

[54] **TIGHT FITTING PLUG CONNECTION AND METHOD FOR MAKING SAME**[76] Inventor: **Bernard Edward Shlesinger, Jr.**,
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22309[22] Filed: **Dec. 27, 1971**[21] Appl. No.: **212,091**[52] U.S. Cl. **339/59 R, 339/17 C, 339/255 R**[51] Int. Cl. **H01r 13/40, H05k 1/04**[58] Field of Search..... 339/17, 18, 59-63,
339/176, 191, 192, 193, 194, 195, 196, 198,
278 C, 278 D, 182, 252, 74, 30, 94[56] **References Cited****UNITED STATES PATENTS**

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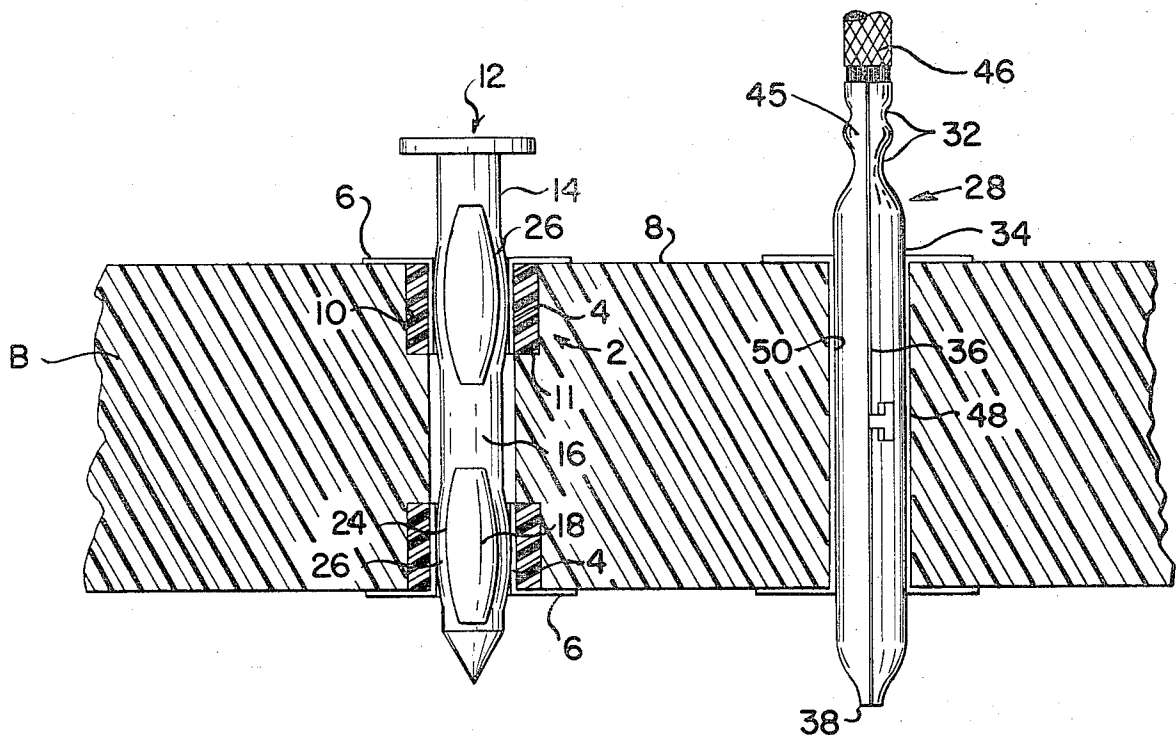
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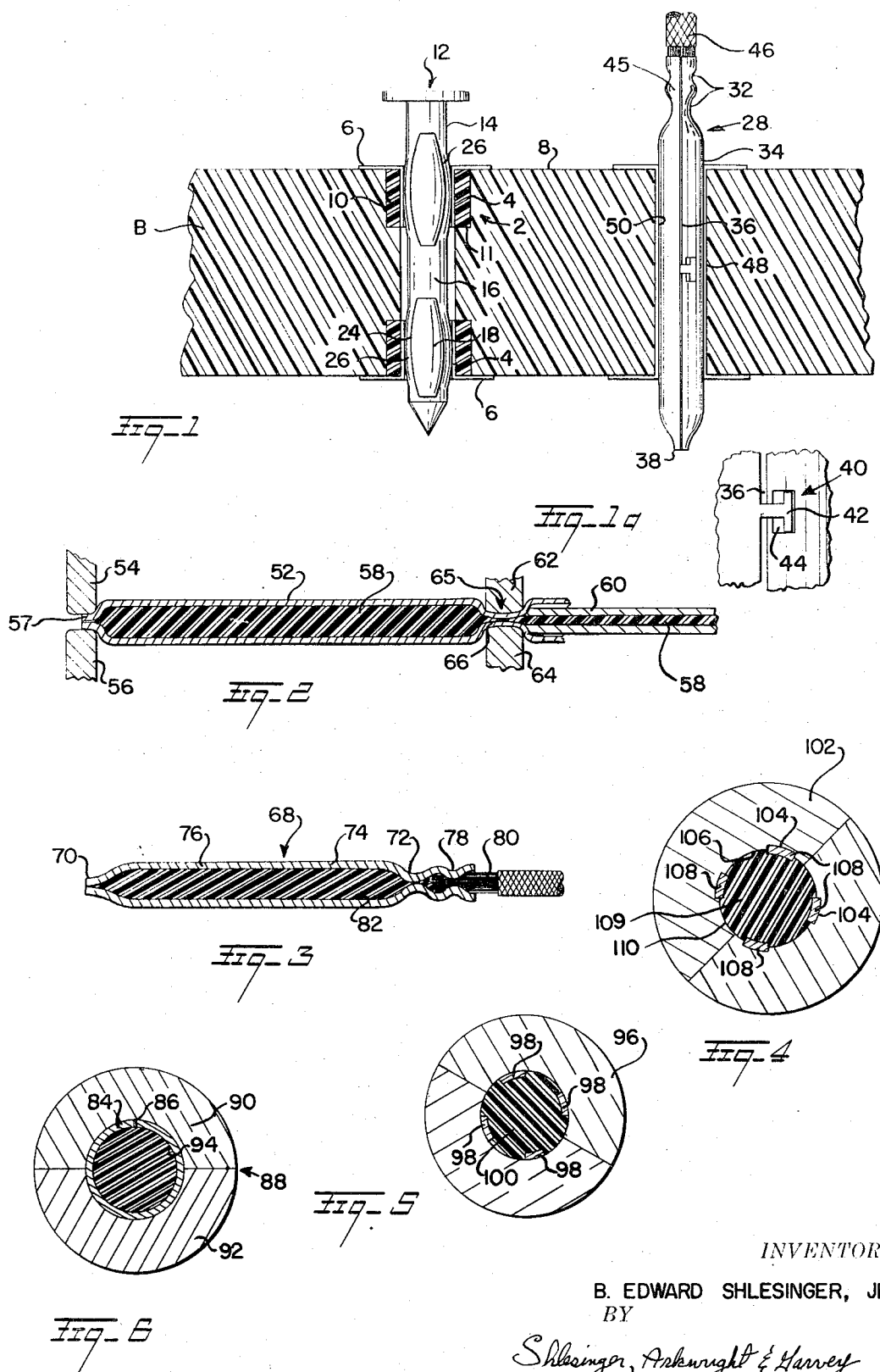
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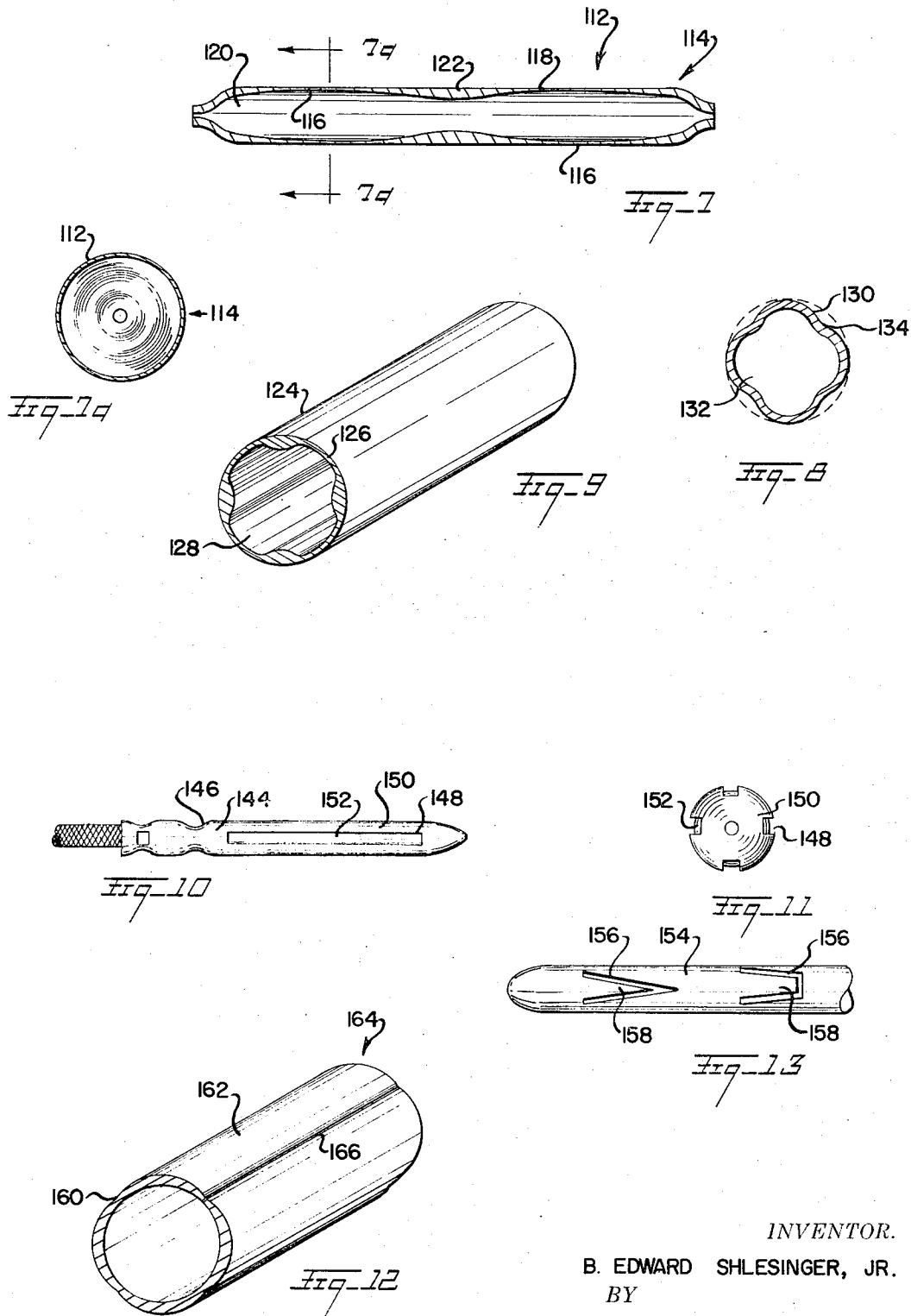
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ABSTRACT

