



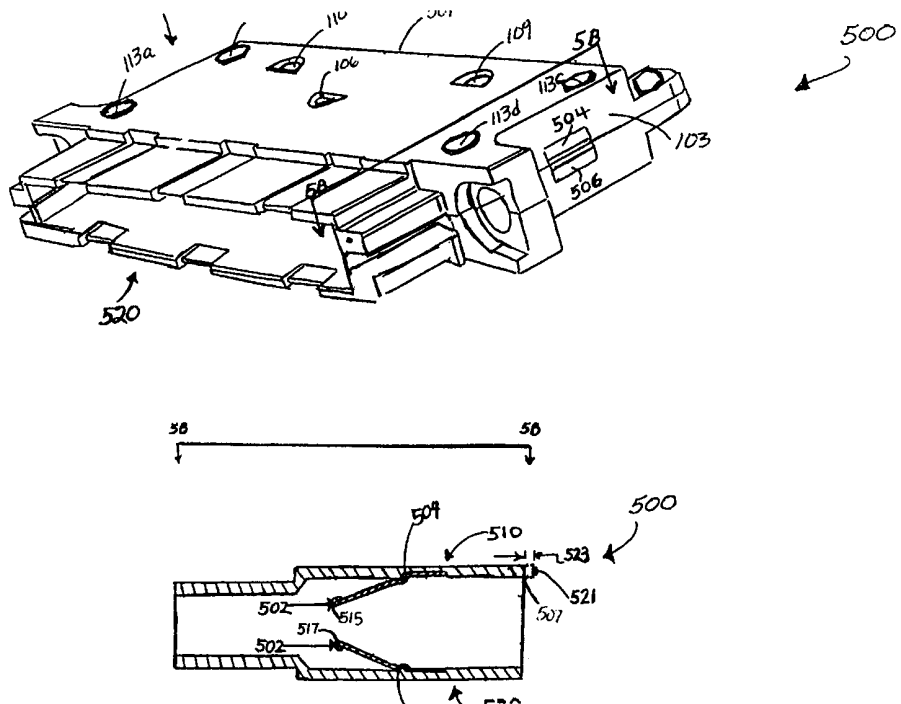
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<p>(21) International Application Number: PCT/US99/11897 (22) International Filing Date: 27 May 1999 (27.05.99) (30) Priority Data: 09/085,311 27 May 1998 (27.05.98) US (63) Related by Continuation (CON) or Continuation-in-Part (CIP) to Earlier Application US 09/085,311 (CIP) Filed on 27 May 1998 (27.05.98) (71) Applicant (for all designated States except US): RAYCHEM CORPORATION [US/US]; 300 Constitution Drive, MS 120/1A, Menlo Park, CA 94025-1164 (US). (72) Inventors; and (75) Inventors/Applicants (for US only): DUTTON, Peter [US/US]; 33120 Gull Court, Fremont, CA 94555 (US). HIGGY, Mohamed, H. [US/US]; 548 Skiff Circle, Redwood City, CA 94065 (US). VALENTA, Jason, T. [US/US]; 207 Vineyard Drive, San Jose, CA 95119 (US). SEATON, Timm [US/US]; 4961 Grange Terrace, Fremont, CA 94555 (US).</p>	<p>(74) Agents: NOVACK, Sheri, M. et al.; Raychem Corporation, Intellectual Property Law Dept., 300 Constitution Drive, MS 120/1A, Menlo Park, CA 94025-1164 (US). (81) Designated States: JP, KR, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>	

(54) Title: ELECTRICAL CONNECTOR WITH SPLIT SHELLS AND RETENTION CLIP AND METHOD OF ASSEMBLING THE CONNECTOR

(57) Abstract

The present electrical connector assembly includes an outer shell capable of receiving at least one electrical contact module. The outer shell works in cooperation with an improved contact module retaining device which secures the electrical contact module within the shell. The combination of the outer shell with the contact module retaining device protects the critical elements of the retaining device from exterior environments, does not interfere with insertion of the module into the shell, and provides for a precise alignment of the module during and after insertion of the module into the shell. In particular, the outer shell is comprised of two half shells which are open during attachment of a contact module retaining device to each of the half shells. The two half shells are joined to form a connector housing after attachment of the module retaining device. The preferred module retaining device is a clip which is attached so that the main body of the clip is in contact with an interior surface of the half shell. The clip is precisely aligned within the half shell using snap fit contacts which hold the clip in position until the half shells are joined, after which the clips may be held in position by contact with the interior surface of the half shell alone. The half shells of the connector assembly may be fabricated from a metal or from a polymer-comprising material.



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1 ELECTRICAL CONNECTOR WITH SPLIT SHELLS AND RETENTION CLIP AND METHOD OF ASSEMBLING THE
2 CONNECTOR

3 BACKGROUND OF THE INVENTION
4

5
6 1. Field of the Invention

7 The present invention relates to the field of electrical connectors, and more
8 particularly to a two-part connector shell assembly which enables the use of a specialized
9 retainer clip. Due to the ability to open the connector shell assembly for insertion of the
10 clip, the clip can be attached to the shell assembly in a manner which provides easy and
11 precise alignment. Further, the clip design provides for load distribution in a manner
12 which reduces stress fatigue. The two-part connector shell assembly may be fabricated
13 from a polymer-comprising material such as a reinforced thermoforming plastic or a
14 reinforced thermosetting plastic, as well as from a metal, due to the ability to mold the
15 individual parts of the connector shell.

16 2. Brief Description of the Background Art

17 Electrical connectors are available in a multitude of different designs, to serve a
18 broad base of requirements. A frequently used design includes a plug and receptacle,
19 each of which includes a contact or terminal module, including a dielectric housing in
20 which contacts or terminals are secured; and a shell member surrounding the housing for
21 physical protection and also for shielding and grounding purposes. Conventional
22 methods for securing the contact module within the protective shell include the use of
23 adhesive materials, locking rings, or other retention hardware.

24 Examples of electrical connectors which are useful in the applications for which
25 the present connector is useful are described below, to provide a background for the
26 present improved connector.

27 U.S. Patent No. 3,993,394 to James Cooper, issued November 23, 1976, discloses
28 a connector half having substantially parallel transverse walls joined by perpendicular

1 sides to provide a substantially rectangular cross-section to receive at least one flat
2 connector wafer inserted therein in a forward axial direction. A transverse rib is formed
3 on an upper face of a wafer facing an inner face of a connector transverse wall. A spring
4 clip cantilevered on the inner face of the connector half is provided. When the wafer is
5 inserted into the connector half, the rib acts as a cam against the spring clip, forcing the
6 spring clip up. The spring clip returns to abut the rear of the rib as the wafer is pushed
7 into position, to retain the wafer in the connector half. A tool is provided for camming
8 the spring clip to allow removal of the wafer.

9 U.S. Patent No. 4,619,490 to Robert Hawkings, issued October 28, 1986,
10 describes a guidance and retention device for terminated connector wafers having a
11 housing and at least one pair of opposed wafer retention members, said members
12 releasably secured to opposed walls of the housing to provide the guidance and retention
13 of rectangular-shaped connector wafers therebetween. The wafer retention members are
14 described as being easily relocated to allow for reorganization of connector wafers and
15 of a wiring array. In particular, these retention members comprise one member
16 releasably connected to a first opposed wall and the other member releasably connected
17 to a second opposed wall, each member having a plurality of guidance portions and
18 retention portions which guide conductor wafers which are inserted in a stacked
19 relationship within the housing.

20 U.S. Patent No. 4,764,130 to Thomas DiClemente, issued August 16, 1988,
21 discloses an electrical connector having a retaining member which has a transverse
22 section seated in an aperture in the connector housing. The forward end of the retaining
23 member is folded back on itself and fits into an opening in the connector housing. A pair
24 of retaining legs extend outwardly from the transverse section to engage an inside surface
25 of the connector housing; these retaining legs work in cooperation with the folded
26 member to hold the retaining member in position within the connector housing. In

1 addition, a second pair of retaining legs extend inwardly into the connector housing
2 passageway to retain the terminal housing in position within the connector housing. The
3 metal shell (connector housing) which surrounds the terminal housing is of a single
4 piece construction, and is used in combination with retaining members are formed from a
5 metal as well, and are described as being stamped and formed from a material having
6 desirable spring characteristics, such as, for example, stainless steel.

7 U.S. Patent No. 4,927,388 to David Gutter, issued May 22, 1990 discloses a
8 single piece protective shell of an electrical connector which includes clip members
9 affixed to the inside of the protective shell, with spring arms of the clips extending
10 forwardly and inwardly to latch behind transverse ribs along the outwardly facing
11 surfaces of the terminal modules inserted into the shell. Each clip includes a pair of
12 outwardly directed tabs along lateral edges of the body section, and the tabs are inserted
13 outwardly through associated longitudinal slits in the shell wall and then bent over along
14 the outward surface of the shell, preferably into recesses to be flush with the outward
15 shell surface. A pair of such clips along the upper inside surface and along the lower
16 inside surface cooperate to retain a pair of terminal modules inserted into the shell.

17 U.S. Patent No. 5,125,854 to Bassler et al., issued June 30, 1992 describes an
18 electrical connector assembly which includes a shield and frame member wherein at least
19 a portion thereof is conductive. A plurality of modular sub-assemblies is mounted in the
20 assembly. A latch mechanism is provided for removably securing each modular sub-
21 assembly to the shield and frame member. The latch mechanism includes a tab which
22 extends from the shield and frame member, wherein the tab has a slot which fits over a
23 projection on the modular sub-assembly.

