and 7B and a cam surface of the contact housing shown in Figs. 5 and 6A-6C, with the contact housing positioned as depicted in Fig. 6C;

Fig. 8 is a side view of the contact portion shown in Figs. 5 and 7A- 7C engaging a male contact;

Fig. 9 is a top perspective view of an alternative embodiment of the electrical connector shown in Figure 1;

Fig. 10A is rear perspective view of an outer contact housing of another alternative embodiment of the electrical connector shown in Figure 1;

Fig. 10B is a side view of the outer contact housing shown in Fig. 10A;

Fig. 11A is a side view of the outer contact housing shown in Figs. 10A and 10B about to engage a contact housing;

Fig. 11B is a side view of the outer contact housing shown in Figs. 10A, 10B, and 11A partially engaging the contact housing shown in Fig. 11 A; and

Fig. 11C is a side view of the outer contact housing shown in Figs. 10A, 10B, 11A, and 11B fully engaging the contact housing shown in Figs. 11A and 11B.

[0019] A presently-preferred embodiment of the invention is illustrated in Figures 1 through 8. The figures are each referenced to a common coordinate system 10 shown in each illustration. The invention provides an electrical connector 11 formed by a plurality of connector modules 12. The electrical connector 11 is adapted to mate with one or more male contacts of a mating connector. The electrical connector 11 also comprises an electrically insulative main housing 13. The connector modules 12 are at least partially disposed within the main housing 13, as explained in detail below.

[0020] Each of the connector modules 12 comprises a contact housing 15, an overmold 18, a plurality of conducting members 20, and a ground assembly 22 (see Figures 2 and 3). The conducting member 20 is formed from an electrically-conductive material. The conducting member 20 comprises a contact portion 24 (see Figure 4). The contact portion 24 includes a side contact beam 24a, a lower contact beam 24b, and a rearward portion 24c. Preferably, the contact beam 24a, the lower contact beam 24b, and the rearward portion 24c are unitarily

formed. The rearward portion 24c has a substantially L-shaped cross section. The contact beams 24a and 24b extend from the rearward portion 24c, and are disposed in substantially parallel orientations.

[0021] The side contact beam 24a includes a contact tab 24d (see Figure 4). The lower contact beam 24b likewise includes a contact tab 24e. The contact tabs 24d and 24e form the forward ends of the respective contact beams 24a and 24b. (The "forward" and "rearward" directions correspond respectively to the y^+ and y^- directions denoted on the coordinate system 10.) A cam surface 24f is formed on an upper edge 24g of the rearward portion 24c. A cam surface 24h is likewise formed on a side edge 24i of the rearward portion 24c. The significance of the cam surfaces 24h and 24j is discussed below.

[0022] The contact member 20 further comprises a signal lead 26 and a contact pin 28 (see Figures 2 and 3). A first end of the signal lead 26 is mechanically coupled to the contact pin 28. An opposing second end of the signal lead 26 is mechanically coupled to the rearward portion 24c of the contact portion 24. This arrangement forms an electrical path between the contact pin 28 and the contact portion 24. Each signal lead 26 includes one or more bends that cause the contact portions 24 and the contact pins 28 to extend in substantially perpendicular directions.

[0023] The ground assembly 22 is formed from an electrically-conductive material. The ground assembly 22 includes a plurality of ground leads 30 (see Figures 2 and 3). Each ground lead 30 adjoins one or more adjacent ground leads 30. A first end of each ground lead 30 is mechanically coupled to a contact pin 32. An opposing second end of each ground lead 30 is mechanically coupled to a first ground contact 34a and a second ground contact 34b. This arrangement electrically couples the contact pin 32 and the ground contacts 34a and 34b. Each ground leads 30 includes one or more bends that cause the ground contacts 34a and 34b lie substantially perpendicular to the contact pins 32.

[0024] The overmold 18 is formed from an electrically insulative material such as plastic. The overmold 18 has a forward face 18a and a lower face 18b (see Figures 2 and 3). The forward face 18a and the lower face 18b are disposed in substantially perpendicular orientations. The overmold 18 is molded around the signal leads 26 of the contact member 20. More particularly, the overmold 18 partially encloses the signal leads 26 so that a portion of each signal lead 26 and the corresponding contact portion 24 extend away from the forward face 18a and the contact pins 28 extend away from the lower face 18b.

[0025] The overmold 18 includes a plurality of grooves 18c (see Figure 3). The grooves 18c extend between the forward face 18a and the lower face 18b. Each ground lead 30 of the ground assembly 22 is partially disposed within a corresponding groove 18c. A portion of each ground lead 30 and the corresponding ground contacts 34a and 34b extend away from the forward face 18a of the overmold 18 when the ground leads 30 are partially disposed within the grooves 18c. In addition, the contact pins 32 of the ground assembly 22 extend away from the lower face 18b of the overmold 18 when the ground leads 30 are so disposed.

[0026] Each overmold 18 can accommodate six conducting members 20 and six ground assemblies 22. Alternative embodiments of the overmolds 18 may accommodate any desired number of conducting members 20 and ground assemblies 22. The contact portions 24 of the conducting members 20 in each connector module 12 are substantially vertically aligned (see Figures 2, 3 and 6A-6C). The contacts 34a and 34b of the ground assemblies 22 in each connector module 12 are likewise substantially vertically aligned. The connector module 12 is shown in a single-ended arrangement. Alterative embodiments of the connector module 12 may comprise two columns of ground contacts 34a, 34b and two columns of contact portions 24 for a differential-pair arrangement.

[0027] The exemplary electrical connector 11 includes thirteen of the connector modules 12 disposed in a side-by-side arrangement. In other words, the connector modules 12 are positioned so that the forward faces 18a of the overmolds 18 are substantially co-planar, and the lower faces 18a of the overmolds 18 are also substantially co-planar. The modules 12 are then inserted into the larger main housing 13 to form the electrical connector 11. The main housing 13 of the exemplary embodiment encloses a portion of the connector modules 12. In particular, the main housing 13 does not enclose the portions of the connector modules 12 forward of the overmolds 18 (see Figure 1). The remaining portions of the connector modules 12 are substantially enclosed by the main housing 13. Alternative embodiments of the main housing 13 may be sized so that the main housing 13 encloses a substantial entirety of the connector modules 12. Further variants of the main housing 13 are discussed in detail below.

[0028] Structural details relating to the contact housing 15 are as follows. Figures 1, 3 and 6A-6C show the contact housing 15 installed on the connector module 12. The contact housing 15 is also depicted in Figure 2.

[0029] A plurality of passages 38 are formed within the contact housing 15 (see Figures 2, 3, and 6A-6C). Figure 5 is a detailed diagrammatical illustration showing one of the passages 38. Each passage 38 is defined by a top wall 38a, an opposing bottom wall 38b, a first side wall 38c, and a second side wall 38d that opposes the first side wall 38c. A cam surface 38e is formed on the bottom wall 38b (see Figure 5). The significance of this feature is discussed in detail below. Each passage 38 extends between (and through) a forward edge 15a and a rearward edge 15b of the contact housing 15. The passages 38 are arranged so that the vertical spacing between the individual passages 38 substantially matches the vertical spacing between the contact por-

tions 24 of the contact members 20. The function of the passages 38 is explained below.

[0030] The contact housing 15 defines a plurality of troughs 39 (see Figures 2, 3, and 6A-6C). The troughs 39 are positioned between the passages 38. Each trough 39 extends between (and through) the forward and rearward edges 15a and 15b of the contact housing 15. The function of the troughs 39 is discussed in detail below.

[0031] The contact housing 15 engages the contact portions 24 of the conducting member 20. In accordance with the present invention, the contact housing 15 can be variably positioned in relation to the contact beams 24a and 24b. This feature permits the contact force between each lower contact beam 24b and a corresponding male contact of a mating connector to be selectively varied, as explained in detail below.

[0032] The contact housing 15 is engaged with the contact portions 24 by aligning each of the passages 38 with one of the contact portions 24 of the conducting members 20. An insertion force is subsequently applied to the contact housing in the rearward (y^-) direction. The insertion force causes the contact portions 24 to become disposed within the passages 38. In addition, the ground contacts 34a and 34b become disposed within the troughs 39.