A connector element for electrical devices and the like comprising: a conductive sleeve having an expandable core receiving portion including a wall; a core of elastic material under compression received in the core receiving portion and exerting an expansion force on the wall of the receiving portion when residing therein; the sleeve being of a material harder than and substantially less compressible than said core material. The sleeve being normally expanded by the pressure of the material under compression so that when mated with its cooperating connector element, the sleeve will grip the cooperating connector element affording positive connection and wipe at all times regardless of the number of connects and disconnects made.

13 Claims, 31 Drawing Figures





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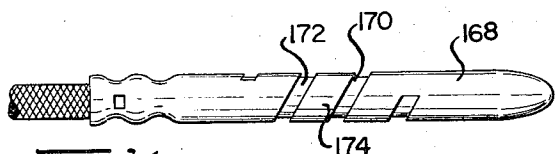


Fig. 14

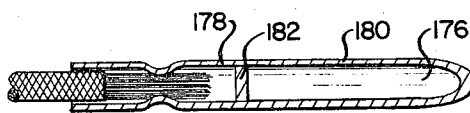


Fig. 15

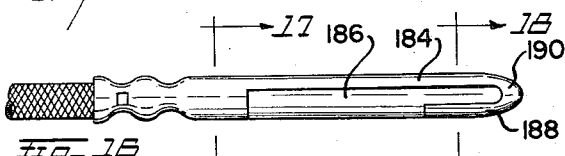


Fig. 16



Fig. 17



Fig. 18

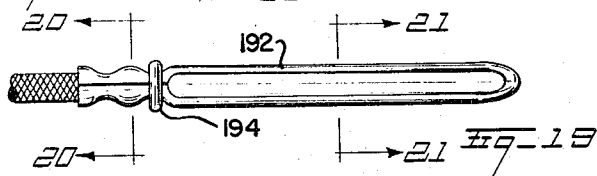


Fig. 19

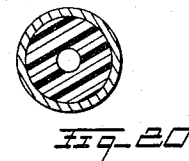


Fig. 20



Fig. 21

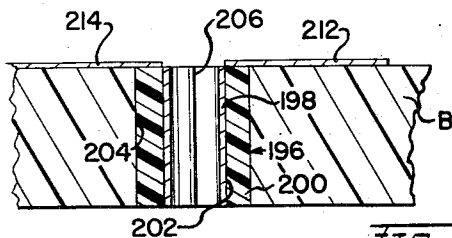


Fig. 22

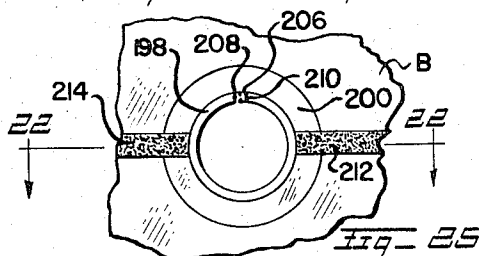


Fig. 23

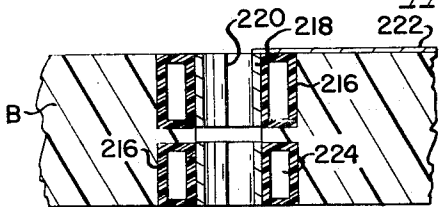


Fig. 24

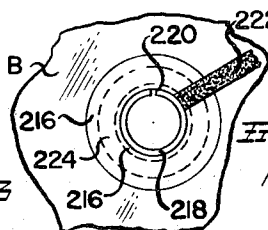


Fig. 25

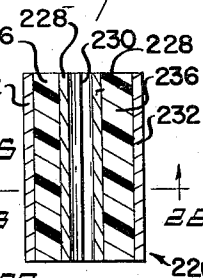


Fig. 26

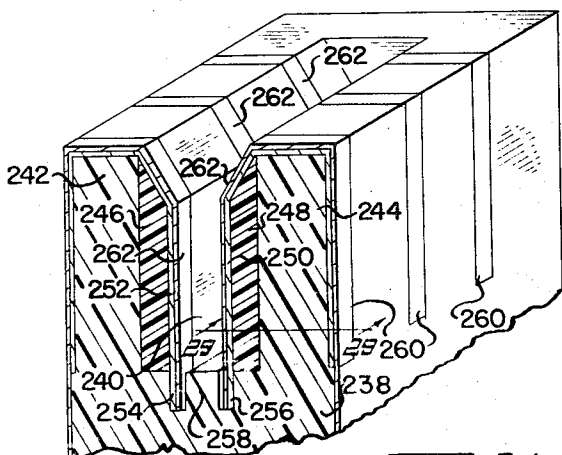


Fig. 27

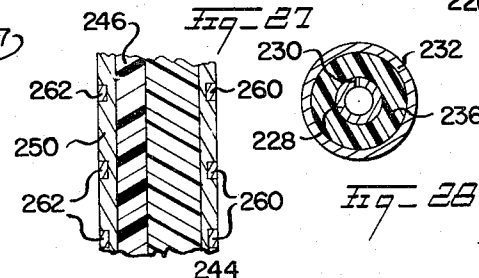


Fig. 28

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TIGHT FITTING PLUG CONNECTION AND METHOD FOR MAKING SAME

HISTORICAL BACKGROUND

Since most existing electrical connectors are made of metal having poor spring tensile properties, they tend to wear out after repeated insertion and withdrawal. This loss of resiliency results in a loosely secured plug and concomitant poor electrical continuity.

Even the addition of springs to contribute to the resiliency of the connector has not afforded a satisfactory solution. The use of mechanical springs, due to the number of moving parts required, greatly increase the cost of production. Additionally, they are not practical for use in miniaturized connectors.