24 U.S. Patent No. 5,145,411 to Pastal et al., issued September 8, 1992, describes a
25 dielectric insert of an electrical connector retained within a metal shell by a plurality of
26 latching ledges formed integrally with the insert member. The ledges are spaced about

1 the periphery of the outer surface of the insert member, and during insertion into the shell
2 member, these ledges are engaged with corresponding stop surfaces defined along inside
3 surfaces of the metal shell.

4 Many of the electrical connectors described above find use in airline applications,
5 and particularly for signal transmission applications. Due to the criticality of reliable
6 performance, the connectors must meet stringent requirements. The exterior of the
7 connector (the shell) is typically conductive and provides electromagnetic shielding. The
8 connector as a whole is tested for mechanical durability, resistance to chemicals and to
9 salt spray. For example, airline connectors are tested for vibration resistance per military
10 standard MIL-STD-1344, which requires that there be no damage or electrical
11 discontinuity after vibration testing.

12 In addition to the requirements for the exterior shell, the connector must provide a
13 means of securing terminal modules within the shell. The means for securing the module
14 should not interfere with insertion of the module into the shell, should not expose the
15 securing means to the exterior environment in a manner which may cause the securing
16 means to fail, and should provide for a careful alignment of the modules within the shell.
17 This latter feature ensures proper electrical engagement within the connector.

18 Not only must the connector meet the technical requirements specified above, but
19 as always, the cost of manufacturing the connector is an important consideration. In the
20 past, the exterior shell of the connector has typically been machined, due to the difficulty
21 in casting a single-piece exterior shell.

22 SUMMARY OF THE INVENTION

23
24 The present electrical connector assembly includes an outer shell capable of
25 receiving at least one electrical contact module. The outer shell works in cooperation
26 with an improved contact module retaining device which secures the electrical contact

1 module within the shell. The combination of the outer shell with the module retaining
2 device protects the critical elements of the retaining device from exterior environments,
3 does not interfere with insertion of the contact module into the shell, and provides for a
4 precise alignment of the module during and after insertion of the contact module into the
5 shell.

6 In particular, a complete electrical connector includes both a plug and a
7 receptacle, and the following description applies to each. The outer shell is comprised of
8 two halves which are open during attachment of a contact module retaining device to
9 each half shell. The two halves are closed after attachment of the contact module
10 retaining device. Preferably, the shell halves, with contact module retaining device in
11 place, are permanently riveted into the closed configuration. A tool is provided which
12 permits easy release of a contact module, if necessary. Typically the outer shell is
13 rectangular in shape. The two-part outer shell may be fabricated from a metal, typically
14 aluminum which is cadmium or nickel plated, depending on the end use application.
15 When the shell is fabricated from a metal, the shell may be machined, but is preferably
16 cast using standard casting techniques, to save costs. In the alternative, the present two-
17 part, split shell may be fabricated from a polymer-comprising material which may be
18 filled with a conductive material and/or is coated with a conductive material to provide
19 EMI shielding and/or RFI shielding, and for rapid electrostatic discharge. The plastic
20 shell halves are preferably injection molded. The closed, assembled shell with module
21 retaining device(s) in place is capable of encompassing at least the portion of a contact
22 module which contains the contacts and is capable of retaining the module after insertion
23 into the assembled shell.

24 The preferred retaining device which secures the electrical contact module within
25 the shell is a clip. In the preferred embodiment, a clip is attached so that the main body
26 of the clip is in contact with an interior surface of each half of the outer shell. When a

1 contact module (which is generally rectangular) is inserted into the connector assembly,
2 the contact module is held in place by a clip on each opposing side (exterior surface) of
3 the module. Initially (prior to closing of the half shells to form an assembled shell with
4 module retaining device) each clip is attached to the half shell by a snap fit. After the
5 shell is closed and riveted (or otherwise fastened together), the clip is entrapped by the
6 walls of the shell and is secured at the proper position by contact with the surfaces of the
7 closed shell.

8 The retaining clip snap fit includes four (4) mechanical contact points which snap
9 into place and a fifth contact point which is an insert shape which extends through an
10 opening in the half shell and is subsequently bent or folded to lie flat within a recession
11 on the exterior of the half shell. Two of the snap fit contact points work in conjunction
12 with the insert to align and secure the clip against a half shell interior surface relative to
13 the leading end and trailing end of the connector. The remaining two of the snap fit
14 contact points align and secure the clip against the shell half interior surface relative to
15 the side edges of the connector, which together with the leading and trailing ends form
16 the rectangular connector body. The side edge snap fit contact points secure the clip so
17 that it cannot become canted at an angle from side edge to side edge of the shell. This
18 five point positioning (alignment and securing) of the retaining clip within the half shell
19 interior ensures proper alignment of the clip prior to joining together of the two half
20 shells. After joining of the two half shells, the clip is trapped in the proper alignment,
21 ensuring proper alignment of the contact module upon insertion into the shell. This
22 proper alignment is critical in ensuring proper electrical engagement between contact
23 modules when two electrical connector assemblies are joined to produce an electrical
24 connection.

25 Due to the rectangular shape of the preferred embodiment connector and the
26 accurate alignment of the retaining clip within the connector shell, an entirely parallel

1 alignment of connecting electrical contact modules is obtained. This parallel alignment
2 enables proper electrical engagement and ease in sealing of the electrically engaged
3 contact elements from the environment.

4 The use of two half shells each having a module retaining clip attached thereto
5 gives rise to a particular method of fabricating an electrical connector assembly, the
6 method comprising:

7 a) snap fitting a retention clip into contact with an interior surface of a half shell
8 while simultaneously inserting a protrusion from the clip surface through an opening in
9 the half shell;

10 b) mechanically securing the protrusion to the exterior surface of the half shell;

11 c) joining two half shells together to form an assembly comprising an exterior
12 shell having a protective outer surface, with a contact module retaining device on the
13 interior surface of each half shell, wherein the assembly is capable of encompassing at
14 least the portion of an inserted contact module, and is capable of retaining the contact
15 module after its insertion into the assembly.

16 Preferably the snap fitting of the contact module retention clip to the half shell
17 occurs by snap fitting of a first pair of snap fit points which secure the retention clip in
18 the direction of the leading and trailing edges of the connector. Preferably the snap fit
19 points are in the form of pre-bent tabs extending from the upper surface of the clip. The
20 upper surface of the clip is placed adjacent to the interior surface of the half shell, and
21 the pre-bent tabs slide into position against the half shell through openings in the half
22 shell and rest against recessed surfaces on the exterior surface of the half shell. As the
23 pre-bent tabs slide into position, an insert shape, which is preferably a substantially
24 straight tab, is inserted through an opening in the shell, to extend up through to the
25 exterior of the half shell. This provides a three point alignment and a secure attachment
26 of the retention clip to the half shell in the direction from leading edge to trailing edge of

1 the connector assembly. A second pair of snap fit points, which align and secure the
2 retaining clip against the shell half interior surface relative to the side edges of the
3 connector is then snapped into place against the half shell interior surface. Preferably the
4 second pair of snap fit points are in the form of bent arms which snap over a step along
5 the edge of each half shell. Subsequent to snap fitting the second pair of snap fit points,
6 the insert shape (tab) is bent into place against the exterior surface of the half shell,
7 preferably bent into a recessed area on the surface of the half shell. The final result is
8 five point positioning of the retention clip which aligns and secures the clip within the
9 half shell.

10 BRIEF DESCRIPTION OF THE DRAWINGS

11
12 Figure 1A shows a projected top view of a preferred embodiment half shell
13 which makes up the upper half of a preferred embodiment connector housing.

14
15 Figure 1B shows a projected bottom view of the half shell shown in Figure 1A.

16
17 Figure 2A shows a projected interior view of a preferred embodiment module
18 retaining clip which is used in combination with the half shell of Figure 1A, in the
19 manner shown in assembly Figures 3A and 3B. The word interior is intended to mean
20 that a major clip surface as shown in Figures 3A and 3B will be facing the interior of the
21 assembled connector.

22
23 Figure 2B shows a side view of the preferred embodiment retaining clip of
24 Figure 2A, as a cross-section of the clip at the location B -- B. The view also includes
25 the insert tab which is located at the center of the clip, but does not include the bent arm
26 at the end of the clip, for purposes of illustration.

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Figure 2C shows a facial view of the Figure 2A retaining clip from the trailing end (the end from which the wires of the connector extend) of the connector assembly.

Figure 2D shows an expanded view of the outer edge of the retaining clip of Figure 2C, which outer edge forms a snap fit against the outer edge of a half shell.

Figure 3A shows a projected view of the upper half of a preferred embodiment connector assembly, including the upper half shell and cooperating upper module retaining clip.

Figure 3B shows a projected view of the lower half of a preferred embodiment connector assembly, including the lower half shell and cooperating lower module retaining clip. The retaining clip is shown with the leading edge tab bent into its final shape for purposes of illustration only. In fact, prior to snap fitting of the clip against the half shell, the leading edge tab has the configuration shown in Figs. 2A and 2B.

Figure 4 shows a cross-sectional view of a plug and receptacle, each of which utilizes the present invention including the split shell with retention clip.

Figure 5A shows a schematic of a three-dimensional view of the assembled EME (Electro Magnetic Effects) Plug shell connector.

Figure 5B shows a schematic cross-sectional view of the connector of Figure 5A, marked to show the position at which the load is applied during the shell material

1 strength testing, and the deflection dimension measured in accordance with MIL. STD.
2 1344.

4 DETAILED DESCRIPTION OF THE INVENTION

5 The present invention pertains to an electrical connector assembly which includes
6 an outer shell capable of receiving at least one electrical contact module. The outer shell
7 is comprised of two half shells which work in cooperation with each other and an
8 improved module retaining clip to secure the electrical contact module within the shell
9 assembly. Typically two module retaining clips are used in a completed assembly, one
10 clip attached to each half shell. This provides a more secure retention of the contact
11 module and provides a precise alignment of the module both during and after insertion of
12 the module into connector assembly.