[0033] The passages 38 are sized so that the cam surface 24f of each side contact beam 24a slidably engages the top wall 38a of a respective passage 38 as the contact housing 15 is mated to the contact portions 24. In addition, the cam surface 24h of each lower contact beam 24b slidably engages the side wall 38c of a respective passage 38 as the contact housing 15 is mated to the contact portions 24. Frictional forces between the cam surfaces 24g and 24h and the respective passage walls 38a and 38c cause the contact housing 15 to remain in position once the insertion force is removed. Alternatively, the passages 38 may be equipped with detents that engage the cam surfaces and thereby lock the contact housing into one of a limited number of possible positions.

[0034] The cam surface 38e on the bottom wall 38b of each passage 38 slidably engages a corresponding lower contact beam 24b as the contact housing 15 is mated to the contact portions 24. More particularly, each cam surface 38e slidably engages a lower surface 24j of the corresponding lower contact beam 24b (see Figures 7A-7C and 8).

[0035] The cam surface 38e contacts the lower surface 24j at a point of contact 43. The point of contact 43 is dependent upon the relative positions of the contact housing 15 and the contact portions 24. For example, the contact housing 15 can be placed in a forward position as shown in Figure 6C. Positioning the contact housing 15 in this manner causes the point of contact 43 to be located at its forward-most position along the lower contact beam 24b, as shown in Figure 7C. In other words, the point of contact 43 is located in relatively close proximity to the contact tab 24e of the lower contact beam 24 when the contact housing 15 is placed in its forward position.

[0036] The contact housing 15 can also be placed in an intermediate position as shown in Figure 6B. Moving the contact housing 15 from its forward position to an intermediate position increases the distance between the point of contact 43 and the contact tab 24e, as shown in Figure 7B. The contact housing 15 can also be placed in a rearward position (see Figure 6A). Positioning the contact housing 15 in this manner causes the point of contact 43 to be located at its rearward-most position along the lower contact beam 24b, as shown in Figure 7A. In other words, the point of contact 43 is located at its farthest position from the contact tab 24e when the contact housing 15 is placed in its rearward position. The significance of variably positioning the point of contact 43 in this manner is explained in detail below.

[0037] The contact portions 24 of the contact members 20 are adapted to engage a male contact of a mating connector, as noted previously. Figure 8 depicts one of the contact portions 24 mated to a male contact 40 of a mating connector. The contact portion 24 and the male contact 40 are mated by sliding the male contact 40 rearward, in the direction denoted by the arrow 46 in Figure 8. The rearward movement of the male contact 40 causes the contact tab 24e (and the adjacent portion of the lower contact beam 24b) to deflect downward, in the direction denoted by the arrow 48.

[0038] The deflection of the lower contact beam 24b is restrained by the cam surface 38e on the bottom wall 38b of the passage 38. The restraining effect of the cam surface 38e, in conjunction with the resilience of the lower contact beam 24b, causes a contact force to develop between the male contact 40 and the lower contact beam 24b (this force is commonly referred to as the "spring rate" of the contact 40). A contact force also develops between the male contact 40 and the side contact beam 24a. A detailed discussion of this contact force is not necessary to an understanding of the invention. Hence, the contact force between the side contact beam 24a and the male contact 40 will not be discussed in detail.

[0039] The contact force between the lower contact beam 24b and the male contact 40 is dependent upon the location of the point of contact 43 between the lower contact beam 24b and the cam surface 38. More particularly, the downward deflection of the lower contact beam 24b, in conjunction with the restraining effect of the cam surface 38e, causes the contact tab 24e to pivot about the cam surface 38e (and the point of contact 43). The resistance of the contact beam 24b to such rotation is inversely proportional to the moment arm between the location of the applied force (the contact tab 24e) and the point of rotation (the point of contact 43). Hence, the resistance of the contact beam 24b (and the resulting contact force between the male contact 40 and the lower contact beam 24b) can be varied by altering the distance

between the contact tab 24e and the point of contact 43. In other words, the effective beam length of the lower contact beam 24b can be altered by varying the location of the point of contact 43.

[0040] The distance between the contact tab 24e and the point of contact 43 can be varied through the selective placement of the contact housing 15, as explained above. For example, placing the contact housing 15 in its forward position minimizes the distance between the contact tab 24e and the point of contact 43 (see Figures 6C and 7C). Thus, the length of the moment arm between the contact tab 24e and the point of contact 43 is at a minimum when the contact housing 15 is so positioned. The relatively small moment arm causes the lower contact beam 24b to exert a relatively large amount of resistance when the contact tab 24e is deflected downward by the male contact 40. Hence, the contact force between the lower contact beam 24b and the male contact 40 is relatively high when the contact housing 15 is located in its forward position.

[0041] Conversely, placing the contact housing 15 in its rearward position maximizes the distance between the contact tab 24e and the point of contact 43, and thereby maximizes the length of the moment arm between the contact tab 24e and the point of contact 43 (see Figures 6A and 7A). The relatively large moment arm causes the contact tab 24e to rotate about the point of contact 43 with a relatively low amount of resistance when the contact tab 24e is deflected downward by the male contact 40. Thus, the contact force between the contact beams 24 and the male contact 40 is relatively low when the contact housing 15 is positioned in this manner. Placing the contact housing 15 in an intermediate position causes the length of the moment arm to lie between its maximum and minimum values. Hence, the contact force lies between its maximum and minimum values when the contact housing 15 is located in an intermediate position. The contact housing 15 remains at a fixed position relative to the contact 24 once the connector is assembled, thereby producing a uniform spring rate. In other words, the spring rate does not vary after the connector is assembled.

[0042] The invention thus permits the contact force between an array of male contacts such as the contacts 40 and an electrical connector such as the electrical connector 11 to be varied within a range of values using a common hardware configuration. This feature permits a single type of electrical connector to be used in various applications that each require a different amount of contact force. Utilizing a common electrical connector in a variety of different applications offers substantial benefits. For example, the use of a common electrical connector reduces the number of different components that the connector manufacturer must produce. Such reductions can lead to substantially lower production costs.

[0043] In addition, inventory-related expenses to both the manufacturer and the user of the common electrical connector can be lowered by reducing the number of different types of connector modules that need to be tracked and stored prior to use. Also, the costs associated with packaging and marketing a multitude of different connector types can be lowered by the use of the common electrical connector.

[0044] Furthermore, the ability to vary the contact force of the electrical connector can allow the contact force to be more closely tailored to a desired value than may otherwise be feasible. More particularly, an electrical connector that produces a desired amount of contact force may be unavailable for a particular application, thereby necessitating the use of an electrical connector that produces a less-than-optimal amount of contact force. The use of an electrical connector such as the connector 11 permits the contact force to be set within a range of values, as noted above. This feature provides the user of the electrical connector with greater flexibility in choosing the actual contact force, and thereby increases the potential for the contact force to be set at or near its optimal value.

[0045] It is to be understood that even though numerous characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosure is illustrative only, and changes may be made in detail, especially in matters of shape, size, and arrangement of the parts, within the principles of the invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

[0046] For example, the contact force between the side contact beam 24a and the corresponding male contact 40 is not variable in the exemplary electrical connector 11. Alternative embodiments of the invention may incorporate features that permit the contact force between the side contact beam 24a and the male contact 40 to be varied.

[0047] Another possible variant of the invention forgoes the use of the contact housings 15. The contact force between the contact beams 24a and 24b and the respective male contacts 40 of this embodiment is determined by the overall length (x dimension) of each overmold 18. More particularly, each overmold 18 is formed in a manner that causes the contact beams 24a and 24b to extend through the forward face 18a, i.e., the forward face 18a is formed around the rearward portions of the contact beams 24a and 24b. The forward face 18a thereby restrains the contact beams 24a and 24b when the contact beams 24a and 24b are deflected by the respective male contacts 40. The length of the overmold 18 determines the location of the forward face 18a in relation to the contact beams 24a and 24b. Hence, the length of the overmold 18 determines the points of restraint of the contact beams 24a and 24b and, thus, the respective contact forces between the contact beams 24a and 24b and the male contacts 40.

[0048] Figure 9 shows another possible variant of the present invention. Figure 9 depicts an electrical connec-

tor 11a having a main housing 13a a fixed outer contact housing 49. The electrical connector 11a is otherwise substantially identical to the electrical connector 11. Structure on the electrical connector 11a that is substantially identical to corresponding structure on the electrical connector 11 is described herein using like reference numerals.