The present solution for this problem of providing a connector having long life and adequate resiliency is known. Several attempts at the solution are shown by Camzi, U.S. Pat. No. 3,031,641; Smith, U.S. Pat. No. 2,502,634; and McFadden, U.S. Pat. No. 3,350,676.

With the development of new plastics having long life and adequate elasticity, it has become possible to incorporate them into a connector unit, thereby providing a natural spring system which is inexpensive and simple to manufacture.

SUMMARY AND OBJECT

This invention relates to an electrical plug and/or receptacle connector which is resiliently biased thereby maintaining a tight connection between it and its mating part. The sheath of the plug is expanded by the presence of compressed material enclosed therein. The sheath is considerably less compressible than the core material, but the presence of slots or thinned portions in the wall permit the radial expansion and/or compression. The plug sheath expands outwardly whereas the receptacle sheath expands inwardly. The receptacle conductive contact member has a backing of elastic material under compression which exerts an expansion force on the conductive member forcing it against a plug inserted therein. In this manner a rigid connector plug may be tightly gripped by the resulting pressure created by the compressed backing material. Both co-operating plug and receptacle may be expandable as taught by this invention.

The connectors are made by introducing an elastic material under pressure into a hollow expansion member and then sealing this expansion member to retain the compressed material. A variation on this process is to place the expansion member, which is slotted, bifurcated or otherwise designed so that it may expand outwardly in a die and then inject the pressurized elastic material, such as a gas, fluid, liquid, plastic, or the like. In the case of plastic, rubber, etc., when the elastic material has solidified, the die is removed and the expansion member will be forced in an outward direction.