13 In particular, the two shell halves are closed after attachment of a module
14 retaining clip to each half shell. Preferably, the half shells, with module retaining clip in
15 place, are permanently riveted or joined with an adhesive, or ultrasonically welded into
16 the closed configuration. The outer shell halves are typically rectangular in shape and
17 may be fabricated from aluminum which is cadmium or nickel plated. In the
18 alternative, the outer shell halves may be fabricated from a polymer-comprising material
19 which is plated with a conductive material.

20 When the shell halves are fabricated from metal, casting (using standard casting
21 techniques) rather than machining is the preferred fabrication method, to reduce costs.
22 Casting is a much less expensive means of fabrication than machining and is particularly
23 cost effective in the present instance where the shell is cast as two separate halves,
24 enabling the use of a simplified mold for casting.

25 When the shell halves are fabricated from a polymer-comprising material,
26 injection molding is a preferred fabrication method in terms of cost. The fabrication cost

1 for a connector injection molded from polymeric material is about 25 % of the cost of a
2 cast metal connector and about 10 % of the cost of a machined metal connector.

3
4 I. DEFINITIONS

5 As a preface to the detailed description, it should be noted that, as used in this
6 specification and the appended claims, the singular forms “a”, “an”, and “the” include
7 plural referents, unless the context clearly dictates otherwise. For example, “a wire” or
8 “a wire bundle” refers to one or more wires or wire bundles and a “contact module”
9 refers to one or more contact modules.

10 Specific terminology of particular importance to the description of the present
11 invention is defined below.

12 The term “connector shell” refers to the wall of a connector assembly which
13 provides at least a protective exterior and which typically but not necessarily provides
14 electromagnetic shielding as well as performing other functional services.

15 The term “connector module” or “contact module” refers to an assembly which
16 includes electrical contacts or terminals. Typically the assembly includes a dielectric
17 material which separates electrically conductive contacts from each other and from the
18 connector housing. The contact module assembly may also include a sealant material
19 designed to prevent the entry of moisture or chemicals into the area of the electrically
20 conductive contacts.

21 The term “electrical connector” refers to a device (plug or receptacle) which is
22 brought into contact with another device (plug or receptacle) in order to make a path
23 through which electrical conduction may occur.

24 The term “insert” or “insert shape”, with reference to a portion of a retaining clip,
25 is intended to mean a protrusion on the surface of the retaining clip which may be

1 inserted into a depression or recession or through an opening in a connector housing or
2 shell, but which does not provide a snap fit against the connector housing.

3 The term "leading end" refers to the end of an electrical connector which
4 contains a transverse face or surface having electrical contacts contained therein and
5 which is attached to another leading end of another electrical connector to form an
6 electrically conductive path between the two connectors.

7 The term "retaining clip" refers to a retaining device which is used to hold a
8 connector module in place once it is inserted within a connector housing.

9 The term "side edge" refers to a longitudinal edge of an electrical connector, two
10 of which, in combination with a leading end and trailing end, form a rectangular-shaped
11 connector.

12 The term "snap fit" with reference to a portion of a retaining clip, is intended to
13 mean a shape on the retaining clip surface which engages with a shape on a surface of a
14 connector housing or shell to fit tightly, providing an attachment point.

15 The term "trailing end" refers to the end of an electrical connector which is
16 opposite the "leading end"; the trailing end is the end from which the wires (which are
17 terminated to the connector electrical contact elements) extend.

18 19 II. THE PREFERRED EMBODIMENT CONNECTOR SHELL ASSEMBLY

20 A cross-sectional view of an electrical connector plug and receptacle, each of
21 which utilize the present invention split shell and retention clip is shown in Figure 4.
22 The principal difference between the paired plug and receptacle, in terms of the split
23 shell, is that the leading edge of the plug is designed to fit into the leading edge of the
24 receptacle. The retention clips are essentially the same. An expanded view of an
25 electrical connector plug including the complete split shell assembly is shown in the
26 combination of Figs. 3A and 3B. Fig. 3A shows the top half of the connector assembly

1 and Fig. 3B shows the bottom half of the connector assembly. The difference between
2 the top half and the bottom half of the connector assembly is minor, being principally a
3 module orientation (guiding and supporting) shape on the interior surface of the
4 connector which does not affect the relationship between the outer split shell and the
5 module retaining device. With this in mind, this disclosure will begin with a detailed
6 description of the top half of the connector assembly, as illustrated in Figs. 1A and 1B.

7 Figure 1A is a projected top view showing the upper surface 102 of the connector
8 assembly top half shell 100. Top half shell 100 is generally rectangular in shape, having
9 a leading end 105, a trailing end 107 and side edges 101 and 103. Top surface 102
10 comprises recessed shape 109, including opening 104; recessed shape 110, including
11 opening 108; and recessed shape 106 having opening 112 (not shown). Snap fit bent tab
12 204 of retaining clip 200 shown in Fig. 2A passes through opening 104 and rests against
13 the recessed surface 109. Snap fit bent tab 208 of retaining clip 200 passes through
14 opening 108 and rests against the recessed surface 110. Tab insert 206 of retaining clip
15 200 passes through opening 112 (not shown on Fig. 1A, but shown as 112 on Fig. 1B)
16 and is subsequently bent to rest against recessed surface 106. These three contact points
17 ensure that retaining clip 200 is properly positioned against the bottom surface 122 of
18 top half shell 100, which is illustrated in the bottom view of top half shell 100 illustrated
19 in Fig. 1B. Bottom surface 122 of top half shell 100 also includes a recessed channel
20 111 in which transverse member 220 of retaining clip 200 rests. Further, recessed
21 surfaces 124 and 128 in raised steps 132 and 134, respectively work in cooperation with
22 snap-fit arms 214 and 218, respectively, to provide a contact location along side edges
23 103 and 101, respectively of top half shell 100. These two snap-fit contact locations
24 prevent retaining clip 200 from becoming canted relative to side edges 103 and 101 of
25 top half shell 100. The combination of the four snap-fit contacts with the one tab insert
26 (which is bent into position after attachment of the retaining clip using the snap-fit

1 contact points) assures that the retaining clip 200 is properly aligned with respect to top
2 half shell 100. In addition, a load applied to retaining clip 200 is distributed along the
3 entire length of transverse member 200, as retaining clip 200 edge 230, which is opposite
4 module retaining arms 210 and 212 rests against recessed wall 137 of the bottom surface
5 of top half shell 100. Top half shell 100 bottom surface 122 also includes structures 117
6 and 119 which help guide a contact module into an assembled shell assembly and to
7 position the contact module within the assembly as shown in Figure 4, which will be
8 discussed in more detail subsequently.

9 With reference to retaining clip 200 shown in Figure 2A, module holding arms
10 210 and 212 extend from transverse member 200 and act to hold a contact module (not
11 shown) in place after insertion into the interior of the connector assembly as shown in
12 Figure 4.

13 A schematic of a cross-sectional view of the module retaining clip through
14 Section B — B shown on Figure 2A, is provided in Figure 2B. This view shows the
15 various angles and radii which are included in retaining clip 200. The radii R_1 , R_2 , and
16 R_3 , provide clearances for the insertion of a contact module (not shown) into the shell
17 assembly (exploded view shown in Figures 3A and 3B). The angle α must be carefully
18 controlled, to permit proper retention of a contact module within the shell assembly, as
19 shown in Figure 4. The angle β provides clearance for insertion of retention clip 200
20 into split shell top half 100 and contributes to the snap fit of the clip 200 into top half
21 shell 100. The angle λ prevents portions of the clip 200 from hanging down inside the
22 shell assembly in a manner which would catch on a contact module as it is inserted or
23 removed. The portion of the cross-section which would represent snap fit arm 218 in
24 Section B -- B is not shown, to provide for clarity in the description.

25 In particular, angle α , which typically ranges from about 9° to about 15° , and
26 most preferably is about $12 \pm 1^\circ$ provides a spring action for module retaining arm 212

1 of retaining clip 200, when the clip 200 is fabricated from the proper material and is
2 properly attached to the bottom surface 122 of top half shell 100. The material of
3 construction for retaining clip 200 must have a springy quality. The spring action
4 permits the retaining arms 210 and 212 to bend, permitting insertion of a contact module
5 into the connector assembly and then to spring back, holding the contact module in place
6 after insertion. Materials having this springy quality include, for example, but are not
7 limited to, beryllium copper and stainless steel alloys, and reinforced plastic materials
8 having similar mechanical properties to these metallic materials. Most preferably, the
9 retaining clip 200 is fabricated from stainless steel alloys.

10 A retaining clip 200 angle β which falls within a range of about 60° to about
11 70° provides adequate clearance for insertion of retaining clip 200 into split
12 shell top half 100 and contributes to the snap fit of snap fit tabs 204 and 208 against
13 recessed surfaces 109 and 110, respectively. A retaining clip 200 angle γ which falls
14 within a range from 0° to about 10° , is adequate to maintain the retaining clip 200 in
15 its proper resting place within recessed channel 111 so that retaining clip 200 will not
16 interfere with the insertion of a contact module into the shell assembly shown in an
17 expanded view in Figures 3A and 3B.

18 Essentially the same cross sectional schematic as that shown in Section B -- B
19 could be drawn for a section through contact module retaining arm 210 and pre-bent tab
20 204.