[0049] The fixed outer contact housing 49 is positioned over the contact housings 15 and the contact portions 24 of the conducting members 20 after the contact housings 15 have been placed in their desired positions relative to the contact portions 24. The outer contact housing 49 is fixed to the main housing 13a by way of an interlocking latch 13b on the main housing 13a that engages a projection 49a on the outer contact housing 49. Penetrations 49b are formed in a forward edge 49c of the fixed outer contact housing 49 to facilitate access to the contact portions 24 by the male contacts 40.

[0050] A further alternative embodiment is shown in Figures 10A through 11C. Figures 10A through 11C depict a portion of an electrical connector 11b having a movable outer contact housing 50 and contact housings 15c. Each contact housing 15c includes a fin 15d located along an upper surface of the contact housing 15c (see Figures 11A-11C). The electrical connector 11c is otherwise substantially identical to the electrical connector 11. Structure on the electrical connector 11c that is substantially identical to corresponding structure on the electrical connector 11 is described herein using like reference numerals.

[0051] The movable outer contact housing 50 is adapted to enclose the contact housings 15c. The outer contact housing 50 is selectively positionable along with the contact housings 15c. The outer contact housing 50 is placed over the contact housings 15c by sliding the outer contact housing 50 in a rearward direction over the contact housings 15c (the rearward direction is denoted by an arrow 52 shown in Figures 11A and 11B). Grooves 50a defined by an upper inner surface 50b of the outer contact housing 50 slidably engage the fins 15d on the contact housings 15c as the housing 50 is slid rearward.

[0052] The rearward movement of the outer contact housing 50 eventually causes a forward edge 15e of each fin 15d to abut a forward edge 50c of the corresponding groove 50a (see Figure 11C). Continued rearward movement of the housing 50 causes the outer contact housing 50 to drive the contact housings 15c rearward, thereby exposing the contact portions 24 of the conducting members 20. The relative positions of the contact housings 15c and the contact portions 24 can thereby be adjusted by way of selecting the lengths of the grooves 50a in the outer contact housing 50. Hence, the contact force between the contact beams 24b of the contact portions 24 and the male contacts 40 of a mating connector can be controlled by way of the outer contact housing 50.

[0053] A projection (not shown) on the outer contact cover 50 can engage latches on the main housing 13 to retain the contact housings 15c together, as in the previously-described embodiment. Penetrations 50d are formed in a forward edge 50e of the outer contact housing 50 to facilitate access to the contact portions 24 by the male contacts 40.

Claims

1. An electrical connector (11) for mating with a male contact of a mating connector, comprising:

   a conducting member (20) including a lead (24c) and a contact beam (24a, 24b) electrically coupled to the lead (24c), the contact beam (24a, 24b) being adapted to resiliently engage the male contact; and

   a contact housing (15), at least a portion of the contact beam (24a, 24b) being disposed within the contact housing (15) so that the contact beam (24a, 24b) is urged into and restrained by the contact housing (15) when the contact beam (24a, 24b) resiliently engages the male contact, whereby a contact force is generated between the contact beam (24a, 24b) and the contact pin.

2. The electrical connector (11) of claim 1, wherein the contact housing (15) is capable of being selectively positioned in relation to the contact beam (24a, 24b) so that a point of restraint on the contact beam (24a, 24b) is selectively variable, whereby the contact force between the contact beam (24a, 24b) and the male contact is capable of being varied on a selective basis.

3. The electrical connector (11) of claim 2, wherein the contact housing (15) is capable of being positioned in a rearward position, a forward position, and an intermediate position.

4. The electrical connector (11) of claim 1, wherein the contact housing (15) has a cam surface and the contact beam is urged into and restrained by the cam surface (24f) when the contact beam resiliently engages the male contact.

5. The electrical connector (11) of claim 1, wherein the contact beam (24a, 24b) includes a contact tab (24d, 24e) for engaging the male contact.

6. The electrical connector (11) of claim 1, further comprising a connector module (12) comprising the conducting member (20), an overmold (18) enclosing at least a portion of the conducting member (20), and the contact housing (15).

7. The electrical connector (11) of claim 6, further comprising a main housing (13) enclosing at least a portion of the connector module (12).

8. The electrical connector (11) of claim 6, wherein the lead is a signal lead (26) and the connector module (12) further includes a ground assembly (22) having a lead portion.

9. The electrical connector (11) of claim 1, wherein the conducting member (20) further includes a contact pin (28) electrically coupled to the lead (26), the contact pin (28) and the contact beam (24a, 24b) being mechanically coupled to opposing ends of the lead (26).

10. The electrically connector (11) of claim 9, wherein a longitudinal axis of the contact pin (28) is substantially perpendicular to a longitudinal axis of the contact beam (24a, 24b).

11. The electrical connector (11) of claim 6, wherein the connector module (12) includes a plurality of the conducting members (20) and at least a portion of the conducting members (20) are substantially vertically aligned.

12. The electrical connector (11) of claim 11, further comprising a plurality of the connector modules (12) positioned substantially side-by-side.

13. The electrical connector (11) of claim 1, wherein the conducting member (20) includes two of the contact beams (24a, 24b).

14. The electrical connector (11) of claim 4, wherein the contact housing (15) defines a passage for receiving at least a portion of the contact beam (24a, 24b) and the cam surface (24f) is disposed within the passage.

15. The electrical connector (11) of claim 14, wherein the conducting member (20) includes a cam surface (24f) for engaging a wall of the passage so that the portion of the contact beam (24a, 24b) is retained within the passage.

16. The electrical connector (11) of claim 8, wherein the contact housing (15) defines a trough for receiving the lead portion of the ground assembly (22).

17. The electrical connector (11) of claim 8, wherein the ground assembly (22) includes a contact pin (32) coupled to a first end of the lead portion (30) and a ground contact coupled to a second end of the lead portion.

18. An electrical connector (11) according to one of the proceeding claims, wherein

the contact beam (24a, 24b) has a first end fixedly coupled to the lead and a second free-standing end for resiliently engaging the male contact so that the contact beam deflects when the contact beam engages the male contact; and wherein

the housing (15) is adapted to inhibit the deflection of the contact beam (24a, 24b) by restraining the contact beam (24a, 24b) at a point of restraint located between the first and the second ends of the contact beam (24a, 24b), whereby a contact force is generated between the contact beam (24a, 24b) and the male contact and the contact force is dependent upon the location of the point of restraint on the contact beam (24a, 24b).

19. The electrical connector (11) of claim 2, wherein the housing (15) is capable of being positioned in (i) a rearward position so that the point of restraint on the contact beam (24a, 24b) is located proximate the first end of the contact beam (24a, 24b) and the contact force between the contact beam (24a, 24b) and male contact has a minimum value, (ii) a forward position so that the point of restraint on the contact beam (24a, 24b) is located proximate the second end of the contact beam (24a, 24b) and the contact force between the contact beam (24a, 24b) and male contact has a maximum value, and (iii) an intermediate position so that the point of restraint on the contact beam (24a, 24b) is located proximate a center of the contact beam (24a, 24b) and the contact force between the contact beam (24a, 24b) and male contact is greater than the minimum value and less than the maximum value.

20. A method of adjusting a spring rate of a contact in an electrical connector (11) before the connector (11) engages a mating connector, comprising the steps of:

providing an electrical connector with a housing (15) and a deflectable contact (24a, 24b), the housing (15) being positionable relative to the contact at a plurality of positions; and

positioning the housing (15) at a predetermined one of the plurality of positions;

wherein the predetermined position of the housing (15) determines the spring rate of the contact (24a, 24b).

21. The method as recited in 20, further comprising the step of maintaining the predetermined position

while the electrical connector (11) engages the mating connector.

22. A kit for making an electrical connector (11) having a contact (24a, 24b) with a predetermined spring rate, comprising:

a plurality of housings (15); and

a deflectable contact mountable to any one of the plurality of housings (15) to form an electrical connector (11);

wherein the housings (15) can engage the contact to provide a predetermined spring rate to the contact, each one of the housings (15) providing a different predetermined spring rate.

23. The kit as recited in claim 22, wherein the plurality of housings (15) are generally similar and the different predetermined spring rates are achieved by selective positioning of the plurality of housings (15) relative to the contact.

