

[54] ELECTRICAL CONNECTOR

[75] Inventor: Kenneth M. Clark, Beaumont, Calif.

[73] Assignee: The Deutsch Company Electronic Components Division, Banning, Calif.

[22] Filed: July 29, 1971

[21] Appl. No.: 167,317

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 83,782, Oct. 26, 1970, abandoned.

[52] U.S. Cl. 339/59 M, 339/217 S

[51] Int. Cl. H01r 13/42

[58] Field of Search..... 339/59-61, 217

[56] References Cited

UNITED STATES PATENTS

3,068,443	12/1962	Nava et al.	339/59 M
3,165,369	1/1965	Maston	339/59 M
3,638,165	1/1972	Anhalt et al.	339/59 R
3,101,229	8/1963	Yopp	339/59 M
3,221,292	11/1965	Swanson et al.	339/217 S
3,336,569	8/1967	Nava	339/217 S
3,394,339	7/1968	Gaskiewicz et al.	339/217 S
3,440,596	4/1969	Frompovicz	339/59 M
3,478,305	11/1969	Chirumbolo	339/217 S
3,631,375	12/1971	Bridle	339/217 S

FOREIGN PATENTS OR APPLICATIONS

90,705	12/1967	France	339/217 S
--------	---------	--------------	-----------

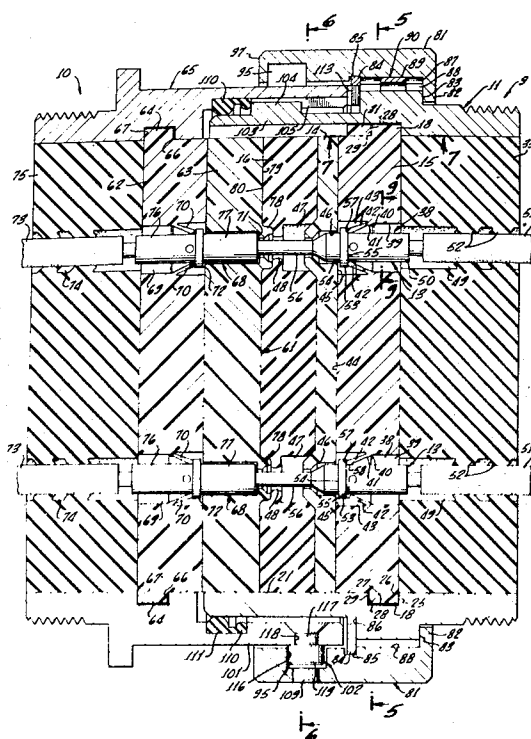
Primary Examiner—Joseph H. McGlynn

Attorney—Richard F. Carr

[57] ABSTRACT

An electrical connector that includes an insert assembly held in the shell by means of outwardly projecting lugs on the insert that are rearwardly moved through longitudinal slots in the shell upon assembly, followed by rotation of the insert to position the lugs between opposed shoulders on the shell, which thereby prevents relative axial movement of the shell and insert. The insert includes continuous openings between the forward and rearward ends, each of the openings receiving a contact which is retained between a rearwardly facing shoulder in each opening and integral resilient fingers on the insert, which incline forwardly and inwardly from the circumferential wall of the opening to engage the rearward contact shoulder. The openings for the contacts include tapering surfaces which contract a longitudinally split insertion and removal tool so that it can enter a smaller portion of the opening adjacent the spring fingers as the contact is installed and removed, allowing the tool to be more readily manufactured in smaller sizes with a relatively wide longitudinal slot. The plug and receptacle are held together by a bayonet coupling that includes pins on the receptacle which enter grooves in a rotatable but axially fixed coupling ring around the plug shell, the bayonet grooves including inner portions that fall within a radial plane and have no forwardly inclined recesses at their inner ends. A detent to prevent inadvertent rotation of the coupling ring after the connector has been mated is provided by a leaf spring which is carried by the plug shell and has an outwardly projecting portion adapted to enter a recess in the inner wall of the coupling ring.