21 Figure 2C shows a facial view of retaining clip 200, with emphasis on snap fit
22 arms 214 and 218 which rest upon recessed surfaces 124 and 128 in raised steps 132 and
23 134, respectively. Figure 2D shows the detail of the bend 222 along the outside portion
24 of snap fit arm 214 to form a snap fit contact lever arm 211. This bend 222 provides a
25 set of snap fit contact points. A first contact point occurs where a horizontal portion 216
26 of snap fit arm 214 rests against recessed surface 124 on the interior or bottom surface

1 122 of top half shell 100, and a second contact point occurs where lever arm 211 of snap
2 fit arm 214 rests against a recessed surface (not shown) on side edge 101. Figure 2D
3 shows a Radius R_4 which depends on the dimensions of the retaining clip and the angle
4 λ , which typically ranges about 7° and about 15° . Angle λ and Radius R_4 contribute to
5 the snap fit contacts along edges side 101 and 103 of top half shell 100, as previously
6 discussed.

7 When the surface 219 of the retaining clip 200 is placed adjacent to the interior
8 surface 122 of the top half shell 100, the pre-bent tabs 204 and 208 can be made to slide
9 into position through openings 104 and 108, respectively, in the top half shell 100, and
10 to come to rest against recessed surfaces 109 and 110, respectively on the exterior
11 surface 102 of the half shell 100. As the pre-bent tabs 204 and 208 slide into position,
12 insert tab 206 is inserted through opening 112 in top half shell 100, to extend up through
13 the exterior surface 102 of the top half shell 100. This provides a three point alignment
14 and a secure attachment of the retaining clip 200 to the top half shell 100 in the direction
15 from leading edge 105 to trailing edge 107 of the connector assembly. A second pair of
16 snap fit contacts, which align and secure the retaining clip 200 against the top half shell
17 100 interior surface 122 relative to the side edges 101 and 103 of the connector are then
18 snapped into place. The second pair of snap fit contacts are in the form of snap fit arms
19 214 and 218 which snap into place against the recessed channel 111 on bottom, interior
20 surface 122. A first snap-fit contact is generated where the horizontal portion 216 of
21 snap fir arm 214 rests against recessed surface 124 of channel 111, while the bent
22 portion 211 rests against a recessed surface (not shown) on side edge 103. A second
23 snap-fit contact is generated where the horizontal portion 215 of snap fit arm 218 rests
24 against recessed surface 128 of channel 111, while the bent portion 213 rests against a
25 recessed surface 130 on side edge 105. Subsequent to snap fitting the second pair of
26 snap-fit contacts, the insert tab 206 is bent into place against the exterior surface 102 of

1 the top half shell 100, to rest against recessed area 106. The final result is five point
2 positioning of the retention clip 200, which aligns and secures the clip within the top half
3 shell 100.

4 One of the preferred embodiment shell and clip assemblies described above has
5 the following dimensions with respect to Figures 1A, 1B, 2A, 2B, and 2C. The length
6 of top half shell 100 from leading edge 105 to trailing edge 107 is approximately 1.5
7 inches. The width of top half shell from side edge 101 to side edge 103 at its broadest
8 dimension is approximately 3 inches. The corresponding retaining clip has a width
9 from bent arm 211 of snap fit arm 214 to bent arm 213 of snap fit arm 218 of about 2.5
10 inches, and a length from the leading edges of bent tabs 204 and 208 to the trailing edges
11 of module retaining arms 210 and 212, respectively of about 2.5 inches.

12 The same description regarding the positioning and attachment of the retaining
13 clip to the half shell is applicable with regard to the bottom retaining clip and the bottom
14 half shell.

15 Figures 3A and 3B in combination provide an exploded view of one connector
16 assembly. Figure 3A represents the top half 300 of the assembly and Figure 3B
17 represents the bottom half 320 of the assembly. The exterior surfaces 102 of top half
18 shell 100 and 302 of bottom half shell 301 provide a protective connector assembly
19 exterior which encompasses at least the portion of a contact module (not shown)
20 necessary to provide proper electrical engagement when two connector assemblies, a
21 plug and a receptacle, containing the proper interfacing electrical contacts are joined.

22 Figure 3A shows the top half 300 of the assembly, illustrating top half shell 100
23 and showing exterior, upper surface 102; interior, lower surface 122; leading end 105;
24 trailing end 107 and side edges 101 and 103. Exterior, upper surface 102 shows recessed
25 areas 106, 109, and 110 which make contact with tabs 206, 204 and 208, respectively of
26 retention clip 200. Also illustrated in Figure 3A is recessed area 130 along side edge

1 103 which makes contact with a portion of snap fit arm 218 of retention clip 200. Top
2 half shell 100 works in cooperation with top retaining clip 200. The illustration of top
3 retaining clip 200 shows an upper surface 220, which attaches to bottom surface 122 of
4 top half shell 100. Top retaining clip 200 includes pre-bent tabs 204 and 208 for snap
5 fitting into top half shell 100; only one of these pre-bent tabs, 204 is visible. Top
6 retaining clip 200 snap fit arms 214 and 218 snap fit onto top half shell 100; only one of
7 the snap fit arms, 218, is shown in detail. Snap fit arm 218 includes a bend 224 and a
8 lever arm 213 which makes contact against recessed area 130 along side edge 103.
9 Snap fit arm 214 includes equivalent functional elements. Top retaining clip 200
10 includes two module retaining arms 210 and 212.

11 Figure 3B shows the bottom half 320 of the assembly, including bottom half
12 shell 301 having exterior, lower surface 302; interior, upper surface 322; a leading end
13 325, a trailing end 327, and side edges 321 and 323. Interior, upper surface 322 includes
14 openings 308 (for insertion of corresponding retention clip 350 pre-bent tab 358) and
15 304 (for insertion of pre-bent tab 354) which are visible and a third opening (for
16 insertion of insert tab 536) which is not visible. Also illustrated in Figure 3B are
17 recessed channel 311 which travels across upper surface 322 of bottom half shell 301 in
18 a transverse direction; recessed steps 332 and 334; and recessed exterior area 330 on side
19 edge 323. Pairs of reinforcement bars, 317 and 319 travel along upper surface 322 in a
20 longitudinal direction, to help guide and position a contact module (not shown) which is
21 inserted into the shell and clip assembly. Bottom half shell 320 works in cooperation
22 with bottom retaining clip 350. Bottom retaining clip 350 includes a lower surface 380
23 which attaches along bottom recessed channel 311 of upper, interior surface 322 of
24 bottom half shell 320. Bottom retaining clip 350 includes pre-bent tabs 354 and 358 for
25 snap fitting into bottom half shell 320 through openings 304 and 308, respectively.
26 Bottom retaining clip 350 also shows insert tab 356 which inserts through an opening

1 (not shown) on interior surface 322. In addition, bottom retaining clip 350 shows snap
2 fit arms 374 and 378, which snap fit onto bottom half shell 320 over recessed steps 334
3 and 332, respectively. Snap fit arm 374 shows a bend 382 and a lever arm 371 which
4 makes contact against recessed area 330 along side edge 323. Snap fit arm 378 shows a
5 bend 384 and a lever arm 373 which makes contact against a recessed area (not shown)
6 along side edge 321. Bottom retaining clip 350 also shows the two module retaining
7 arms 360 and 362.

8 After attachment of top retaining clip 200 to top half shell 100 and attachment of
9 bottom retaining clip 350 to bottom half shell 320, top half 300 and bottom half 320 of
10 the assembly are joined together, preferably by riveting. The riveting locations are
11 shown in Figure 1A at locations 113a through 113d. The riveting locations are also
12 shown in Figure 3B at locations 313b, 313d, and 313e (313a is hidden).

13 Figure 4 shows a cross-sectional view of an entire electrical connection 400,
14 including a plug 420 and a receptacle 430. Plug 420 includes top half shell 421, which
15 works in cooperation with top retention clip 423 having module retaining arm 425. Plug
16 420 also includes bottom half shell 422, which works in cooperation with bottom
17 retention clip 424 having module retaining arm 426. A contact module 428; having
18 electrical contacts 430 is shown retained by retention clips 423 and 424.
19 Receptacle 430 includes top half shell 431, which works in cooperation with top
20 retention clip 433 having module retaining arm 435. Receptacle 430 also includes
21 bottom half shell 432, which works in cooperation with bottom retention clip 434 having
22 module retaining arm 436. A contact module 438; having electrical contacts 440 is
23 shown retained by retention clips 433 and 434.

1 III. A METHOD OF ASSEMBLING THE PREFERRED EMBODIMENT
2 CONNECTOR ASSEMBLY

3
4 The use of two half shells each having a module retaining clip attached thereto
5 gives rise to a particular method of fabricating an electrical connector assembly. The
6 method is as follows.

7 With reference to Figures 1A, 1B, and 2A:

8 a) a retention clip 200 is attached to the interior of surface 122 of a half shell 100
9 as follows:

10 i) inserting pre-bent tabs 204 and 208 through openings 104 and 108 from
11 interior surface 122 of half shell 100, immediately followed by the insertion of insert tab
12 206 through opening 112 located on interior surface 122 of half shell 100.

13 ii) while inserting pre-bent tabs 204 and 208, lower surface 219 of
14 retaining clip 200 is placed in contact with recessed channel 111 on the interior surface
15 122 of half shell 100. Contact between lower surface 219 of retaining clip 200
16 transverse member 220 extends the entire length of recessed channel 111.

17 iii) lower surface 219 of snap fit arms 218 and 214 is placed in contact
18 with the recessed surface of steps 128 and 124 respectively and snapped into place so
19 that horizontal portion 215 of snap fit arm 218 rests against recessed surface 128 of
20 channel 111, while the bent portion 213 rests against a recessed surface 130 on side edge
21 105. Essentially simultaneously, horizontal portion 216 of snap fit arm 214 rests against
22 recessed surface 124 of channel 111, while the bent portion 211 rests against a recessed
23 surface (not shown) on side edge 101.

24 b) insert tab 206 is bent over to make contact with recessed area 106 on the
25 exterior, upper surface 102 of half shell 100.