24. The kit as recited in claim 22, wherein each housing (15) is different than the other of the housings.

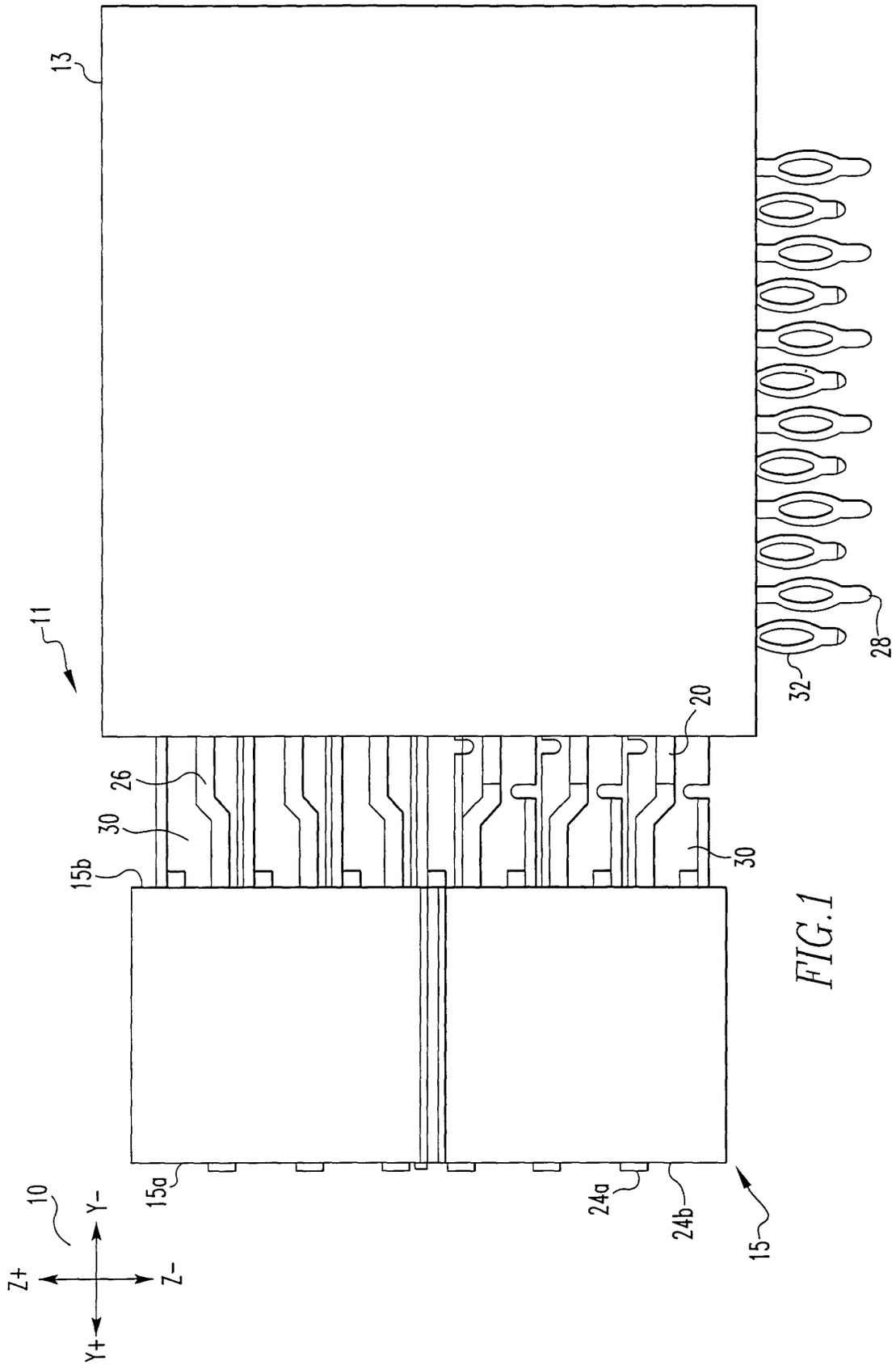

FIG. 1

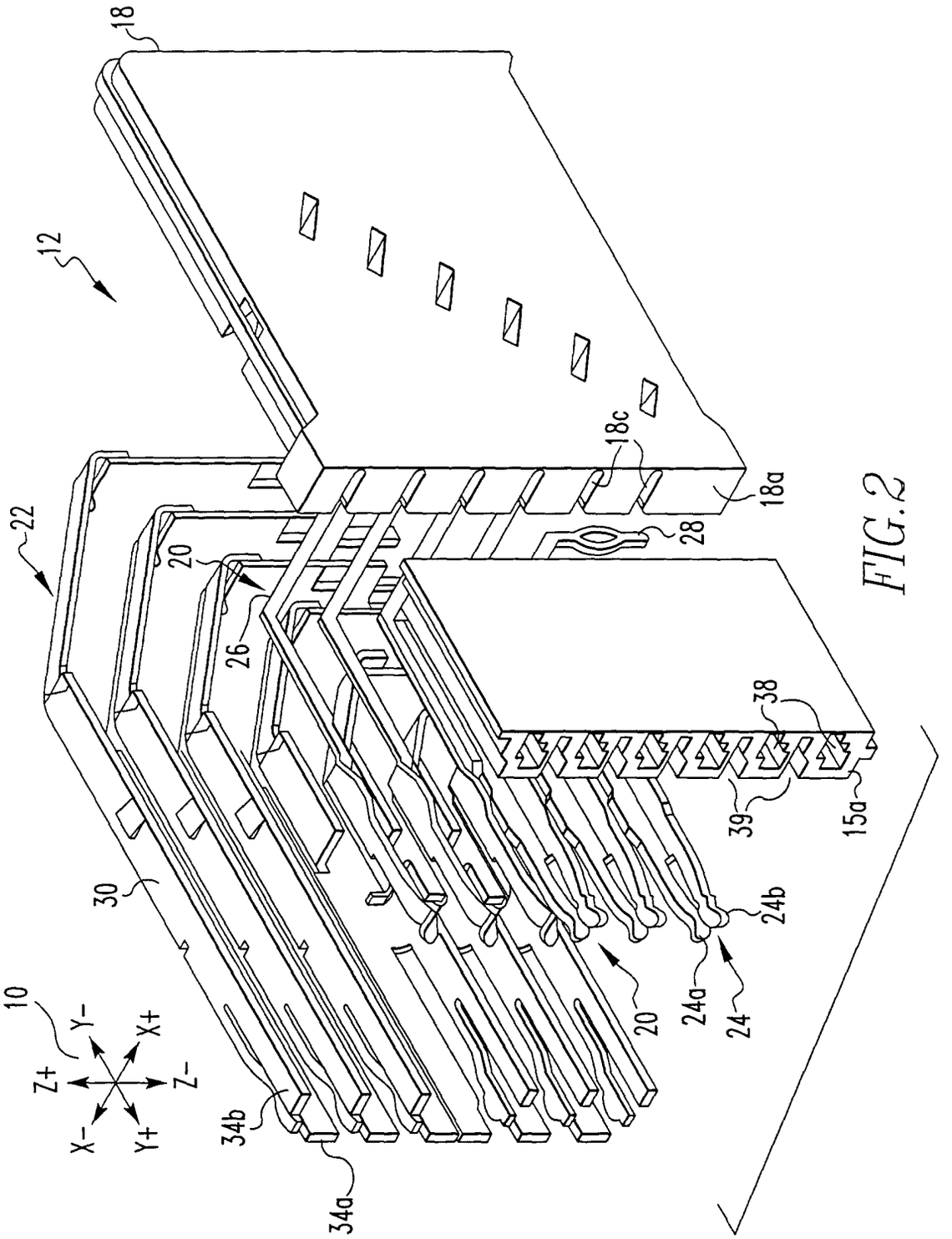
18
12
22
20
26
18c
18a
28
38
39
15a
30
24b
24a
24
20
10
Y-
X+
Z+
Z-
X-
Y+
34b
34a