It is an object of this invention to provide a plug connector of great utility for use with printed circuit boards and prewired modules.

It is a further object of this invention to provide a plug and receptacle which, due to their inherent resiliency, will be securely connected upon mating.

It is another object of this invention to provide a resilient connector without the use of mechanical springs and the like which lose resiliency and may eventually break under prolonged use.

It is a further object of this invention to provide a plug connector which is simple in design and relatively free of moving parts.

A still further object of this invention is to provide a plug connector which may be of very small size and still possess the requisite resiliency to insure a tight connection.

A still further object of this invention is to provide a plug and receptacle which may be economically mass produced with standard machinery.

The foregoing and other objects and advantages of this invention will appear from the following detailed description, taken in connection with the accompanying drawings, in which:

FIG. 1 is an enlarged fragmentary section showing several embodiments of the invention;

FIG. 1a is an enlarged fragmentary view of a portion of FIG. 1;

FIG. 2 is a sectional view in elevation of the connector plug showing the introduction of pressurized elastic material therein;

FIG. 3 is a sectional view in elevation of the plug in connector which has been filled with compressed elastic material and crimped to an electrical lead;

FIGS. 4, 5 and 6 are cross-sectional views of various embodiments of the plug connector positioned in machine dies;

FIG. 7 is a sectional view in elevation of another embodiment of the plug connector before the compressed elastic material has been introduced therein;

FIG. 7a is a cross-sectional view of FIG. 7 taken along line 7a—7a and viewed in the direction of the arrows;

FIG. 8 is a cross-sectional view of a further embodiment of the plug connector;

FIG. 9 is a perspective view of another embodiment of the plug connector;

FIG. 10 is a side elevational view of a further embodiment of the plug connector;

FIG. 11 is a front end view of FIG. 10.

FIG. 12 is a perspective view of another embodiment of the plug connector;

FIGS. 13 and 14 are side elevational views of further embodiments of the plug connector;

FIG. 15 is a sectional view in elevation of a gas filled embodiment of the plug connector;

FIG. 16 is a side elevational view of a further embodiment of the plug connector;

FIG. 17 is a cross-sectional view of FIG. 18 taken along line 17—17 and viewed in the direction of the arrows;

FIG. 18 is a cross-sectional view of FIG. 16 taken along line 18—18 and viewed in the direction of the arrows;

FIG. 19 is a side elevational view of a still further embodiment of the plug connector;

FIG. 20 is a cross-sectional view of FIG. 19 taken along line 20—20 and viewed in the direction of the arrows;

FIG. 21 is a cross-sectional view of FIG. 19 taken along line 21—21 and viewed in the direction of the arrows;

FIG. 22 is a sectional view in elevation of one embodiment of the plug receptacle;

FIG. 23 is a sectional view in elevation of a gas filled embodiment of the plug receptacle;

FIG. 24 is a perspective view of an edge connector embodiment of the plug receptacle;

FIG. 25 is a top view of FIG. 22;

FIG. 26 is a top view of FIG. 23;

FIG. 27 is a longitudinal cross-sectional view of a further embodiment of the receptacle;

FIG. 28 is a cross-sectional view of FIG. 27 taken along line 28—28 and viewed in the direction of the arrows;

FIG. 29 is a cross-sectional view of FIG. 24 taken along line 29—29 and viewed in the direction of the arrows.

FIGS. 1 AND 1a

Disposed within an orifice of circuit board B, is resilient receptacle 2. Receptacle 2 is comprised basically of a conductive sleeve or ferrule 4 of metal or a conductive plastic having a portion 6 positioned on the surface 8 of circuit board B. The space between the conductive sleeve 4 and the wall 10 of the orifice is filled with an elastic material 11 under pressure. The outward force exerted on the conductive sleeve 4 by this elastic material 11 results in a tight connection between receptacle 2 and plug connector 12. Further description of the receptacle 2 will be taken up in conjunction with a discussion of FIG. 22.

Plug connector 12 comprises a conductive sheath 14 and a core receiving portion 16 integral therewith. The core receiving portion 16 is filled with an elastic material which is under pressure. This core material 18 may be any substance which as a high degree of elasticity when it is compressed, such as rubber or a resilient plastic. Additionally this elastic material 18 may be either a dielectric or a conductor.

A number of slots 24 have been cut out of the core receiving portion 16. These slots 24 are separated from each other in a circumferential direction by expansion ribs 26, i.e., the portions of the core receiving sheath which remain. Since the expansion ribs 26 are structurally weakened by the absence of the sheath material in the area of slots 24, they will bow out as a result of the outward force exerted by the pressurized core material 18. When with the expansion ribs 26 bow out, they come into contact with the conductive sleeve 4. The force exerted by expansion ribs 26 on conductive sleeve 4 causes connector 12 to be tightly secured by receptacle 2.