26 With reference to Figures 3A and 3B:

1 c) the procedure described in steps a) and b) above with reference to a half shell
2 and a retaining clip is carried out twice, once with respect to the top half of an assembly
3 300 and once with respect to the bottom half of an assembly 320.

4 d) assembly top half 300 is brought into contact with assembly bottom half 320
5 so that portions of interior, lower surface 122 of top half 300 are in contact with portions
6 of the interior, upper surface 301 of bottom half 320, whereby an aligned rectangular-
7 shaped connector exterior housing is produced.

8 e) assembly top half 300 is fastened to assembly bottom half 320.

9 Preferably the attachment of assembly top half 300 to assembly bottom half 320
10 is by a permanent means, such as riveting. Other joining means, both permanent and
11 non-permanent, such as soldering, adhesive bonding, and screwing are also
12 contemplated.

13 Particular advantages to this connector assembly include: 1) the five point
14 contact alignment, which precisely aligns the retaining clip within the connector split
15 shell assembly, ensuring solid parallel alignment of the interfacing contact surfaces of a
16 contact module inserted therein and reliable electrical engagement when two connector
17 interfaces are joined; 2) the fact that the retaining clip force loading is extended over the
18 entire transverse member of the retaining clip (the edge of the retaining clip rests against
19 a recessed wall surface within the half shell); 3) the fact that there is no exposed
20 protrusion on the interior of the assembly which can interfere with the insertion of a
21 contact module, reducing the possibility of a rupture in the interfacial seal portion of the
22 contact module; and, 4) the fact that once the connector is fully assembled, the retaining
23 clip is locked into position within the interior of the housing by contact with interior
24 housing surfaces, so that if one or all of the tabs (both the pre-bent and insert tabs) are
25 broken off for any reason, the connector will remain functional without any movement
26 of the electrical components within the housing.

1 IV. MATERIALS OF CONSTRUCTION FOR THE PREFERRED EMBODIMENT
2 CONNECTOR ASSEMBLY
3

4 As previously described, the two halves of the outer shell of the connector may
5 be fabricated from a metal, typically aluminum, which may be machined or cast into the
6 desired shape. Casting is preferred, as the split shell design permits use of a simplified
7 casting mold and makes casting less expensive than machining.

8 In addition, the two halves of the outer shell of the connector may be fabricated
9 from a polymer-comprising material. Use of a polymer-comprising material offers the
10 advantages of a more corrosion-resistant connector and a lower cost of fabrication,
11 including increased tooling life. The preferred method for fabrication from a polymeric
12 material is injection molding. The preferred embodiment half shells of the connector
13 assembly for which data is subsequently presented herein were injection molded using
14 standard plastic injection molding techniques. The polymer-comprising material used
15 for injection molding was either Ultem® (Polyetherimide) P/N RTP 2199 X 79499
16 (glass reinforced at 30 to 40 % by weight) or Ultem® P/N RTP 2199 X 79498B
17 (reinforced using nickel coated carbon fiber at 12 % by weight).

18 Various polymer-comprising materials may be used for fabrication, so long as
19 these materials produce a connector outer shell which meets the specifications of the end
20 user. For example, the present connector is used in numerous aeronautical applications.

21 The applicable specification for these applications includes requirements for
22 EMI//RFI/ESD (electromagnetic interference/radio frequency interference/electrostatic
23 discharge) protection. In addition, the connector must have a reliable low-impedance
24 path to ground, as described in MIL-C-3899 and ARINC (Aeronautical Radio
25 Incorporated) Specification 600. As a result of these requirements, the connectors are
26 tested for shield grounding capabilities. To meet these requirements, the polymer-
27 comprising material used to fabricate the connector may provide some conductivity to
28 assist in electrostatic discharge; typically the primary means of making the product

1 conductive is plating the surface with a conductive material, to provide an acceptable
2 electrostatic discharge rate. One preferred manner of increasing conductivity is to add a
3 filler material such as glass, carbon or graphite fibers to the polymeric material, where
4 the filler material contains or is coated with a conductive material to impart
5 conductivity.

6 In addition, some connector specifications require, and in many instances it is
7 desirable that at least the exterior of the connector provide EMI/RFI protection. In the
8 event the polymer-comprising material does not provide such protection, a layer or
9 coating of protective material is provided at the exterior surface of the connector. One
10 of the preferred protective coatings is nickel, which has been applied over the exterior of
11 aluminum connector shells and which can be applied over the exterior surface of a
12 polymer-comprising material. The advantage of nickel plated polymeric material is that
13 it is possible to provide a light weight connector shell without setting up a galvanic
14 coupling of the kind which results from nickel coating of an aluminum shell.

15 Some connector specifications require, and in many instances it is desirable that
16 the connector be flame retardant and resistant to salt spray corrosion. Although many
17 polymeric materials are salt spray resistant, some are more so than others and the
18 polymeric material should be selected with this characteristic in mind. In most cases,
19 polymeric materials are not naturally flame retardant, and it is necessary to use a flame
20 retardant additive.

21 Further, the connector assembly, including retention clip, is tested to be certain
22 that the connector assembly placed under a particular mechanical load will not deflect in
23 a manner which can result in loss of environmental sealing between the halves of the
24 connector.

25 To enhance the mechanical properties of a polymer-comprising material, it is
26 common to add a filler material such as, but not by way of limitation, glass fibers, glass

1 particulates, carbon fibers, carbon particulates, graphite fibers, graphite particulates, and
2 combinations thereof.

3 The deflection requirement for the connector assembly has been one of the main
4 determining factors in the selection of aluminum as the fabrication material for the
5 exterior shell of the connector. Previous attempts to fabricate a connector assembly
6 having a single piece exterior housing or shell from a polymer-comprising material were
7 unsuccessful, because the fabricated connector assembly could not meet deflection
8 requirements. However, applicants have discovered that the two part, split shell design
9 and the retaining clip design of the present connector enables fabrication techniques
10 which make it possible to use new polymer-comprising materials which produce a
11 connector with acceptable deflection characteristics. Typically such polymer-
12 comprising materials are fiber filled engineering plastic materials which provide
13 excellent high temperature performance, which can be made conductive and flame
14 retardant by the addition of proper fill material, and flame retardant, respectively.

15 Table 1, below, shows comparative deflection test data for the preferred
16 embodiment split shell connector of the present invention fabricated from aluminum and
17 fabricated from two preferred engineering plastics. Figures 5A and 5B illustrate the
18 manner in which the load was applied and the deflection was measured for a connector
19 assembly during deflection testing.

20 With reference to Figures 5A and 5B, the connector assembly 500 includes a top
21 half shell 510 and a bottom half shell 520, with top retention clip 504 and bottom
22 retention clip 506. A deflection loading 502 was applied to the leading edge 515 of top
23 retention clip 504, and to the leading edge 517 of bottom retention clip 506. The
24 deflection 523 which results was measured at point 521 at the trailing edge 507 of the
25 connector 500. The deflection load 502 was applied using an Instron 4202 in
26 combination with a fixture (not shown) designed to apply the load to leading edges 515

1 and 517 of retention clips 504 and 506, respectively. The amount of deflection 523 was
 2 measured using a Mitutoyo dial indicator 513-212 which was connected to a ball
 3 positioned at point 521 in the center of the wall of half shell 510.

4 The maximum deflection loading 502 applied was 200 lbs. (890 N), applied
 5 evenly over the entire load application surface of leading edges 515 and 517. The speed
 6 of travel of the Instron head was 0.02 inch (0.5 mm) per minute.

7
 8 Table 1

9 Comparative Data Aluminum and Polymer-Comprising Connector Assemblies
 10 Deflection of Assembly at Various Loadings
 11

Aluminum Shell #1		Aluminum Shell #2		RTP #1 Shell #1		RTP #1 Shell #2		RTP #2 Shell #1		RTP #2 Shell #2	
L	D	L	D	L	D	L	D	L	D	L	D
50	1.0	50	2.5	50	1.4	50	2.5	50	2.6	50	3.5
100	2.5	100	3.8	100.9	2.7	100	3.5	100	3.5	100	5.3
150	3.8	150	4.9	150	4.1	150	5.5	150	4.2	150	7.6
200	5.0	200	5.7	200	5.7	200	7.5	200	5.4	200	9.9
150	4.4	150	5.1	150	4.7	150	6.6	150	5.2		*
100	3.7	100	4.6	100	3.6	100	5.2	100	3.9		*
50	2.8	50	3.2	50	2.3	50	3.5	50	3.0		*

12 Where L = Load Applied in lbs.; and D = Deflection in inches x 10⁻³.

13
 14 Where RTP #1 is RTP 2199 X 79498B, which is a polyetherimide (PEI) (Ultem® Type
 15 “B”, General Electric) containing 25 % by weight nickel-coated carbon fiber, and which
 16 is available from RTP Company of Winona, Minnesota.

17
 18 Where RTP #2 is RTP 2199 X 79498A, which is a polyetherimide (PEI) (Ultem® Type
 19 “B”, General Electric) containing 40 % by weight nickel-coated carbon fiber, and which
 20 is available from RTP Company of Winona, Minnesota.
 21

1 * Testing was discontinued because the sample broke, with separation along the clip
2 retainer channel. There appears to be striation in the sample coloring, which may
3 indicate an improperly molded sample.
4

5 This data shows that the fiber filled polyetherimide connector assembly samples
6 evaluated are capable of providing deflection characteristics roughly equivalent to those
7 obtained for aluminum connector assembly samples. The amount of deflection observed
8 was below the acceptable limit, which is in the range of less than about 12×10^{-3} inches.