FIG.2

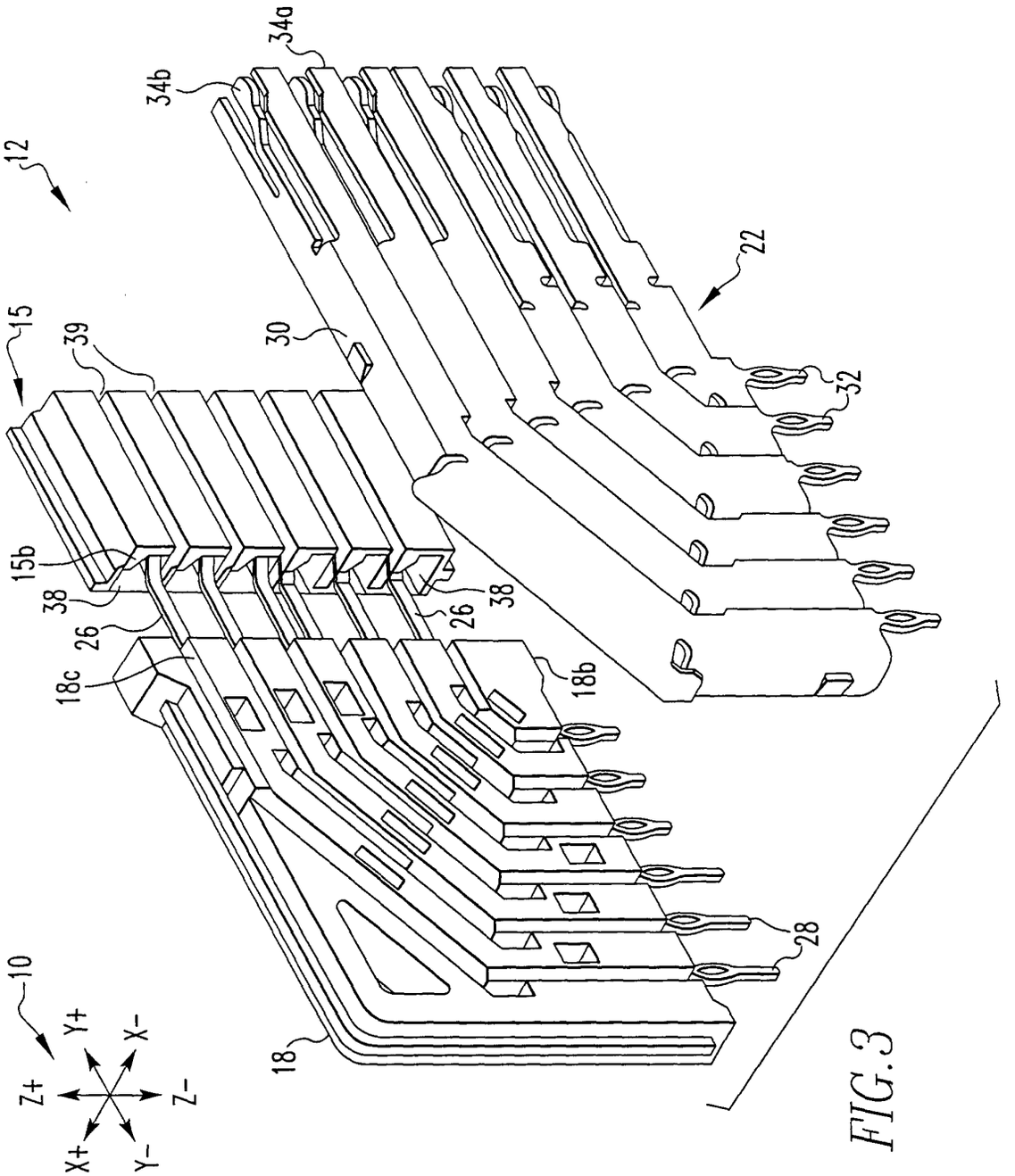

FIG. 3

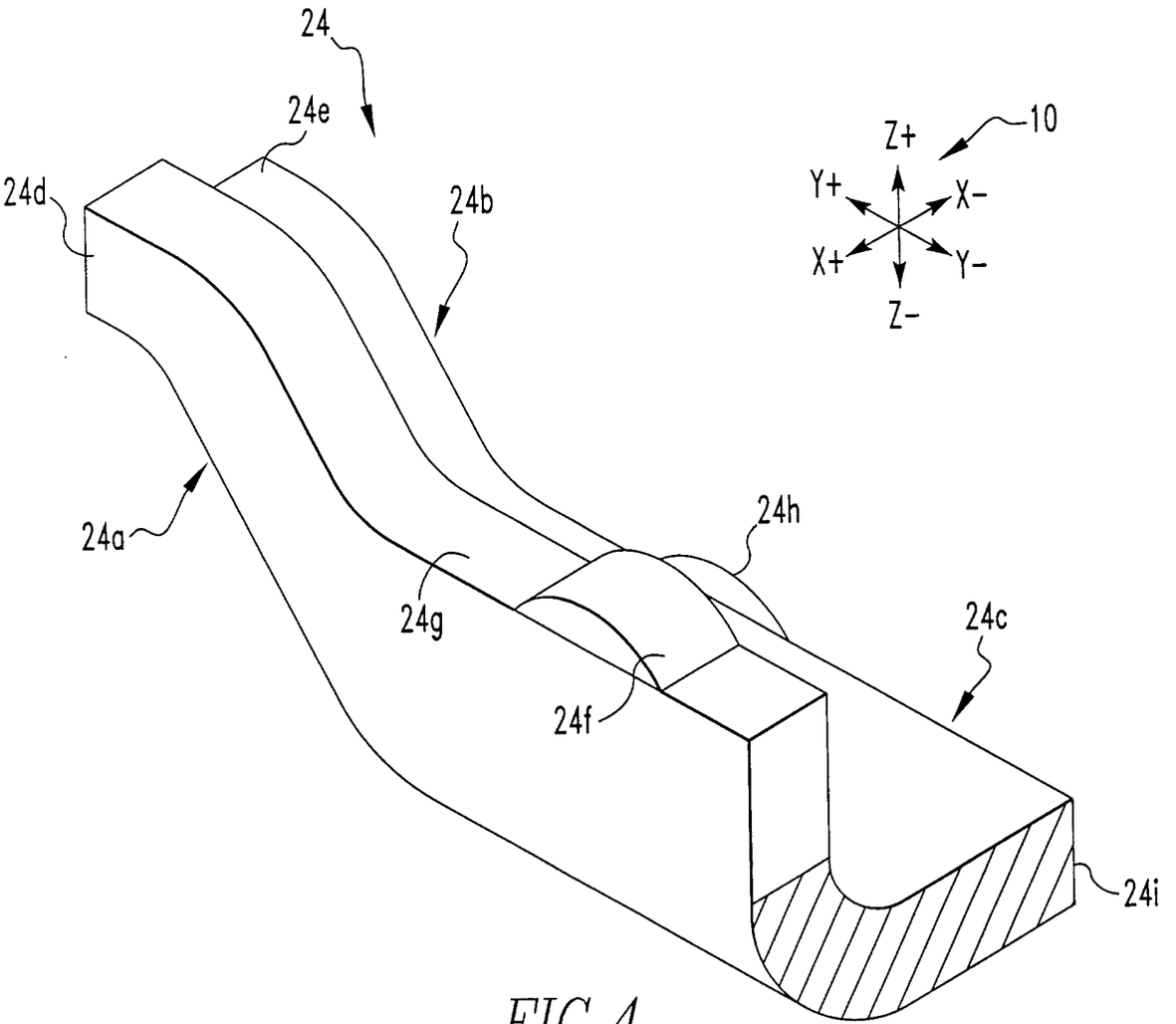

FIG. 4

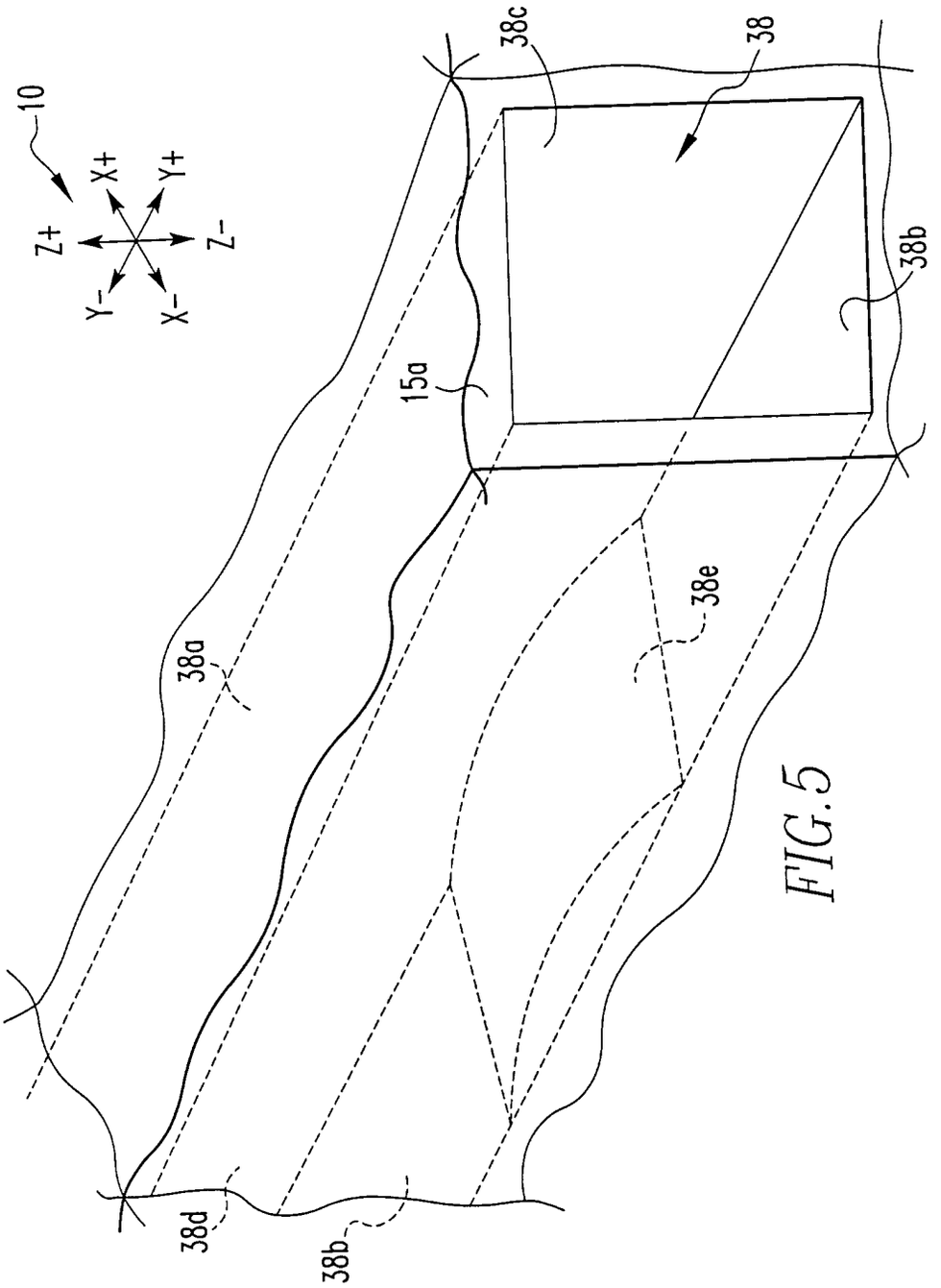

FIG.5

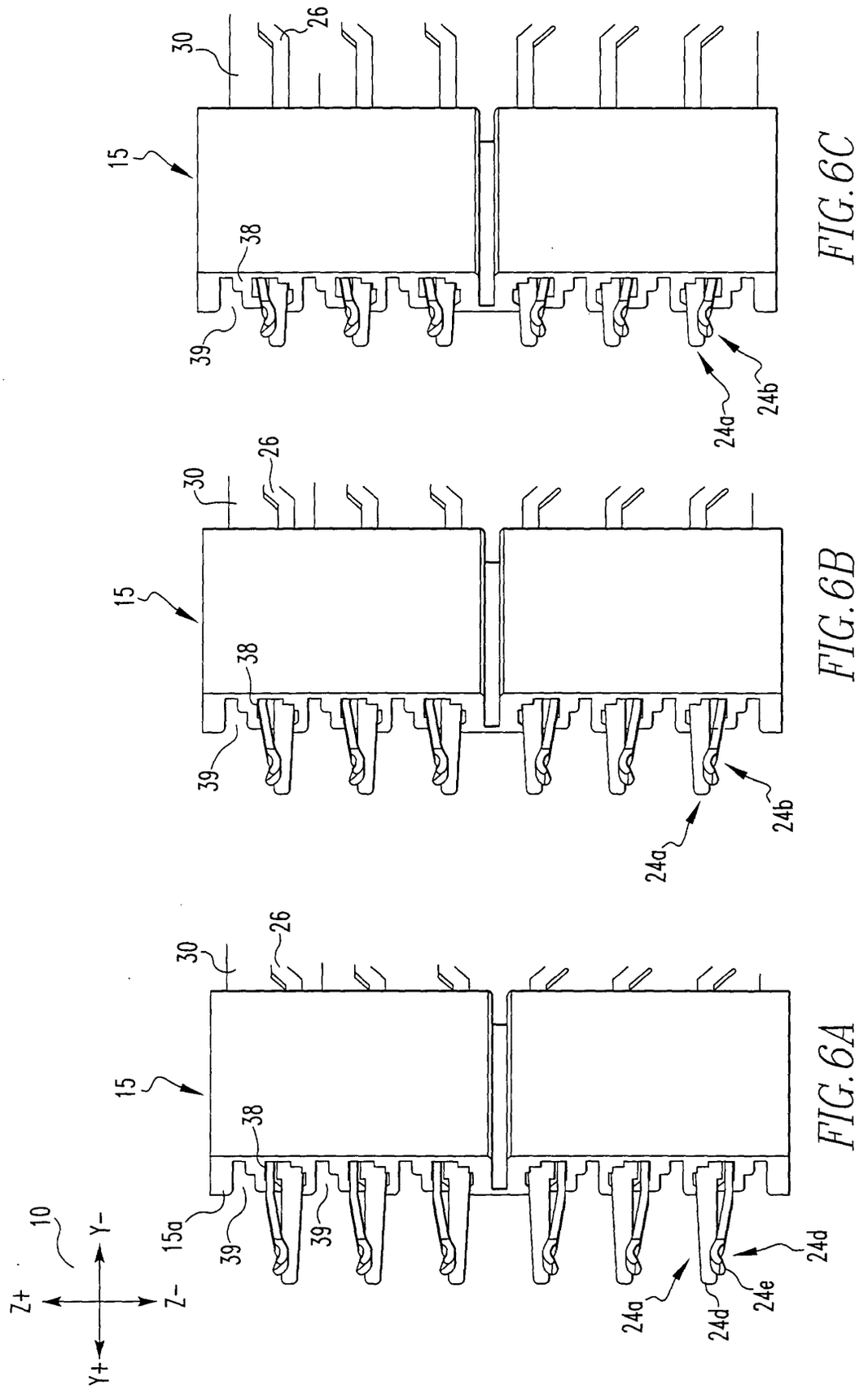