When the connector 12 is inserted into receptacle 2, both the elastic core 18 and elastic backing 11 are compressed and exert an outward force bringing expansion ribs 26 and conductive sleeve 4 into a tight electrical connection. Additionally, this type electrical connection effects extremely good wiping of the contact surfaces 26 and 4 as the plug connector 12 is inserted.

Another embodiment of the plug connector is also shown in FIG. 1. Plug connector 28 comprises a conductive plastic or metal sheath 32 of highly conductive and relatively noncompressible material and having a hollow cylindrical core receiving portion 34 integral therewith. It is obvious that the sheaths 4 or 32 may be of non-conductive material having a conductive coating. A longitudinal slot 36 is cut through the wall of core receiving portion 34 and extends through the leading end 38 of the connector. When pressurized core material (similar to material 18) is introduced into the interior of core receiving portion 34, the resulting outward force exerted by the core material on the inside

walls of sheath 34 will cause slot 36 to widen. This results in the core receiving sheath 34 having a greater outside diameter than it did before the material was introduced.

As shown in FIG. 1a, the core receiving sheath is provided with locking means 40 to limit the degree to which slot 36 can widen. As slot 36 widens and narrows, tongue 42 is allowed a limited amount of movement in opening 44 which has been cut out of sheath 34.

The upper portion 45 of conductive sheath 32 has been crimped about or otherwise secured to an electrical lead 46. A plug connector 28 is inserted into receptacle 48, the two edges of core receiving portion 34 are brought together thereby narrowing slot 36. This causes the core material disposed within portion 34 to be compressed and the resulting outward force effects a tight electrical connection between the outside surface of core receiving portion 34 and receptacle wall 50.

FIGS. 2 THROUGH 6

The connector can be made as follows:

Hollow tubular member 52, made of expansible conductive material, is crimped at one end by jaws 54 and 56 thereby forming a fluid tight closure 57. Tubular member 52 is then filled with an elastic material 58 which is injected under pressure into member 52 by nozzle 60. Elastic material 58 is preferably pressurized and compressed by the introduction of additional elastic material 58. The outward force exerted on the walls of member 52 by the compressed material 58 causes an increase in the volume of space enclosed within member 52. At this time jaws 62 and 64 crimp the other end 65 of tubular member 52 forming a second fluid tight closure 66. The pressurized material 58 is thereby enclosed within the confines of tubular member 52 which remains in an expanded position by itself. The crimping action of the jaws 62 and 64 cause compression, building up a permanent pressure in the filled chamber of tubular member 52.

FIG. 3 shows a plug connector 68 of the type made by the process described in connection with FIG. 2. Closures 70 and 72 retain pressurized material 74 within the confines of conductive sheath 76. The portion 78 of conductive sheath 76 beyond neck 72 has been crimped about electrical lead 80. When plug connector 68 is inserted into a receptacle having a smaller diameter than the diameter of connector 68, the outer circumference of conductive sheath 76 will be reduced and the pressurized material 74 compressed. The outward force of material 74 exerted on the inner wall 82 of conductive sheath 76 will urge conductive sheath 76 into its enlarged position thereby effecting a tight electrical connection.

A method of making the plug connectors shown in FIG. 1 is indicated in FIG. 6. The conductive sheath 84 having a longitudinal slot 86 is encased in a machine die 88 having cooperating halves 90 and 92. Pressurized elastic material 94 is then introduced into the hollow interior of conductive sheath 84 and the two ends (not shown) of sheath 84 are closed either permanently as by crimping or temporarily by end capping with additional machine dies, (not shown). The elastic material 94 is then allowed to solidify into a semi-rigid stage and the die 92 is removed. When conductive sheath 84 is no longer restrained by die halves 90 and 92, the out-

ward force exerted by elastic material 94 will cause slot 86 to widen and the outer circumference of conductive sheath 84 to increase.

A similar process is employed to manufacture the type of plug connector 12 shown in FIG. 1. FIG. 5 shows the connector encased in die 96 which prevents the outward radial displacement of expansion ribs 98. The area enclosed by die 96 and expansion ribs 98 is filled with a pressurized elastic material 100, this area is sealed and the material 100 is allowed to solidify. When die 96 is removed, expansion ribs 98 will be forced to bow outwardly due to the force exerted by the compressed elastic material 100. Since elastic material 100 is now in a solid state, it will be contained generally by expansion ribs 98.