9 Table 2, below shows repetitive test data for the preferred embodiment split shell
10 connector of the present invention fabricated from RTP 2199 X 79499, which is a
11 polyetherimide (Ultem® Type "C", General Electric) containing (filled with) about 40
12 % by weight glass fibers, and which is available from RTP Company of Winona,
13 Minnesota. The test method used was the same as that previously described with
14 reference to Figures 5A and 5B.

1
2
3
4
5

Table 2

Repetitive Data for the Deflection of A Split Shell Connector Assembly
Fabricated From RTP 2199 X 79499

Connector Assembly #1		Connector Assembly #2		Connector Assembly #3		Connector Assembly #4		Connector Assembly #5	
L	D	L	D	L	D	L	D	L	D
50	0.5	50	3.4	50	2.0	50	3.4	50	3.4
100	1.4	100	5.6	100.9	3.3	100	4.4	100	4.8
150	2.2	150	8.0	150	5.1	150	6.4	150	6.8
200	2.5	200	10.5	200	7.0	200	8.1	200	9.0
150	2.5*	150	9.2	150	5.7	150	6.9	150	7.6
100	2.5*	100	7.5	100	4.6	100	5.5	100	6.3
50	2.5*	50	5.6	50	3.1	50	4.0	50	4.6

6
7
8
9

* The dial indicator stuck in place. Comparison with the other data in this Table 2 indicates that all of the data for Connector Assembly #1 in this Table 2 may be suspect. Where L = load applied in lbs; and D = Deflection in inches x 10⁻³.

10
11
12
13

Although the deflection data for Connector Assemblies #2 through #5 at an applied load of 200 psi varies somewhat from sample to sample, between about 7.0 and about 10.5 inches x 10⁻³, all of this data is well within an acceptable range (less than about 12 inches x 10⁻³).

14
15
16
17

One skilled in the art can make use of comparable engineering plastics to fabricate the split shell connector assembly of the present invention, and applicants do not intend to limit their description of polymeric materials which can be used to those specifically described herein.

18
19

The retention clip may be fabricated from a material which has mechanical properties which are substantially equivalent to high strength copper alloy or to stainless

1 steel. In general, the retention clip material should exhibit a deflection which is at least
2 as low as that of the split shell housing material.

3 The above described preferred embodiments are not intended to limit the scope
4 of the present invention, as one skilled in the art can, in view of the present disclosure,
5 expand such embodiments to correspond with the subject matter of the invention
6 claimed below.

CLAIMS

We claim:

- 1 1. An electrical connector assembly comprising two half shells which are joined
2 together to form a connector housing, wherein, prior to said joining, each half shell has
3 attached thereto a module retaining device which is positioned within said half shell by a
4 minimum of three contact points, and wherein at least two of said contact points are
5 snap-fit attachments.

- 1 2. The electrical connector assembly according to Claim 1, wherein there are five
2 contact points, and at least four of said contact points are snap-fit attachments.

- 1 3. The electrical connector assembly according to Claim 1, wherein one of said
2 contact points comprises an insert which passes through an opening in said half shell and
3 wherein said at least two snap-fit attachments are pre-bent inserts, each of which passes
4 through an opening in said half shell.

- 1 4. The electrical connector assembly according to Claim 3, including two additional
2 snap-fit attachment points which do not pass through an opening in said half shell.

- 1 5. The electrical connector assembly according to Claim 1, wherein said three
2 contact points align said module retaining device with respect to a leading edge and
3 trailing edge of said connector.

- 1 6. The electrical connector assembly according to Claim 2, wherein two of said
2 four snap-fit attachment points align the module retention device with respect to the side
3 edges of said connector.

1 7. An electrical connector assembly comprising a half shell having attached thereto
2 a retaining clip, wherein said half shell includes at least two openings passing from an
3 interior of said half shell to an exterior of said half shell, and wherein said retaining clip
4 includes at least two pre-bent tabs which pass through said at least two openings,
5 whereby said retaining clip is snap fitted to rest against said interior surface of said half
6 shell.

1 8. An electrical connector assembly according to Claim 7, wherein said half shell
2 includes a recessed channel along an interior surface, and wherein a major surface of
3 said retaining clip rests on said recessed channel surface.

1 9. An electrical connector assembly according to Claim 8, wherein said half shell
2 also includes at least two step features, with each of said step features having at least two
3 surfaces having recessed areas thereon, and wherein said retaining clip includes
4 corresponding lever arms, which lever arms form a snap fit with said at least two step
5 features having recessed areas thereon.

1 10. A contact module retaining clip for use in combination with an electrical
2 connector housing, said clip comprising a major surface having two opposite edges bent
3 to form a step along each edge, said major surface also having at least two pre-bent tabs
4 extending from a third edge which is adjacent to both of said bent edges.

1 11. A method of assembling an electrical connector assembly, the method
2 comprising:

3 a) snap fitting a module retaining clip into contact with an interior surface of a
4 connector housing portion which is a half shell, while simultaneously inserting a

5 protrusion from said retention clip surface into a first opening through said half shell;

6 and

7 b) mechanically securing the protrusion to the exterior surface of the half shell;

8 and

9 c) joining two half shells together to form an assembly housing having a module
10 retaining device on an interior surface of each half shell.

11
1 12. A method according to Claim 11, wherein said snap fitting includes at least four
2 snap-fit contact points.

1 13. A method according to Claim 12, wherein two of said four snap-fit contact points
2 comprise pre-bent tabs extending from an edge of said module retaining clip, wherein
3 one of said two pre-bent tabs slides into position through a second opening in said half
4 shell and the other of said two pre-bent tabs slides into position through a third opening
5 in said half shell, where each of said pre-bent tabs comes to rest against a recessed
6 surface on the exterior of said half shell.

1 14. A method according to Claim 13, wherein said protrusion is a substantially
2 straight tab which is inserted through said first opening in said half shell.

1 15. A method according to Claim 14, wherein each of the remaining two of said four
2 snap-fit contact points comprise a bent arm which can be snapped over a protrusion, and
3 wherein at least a portion of said protrusion is located on an interior surface of said half
4 shell.

1 16. The electrical connector assembly of Claim 1 or Claim 7, wherein said half shells
2 are fabricated from a polymer-comprising material.

1 17. The electrical connector assembly of Claim 16, wherein said polymer-comprising
2 material contains a filler material selected from the group consisting of glass fibers,
3 glass particulates, carbon fibers, carbon particulates, graphite fibers, graphite
4 particulates, and combinations thereof.

1 18. The electrical connector assembly of Claim 17, wherein said filler material contains
2 or is coated with a conductive material, whereby conductivity is imparted to said
3 polymer-comprising material.

1 19. The electrical connector assembly of Claim 16 or Claim 17, or Claim 18, having a
2 coating applied to the exterior surface thereof, wherein said coating provides protection
3 from electromagnetic interference or radio frequency interference or a combination
4 thereof.

1 20. The electrical connector assembly of Claim 16 or Claim 17, or Claim 18, wherein
2 said polymer-comprising material contains a flame-retardant additive.

1 21. The electrical connector assembly of Claim 19, wherein said polymer-comprising
2 material contains a flame-retardant additive.

1 22. The electrical connector assembly of Claim 16, wherein said half shells are injection
2 molded.

1 23. An electrical connector assembly comprising two half shells which are joined
2 together to form a connector housing, wherein said half shells are fabricated from a
3 polymer-comprising material containing a reinforcing filler material.

- 1 24. The electrical connector assembly of Claim 23, wherein said reinforcing filler
2 material imparts conductivity to said half shells.
- 1 25. The electrical connector assembly of Claim 23 or Claim 24, wherein an exterior
2 surface of said half shells exhibits a coating which provides protection from
3 electromagnetic interference or radio frequency interference or a combination thereof.
- 1 26. The electrical connector assembly of Claim 23 or Claim 24, wherein said polymer-
2 comprising material contains a flame-retardant additive.
- 1 27. The electrical connector assembly of Claim 25, wherein said polymer-comprising
2 material contains a flame-retardant additive.