FIG. 6C

FIG. 6B

FIG. 6A

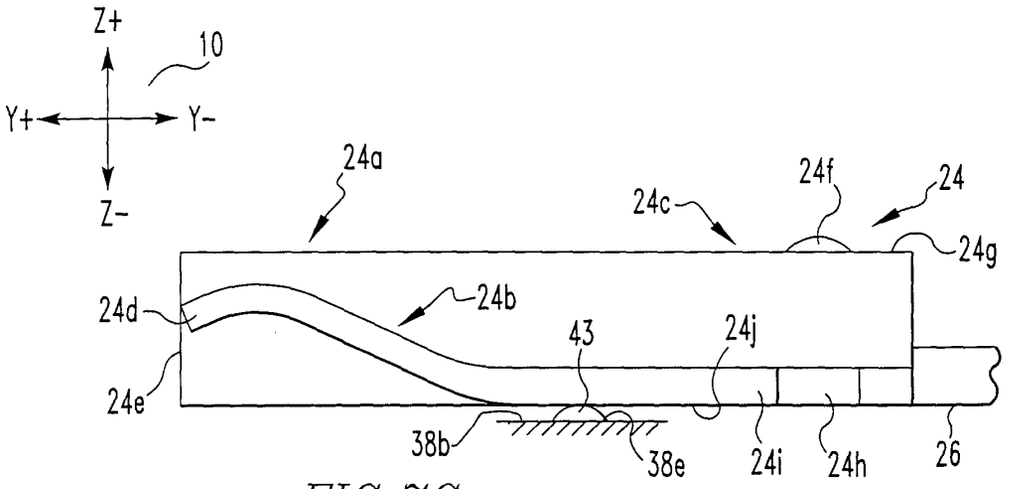

FIG. 7C

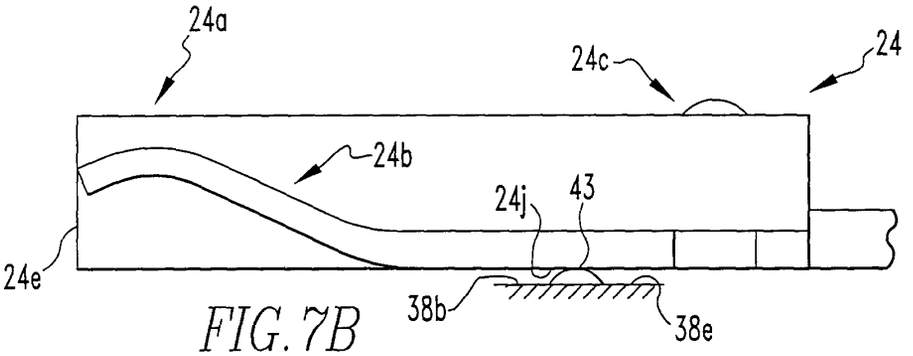

FIG. 7B

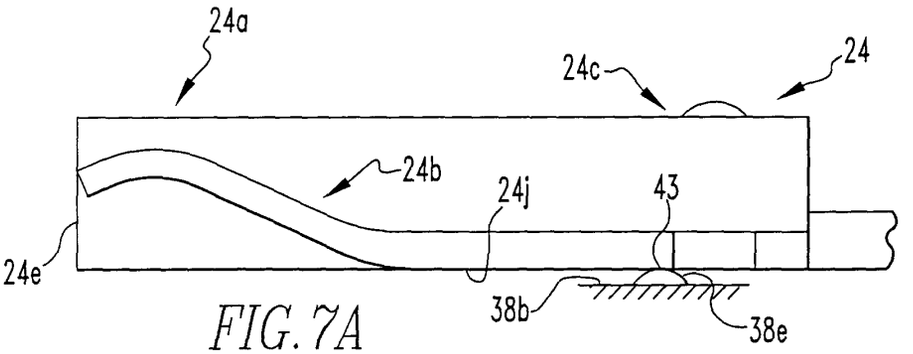