In FIG. 4 is shown a slight variation on the type of die which was used in the method of FIG. 5. In this instance, die 102 has a number of recesses 104 in its inside surface 106 to receive expansion ribs 108 when the connector is inserted in the die 102. When elastic material 109 is introduced, allowed to solidify, and the die 102 removed, the circumference defined by expansion ribs 108 will be greater than that defined by the outside surface 110 of core 109. This will allow the expanded connector to be inserted into an appropriate receptacle without the walls of the receptacle coming into contact with the core 109. In this manner, the frictional forces opposing insertion are minimized.

FIGS. 7, 8 AND 9

Instead of slotting the conductive sheath 112 of connector 114 as was done in FIG. 1, portions 116 of the sheath wall 118 may be thinned. FIG. 7 shows such a conductor in which the thinned flexible areas 116 are annular and encompass the core area 120. When the core area 120 is filled with a pressurized elastic material (not shown) the thinned flexible areas 116 will expand due to the internal pressure. Abutting the thinned flexible areas 116 are thick and relatively non-flexible areas 122 which will not be substantially expanded. Obviously, too much internal pressure on the flexible areas may cause ballooning which, if excessive, may make for difficult connection.

An additional embodiment is to form the conductive sheath 124 having longitudinal thinned portions 126 formed in its walls as shown in FIG. 9. As was the case with the embodiment shown in FIG. 7, the introduction of pressurized material within core area 128 will cause the thinned portions 126 to expand outwardly.

FIG. 8 shows a further embodiment of the connector wherein the conductive sheath 130 is fluted. The addition of pressurized material within core area 132 will cause the depressed portions 134 to be displaced outwardly.

FIGS. 10 THROUGH 13

FIG. 10 shows yet another embodiment of the plug connector wherein the core receiving portion 144 of conductive sheath 146 has a series of longitudinal slots 148 cut into it. These slots are circumferentially separated from one another by a series of expansion ribs 150 comprising the non-slotted portion of core receiving sheath 144. When pressurized core material 152 is introduced into core receiving portion 144, expansion ribs 150 bow outwardly.

In FIG. 13, core receiving sheath 154 has a number of generally U or V-shaped slots 156 cut into it. When

pressurized core material is introduced into the core receiving sheath, the tongue portions 158 will be displaced outwardly. This type of connector would be useful in conjunction with a receptacle (not shown) having a ridge or the like on its inside wall thereby preventing or making difficult the removal of the inserted connector.

FIG. 12 shows an embodiment of the plug connector closely related to the one shown in FIG. 9. In this instance, the longitudinal thinned portions 160 are formed by removing a portion of the outside surface 162 of core receiving sheath 164. Additionally, a slot 166 has been cut through the wall of sheath 164.

FIG. 14 shows a further embodiment of the plug connector wherein the core receiving portion 168 has a helical slot 170 cut in it. When pressurized core material 172 is introduced into the volume encompassed by sheath 168, the external circumference of core receiving sheath 168 will be increased due to the "cork screwing" effect of the helical strip 174 running adjacent to slot 170.

FIG. 15

A further variation would be to introduce a gas into the expansion chamber 176 of conductive sheath 178, increase the pressure of the gas until the walls 180 of expansion chamber 176 are expanded outwardly, and then seal expansion chamber 176 by means of a plug 182.

FIGS. 16 THROUGH 21

In FIG. 16 the core receiving portion 184 is formed in the shape of a J enclosing a core of elastic material 186. With this design, leg 188 pivots about bend 190 contracting and releasing the core material 186 enclosed within.

In FIG. 19 the expandable core receiving portion 192 is U-shaped and the ends of the U are secured together by a retaining ring 194. As is best shown in FIG. 21, the core receiving portion 192 has a rectangular cross-section.

FIGS. 22, 23, 25, 26, 27, AND 28

In addition to the plug-type connector previously described, basically the same design consideration may be applied to a connector receptacle. The broad aspects of this were considered in connection with FIG. 1.

Installed in circuit board B is a receptacle 196 comprising a conductive plastic or metal sleeve or ferrule 198 to which is attached a backing 200 of elastic material under compression. This backing material 200 is supported by the conductive sleeve 198 and exerts an expansion force on its inside surface 202. The backing material 200 is further supported by the wall 204 of the circuit board B. Cut into conductive sleeve 198 is a slot 206 to allow the inside circumference of conductive sleeve 198 to increase and decrease. Since conductive member 198 is made of a material harder and substantially less compressible than the elastic backing material 200, the introduction of a plug and connector (not shown) having a circumference greater than the inner circumference of sleeve 198 will cause this inner circumference to be increased resulting in the widening of slot 206 and the compression of backing material 200. The inner circumference of sleeve 198 is prevented from decreasing beyond a certain limit by adjoining edges 208 and 210 abutting against each other. In elec-

trical contact with inner sleeve 198 are printed circuit leads 212 and 214.