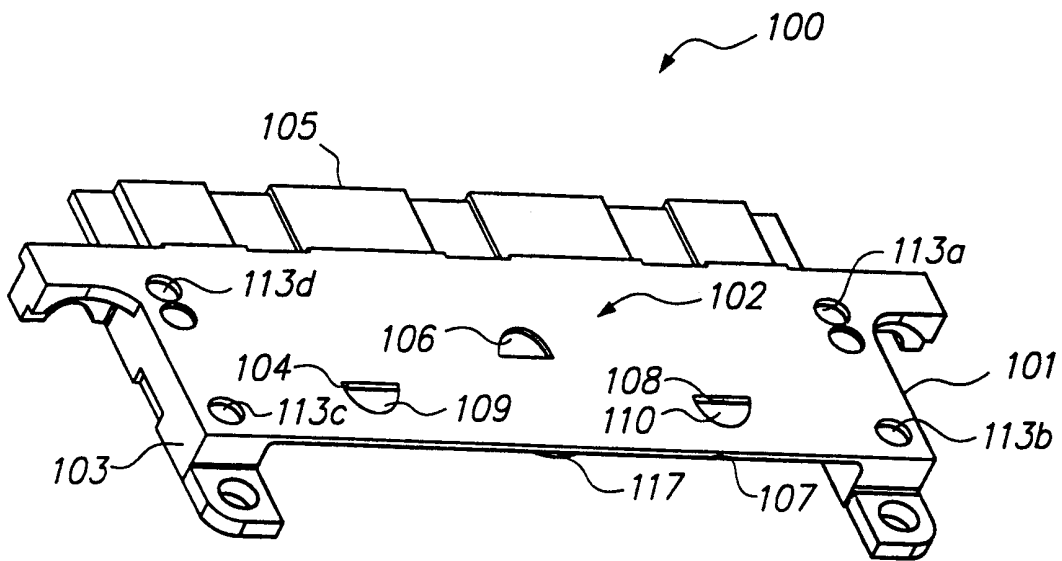


FIG. 1A

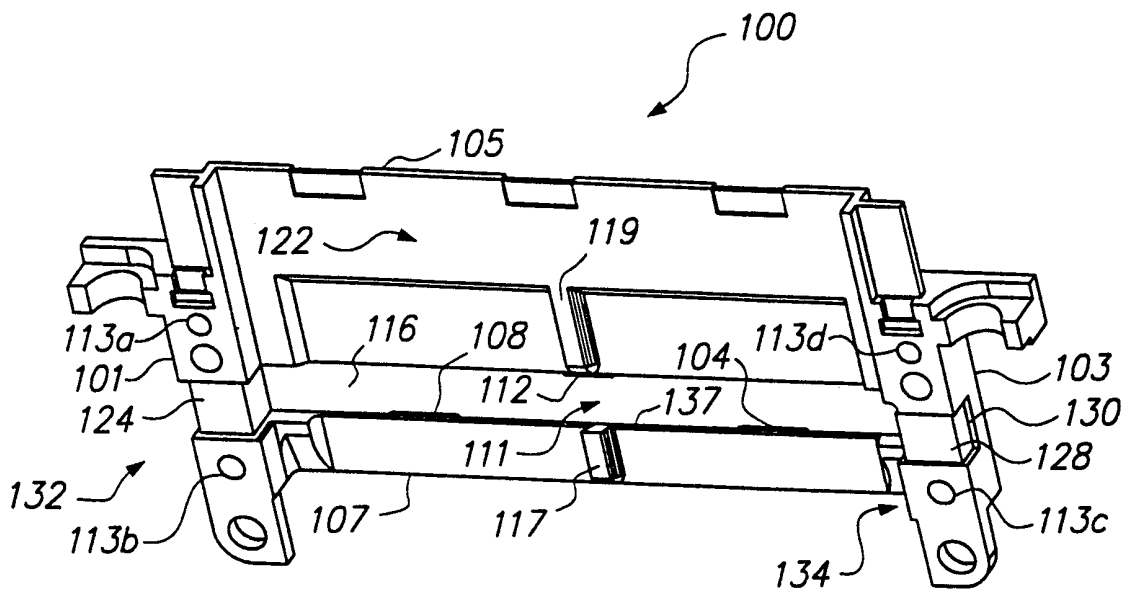
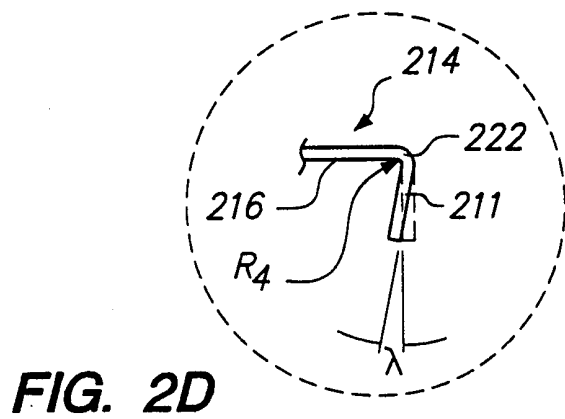
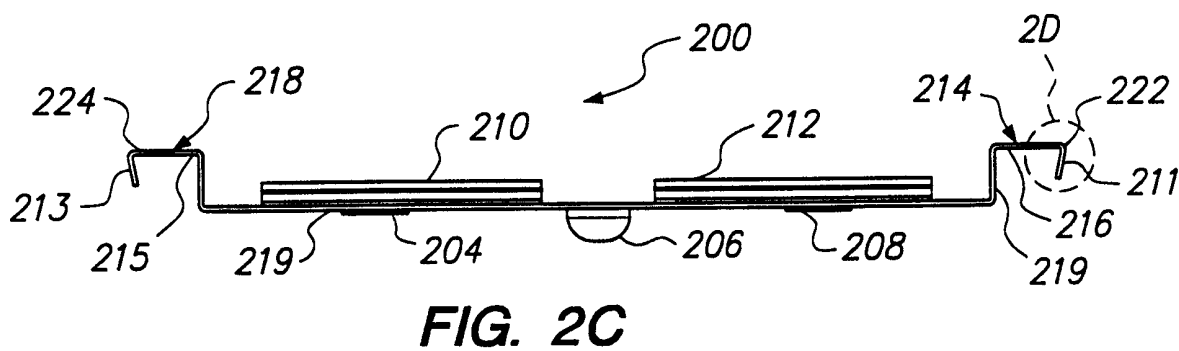
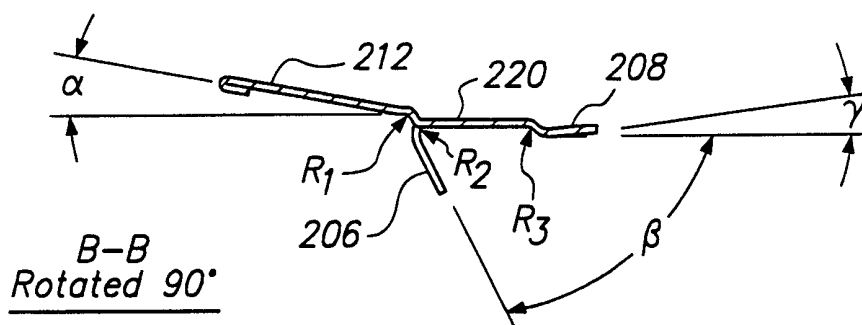
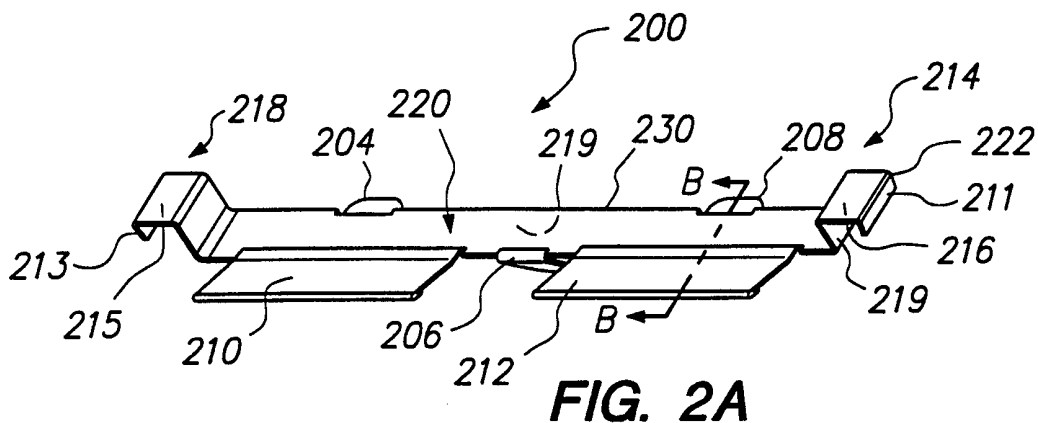