FIG. 7A

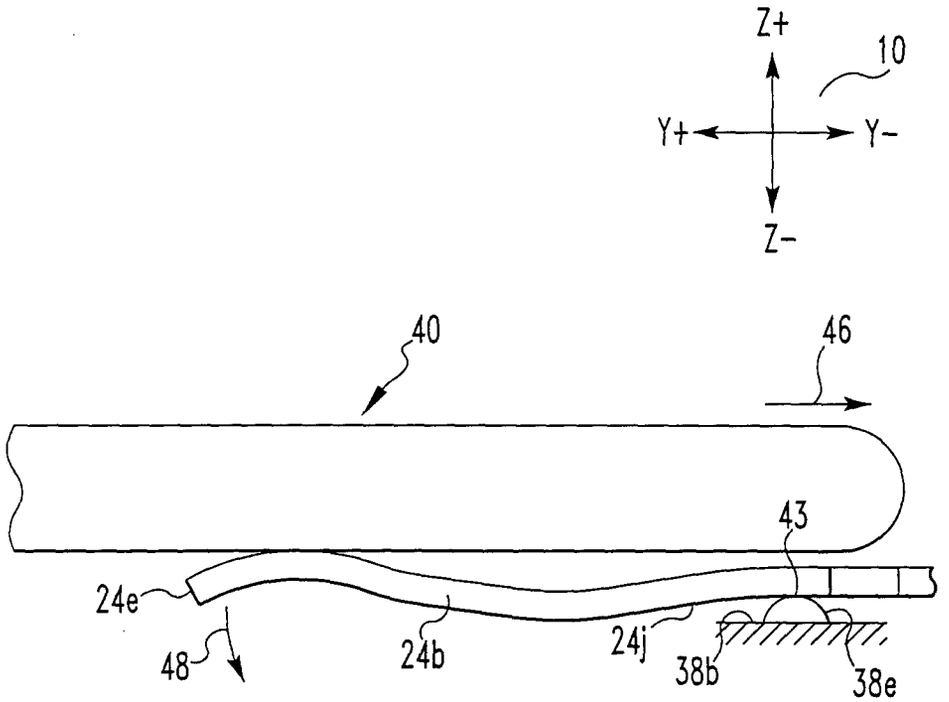

FIG.8

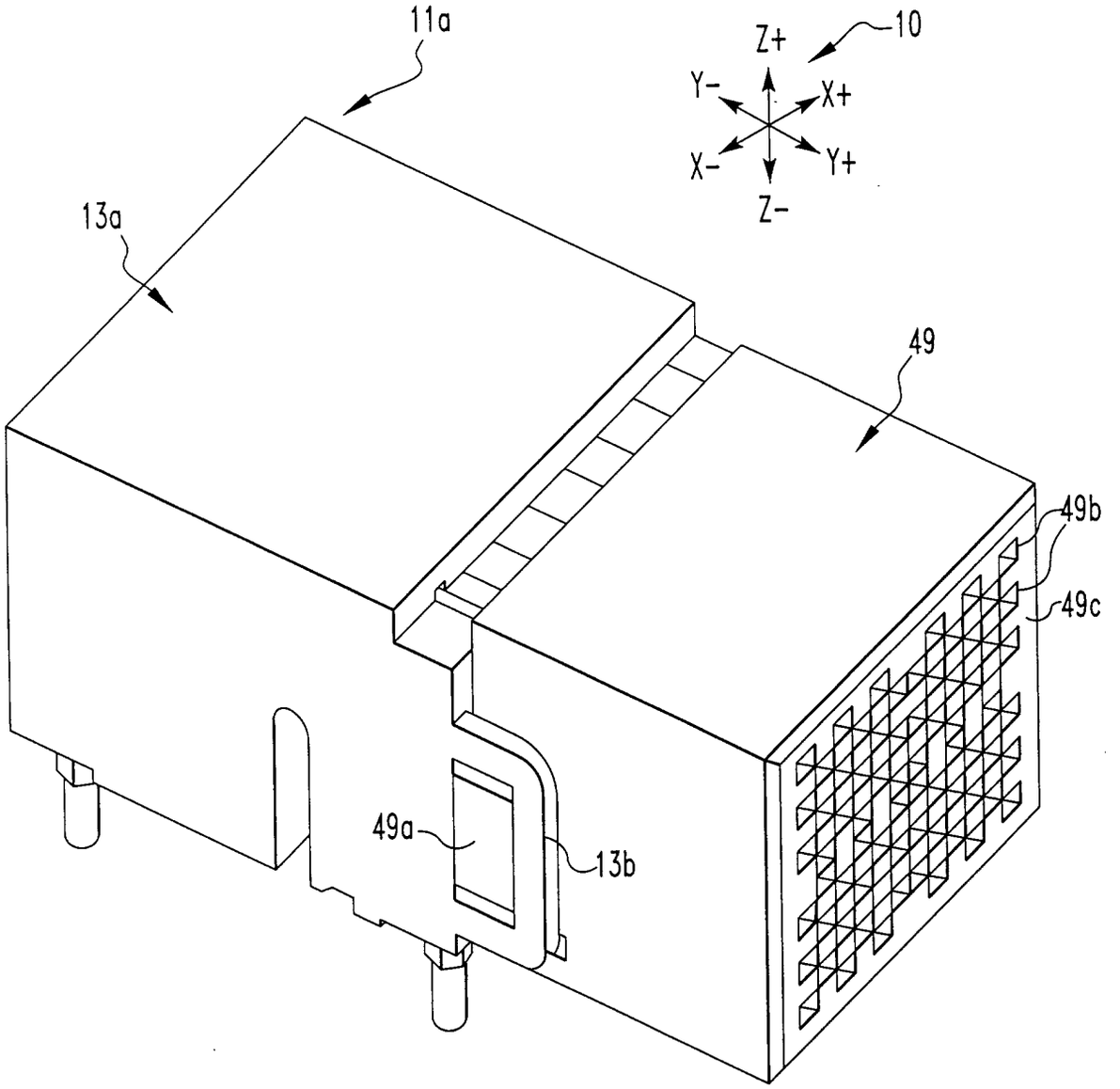

FIG. 9

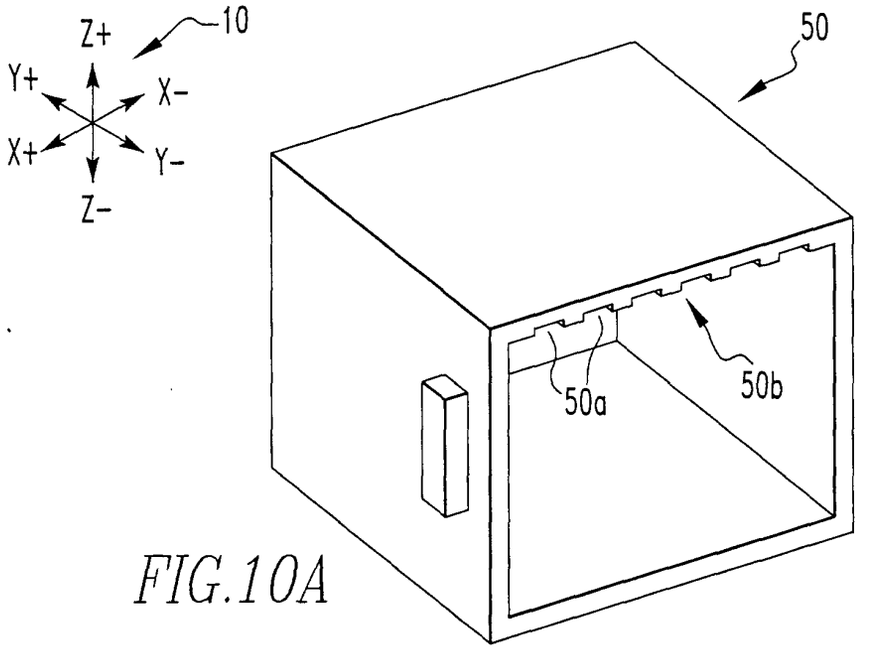

FIG.10A