As shown in FIG. 23, an additional embodiment of the tight fitting receptacle is to mount a number of air tight plastic envelopes 216 in circuit board B. The conductive sleeve 218, having a slot 220, is secured to the backing envelopes 216 and printed circuit lead 222. When gas is introduced into the expansion chambers 224, the flexible backing envelopes 216 will expand thereby decreasing the inner circumference of conductive sleeve 218 in the manner previously described.

Additionally, as is shown in FIG. 27, the tight fitting receptacle 226 may comprise an inner conductive sleeve 228, having a slot 230 therein, and an outer concentric sleeve 232. When the expansion chamber, which lies between the two sleeves, 232 the 228, is filled with a pressurized core material 236, the inner circumference of the inner sleeve 228 will decrease in the manner previously described. The outer sleeve 232, not being slotted, will undergo no expansion.

FIGS. 24 AND 29

A further embodiment of the tight fitting receptacle is the edge connector shown in FIG. 24. This type of connector would be useful where it is desired to make a multiple connection to a printed circuit board or the like.

The edge connector 237 comprises a base 238 having a slot 240 therein. Retained or supported by the skirts 242 and 244 are parallel strips of backing 246 and 248 of elastic material under compression. Further supporting and containing the backing strip 246 and 248 are a pair of spaced plates 250 and 252. The spaced plates 250 and 252 are movable due to the space between the ends 254 and 256 of the plates and the tongue 258. As plates 250 and 252 are displaced in directions opposite to each other, e.g., due to the insertion of an edge connector, the elastic backing strips 246 and 248 are compressed. This affords a gripping action on the inserted connector (not shown).

To provide electrical connection between the inserted connector (not shown) and the printed circuit leads 260 and contact strips 262 may be printed or electrodeposited on the surface of plates 250 and 252, or otherwise manufactured.

While this invention has been described in connection with different embodiments thereof, it will be understood that it is capable of further modifications, and this application is intended to cover any variations, uses, or adaptations of the invention following, in general, the principles of the invention and including such departures from the present disclosure as come within known or customary practice in the art to which the invention pertains, and as may be applied to the essential features hereinbefore set forth and followed in the scope of the invention or the limits of the appended claims.

Having thus described my invention, what I claim is:

1. A removable, reusable electrical connector element for mating connector components and the like comprising:

- a. a conductor sheath having a substantially regularly shaped surface and a resilient, compressible, flexible and expandable spring wall portion

b. a core of resilient elastic material in contact with said conductive sheath and at all times under compression and at all times exerting a force on said spring wall portion

c. said spring wall portion being slightly and non-abruptly deformed by said core material and at all times under stress

d. said sheath including means for permitting flexing of said spring wall portion inwardly and outwardly, and

e. said sheath being substantially less compressible than said core material.

2. A connector element as in claim 1 and wherein:
a. said core is comprised of resilient plastic material.

3. A connector element as in claim 2 and wherein:
a. said core plastic material is conductive.

4. A connector element as in claim 2 and wherein:
a. said sheath includes at least one slot extending parallel to the longitudinal axis of said connector.

5. A connector element as in claim 2 and wherein:
a. said sheath includes at least two slots aligned and parallel to the longitudinal axis of said connector.

6. A connector element as in claim 5 and wherein:
a. said sheath includes a series of slots spaced radially about the axis of said sheath.

7. A connector element as in claim 1 and wherein:
a. said sheath is cylindrical in configuration.

8. A reusable electrical connector element for a mating connector component and the like comprising:

a. a conductive member having a substantially regularly shaped surface and a resilient, compressible, flexible, expandable spring backing receiving portion

b. a backing of resilient, elastic material in contact with said conductive member and at all times under compression and at all times exerting a force on said spring backing receiving portion

c. said spring backing receiving portion being slightly and non-abruptly deformed by said backing and at all times under stress,

d. said conductive member including means for permitting flexing of said spring backing receiving portion inwardly and outwardly

e. said conductive member being substantially less compressible than said backing, and

f. stop means associated with said conductive member for limiting the amount of closing of said backing receiving member.

9. A connector element as in claim 8 and wherein:
a. said conductive member is a sleeve.

10. A connector element as in claim 9 and wherein:

a. said backing supports a second sleeve mounted concentric with said first mentioned sleeve.

11. A connector element as in claim 9 and wherein:

a. said stop means includes a split in said sleeve.

12. A connector element as in claim 11 and wherein:

a. said stop means includes the side edges of said split.

13. A connector element as in claim 9 and including:

a. a base member

b. an opening in said base member, and

c. said backing mounted in said opening.

* * * * *