FIG. 1B



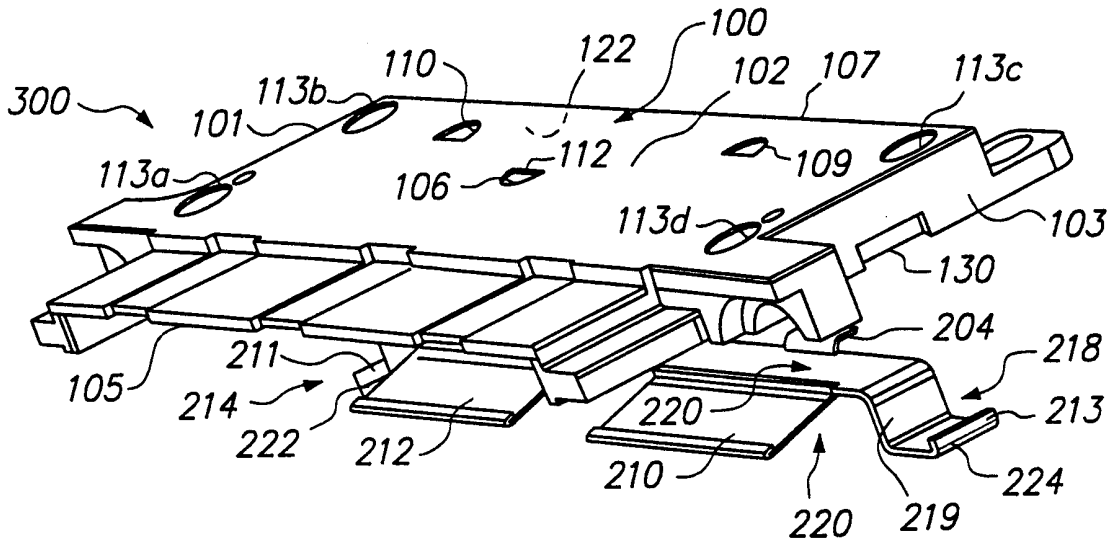


FIG. 3A

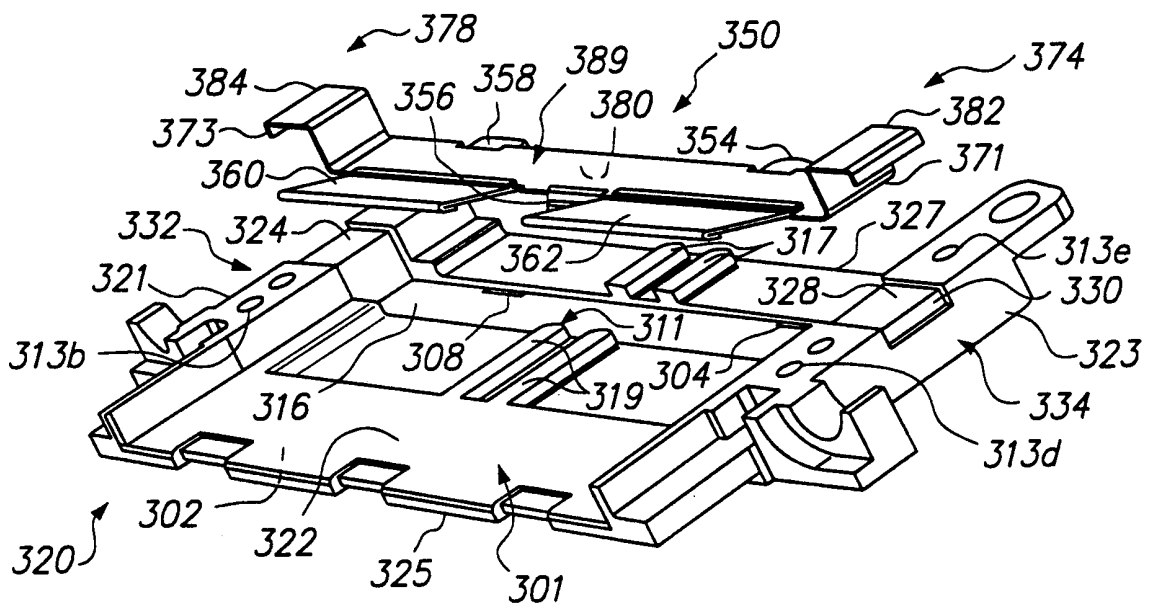


FIG. 3B

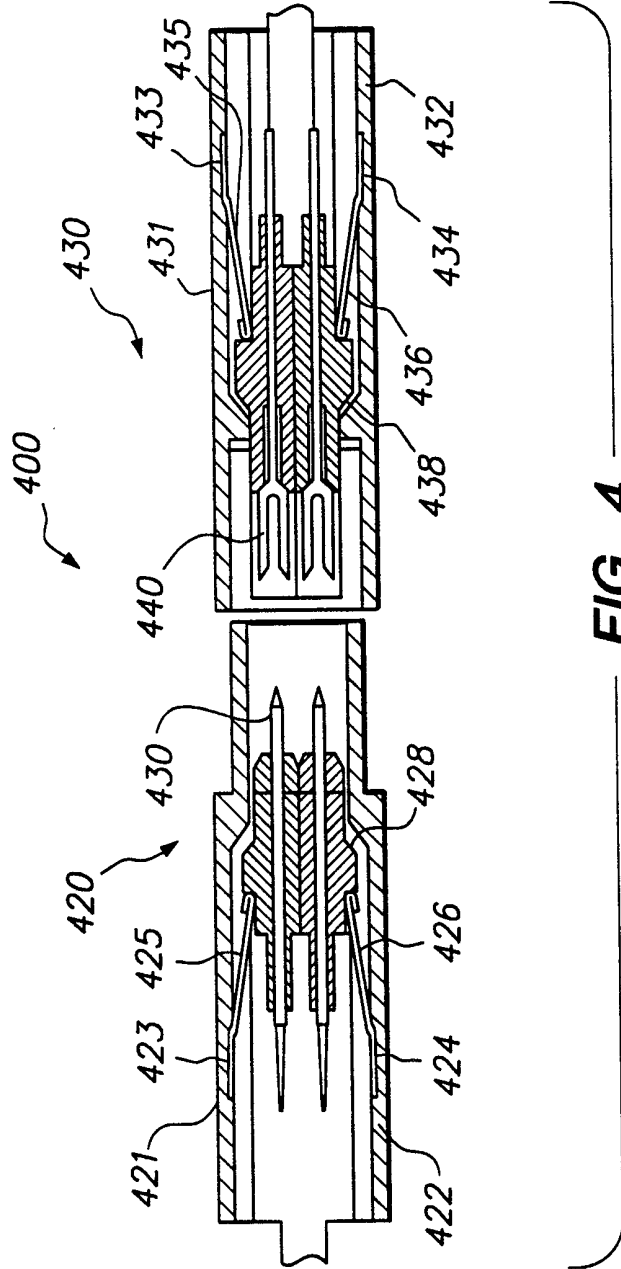


FIG. 4

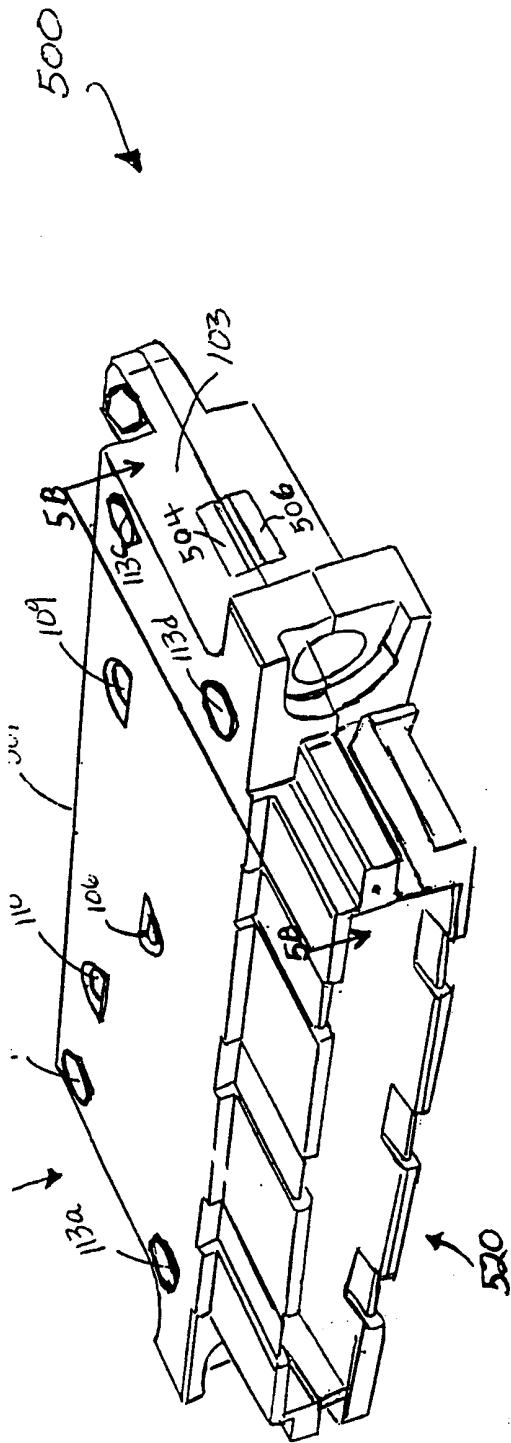
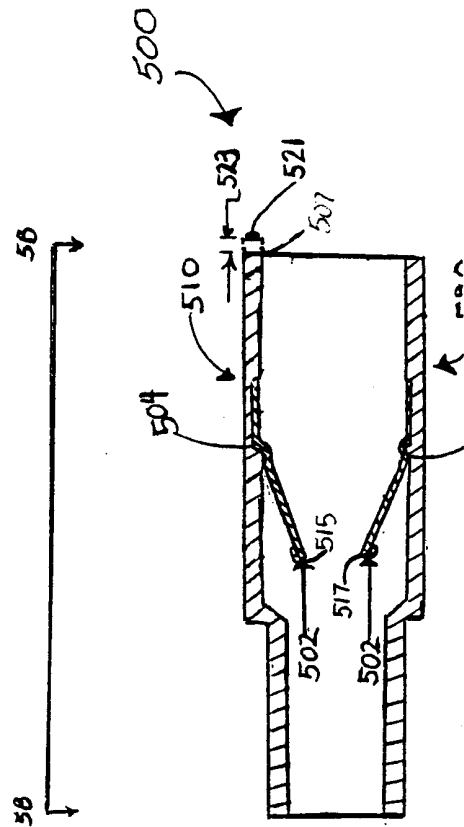


Fig. 5A



INTERNATIONAL SEARCH REPORT

Int. application No.
PCT/US 99/11897

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H01R 13/00, H01R 13/506
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H01R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3711813 A (S. BRYANT), 16 January 1973 (16.01.73), figure 1, abstract, detail 22 --	1,7,10,11, 16,23
Y	US 5125854 A (M.P. BASSLER ET AL), 30 June 1992 (30.06.92), figure 2, abstract, detail 82 --	1,7,10,11, 16,23
A	EP 0450281 A1 (WABCO WESTINGHOUSE FAHRZEUGBREMSEN GMBH), 9 October 1991 (09.10.91), figure 2, claim 2 --	1-27

Further documents are listed in the continuation of Box C. See patent family annex.

<p>* Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"I" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&" document member of the same patent family</p>
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Date of the actual completion of the international search 24 August 1999	Date of mailing of the international search report 24.09.99
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Name and mailing address of the International Searching Authority European Patent Office P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel(+31-70)340-2040, Tx 31 651 epo nl, Fax(+31-70)340-3016	Authorized officer Vilho Juvonen / MR
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 99/11897

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 3328242 A1 (SIEMENS AG), 21 February 1985 (21.02.85), figure 1, abstract -- -----	1-27

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US 99/11897

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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US 5125854 A	30/06/92	DE 69205353 D,T EP 0523491 A,B JP 2561885 B JP 5217633 A KR 9602138 B	25/04/96 20/01/93 11/12/96 27/08/93 10/02/96
EP 0450281 A1	09/10/91	CS 9100931 A CZ 280357 B DE 4010836 A DE 59105070 D JP 4230975 A US 5368499 A	17/12/91 13/12/95 10/10/91 00/00/00 19/08/92 29/11/94
DE 3328242 A1	21/02/85	DE 3335665 A	04/04/85