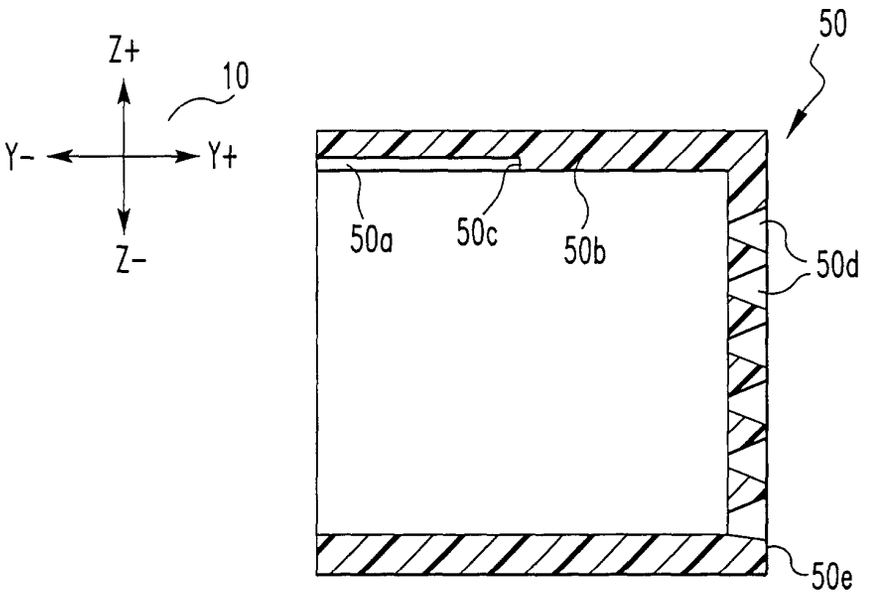

FIG.10B

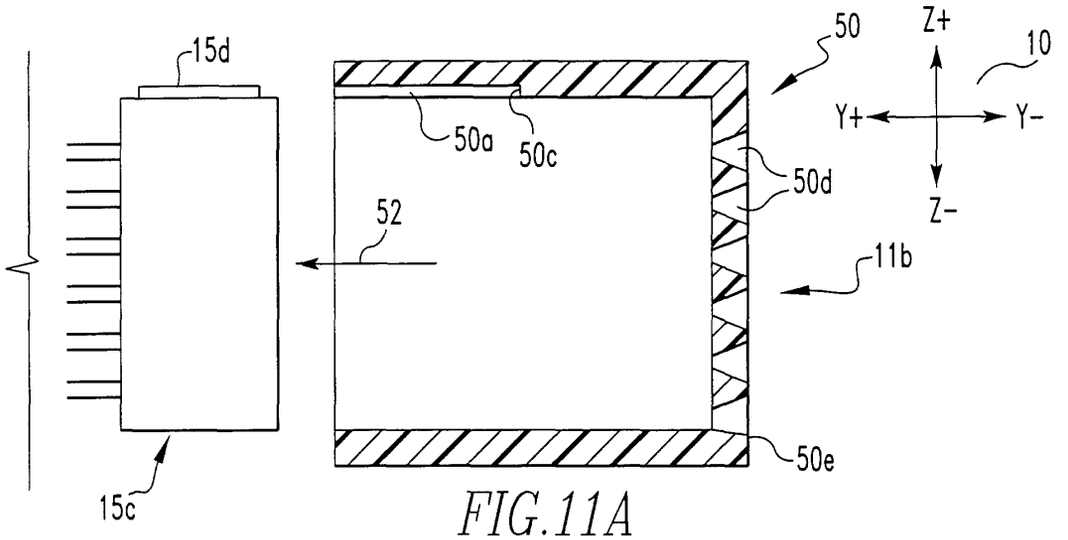

FIG.11A

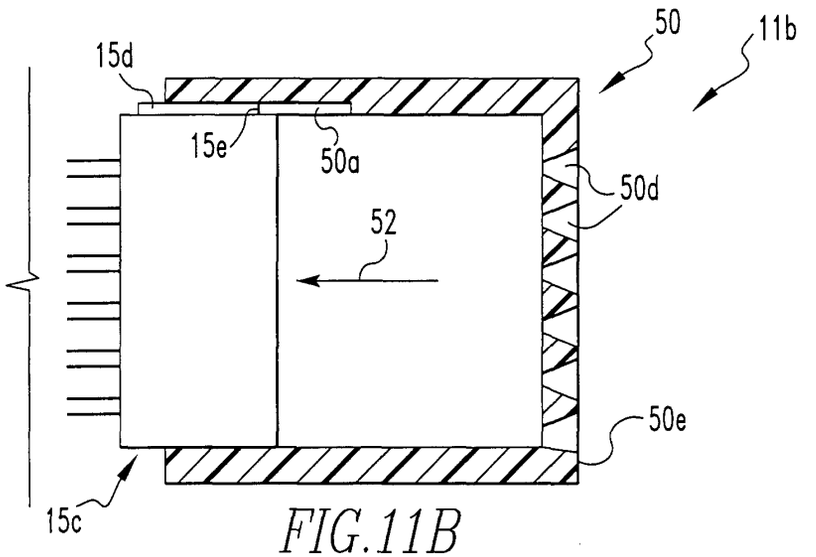

FIG.11B

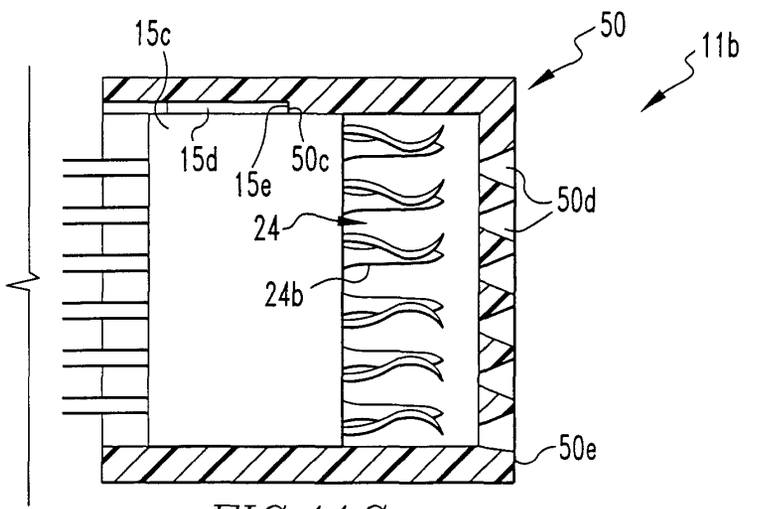

FIG.11C