24 Claims, 30 Drawing Figures



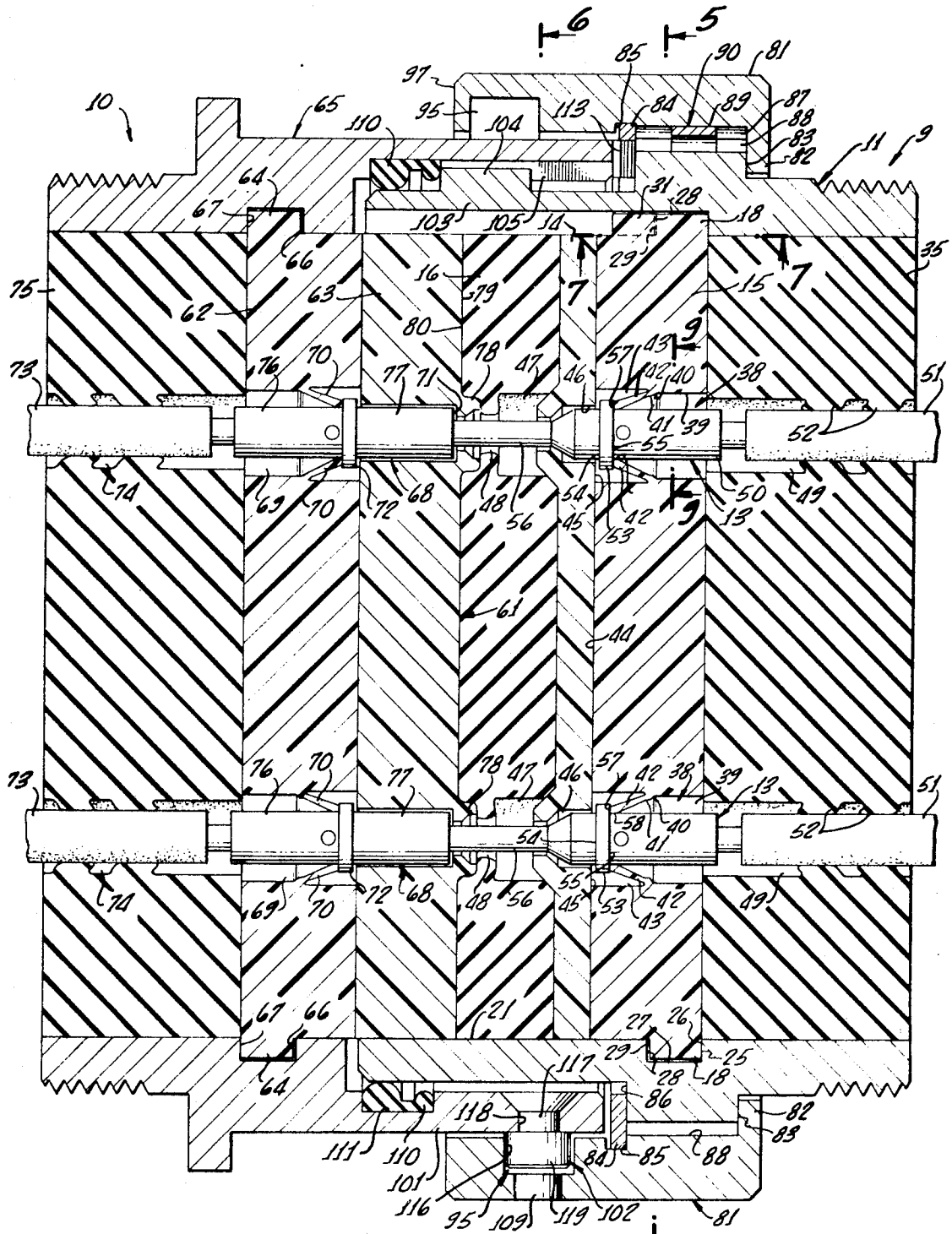


FIG. 3.

INVENTOR.
KENNETH M. CLARK
BY *[Signature]*
ATTORNEYS.

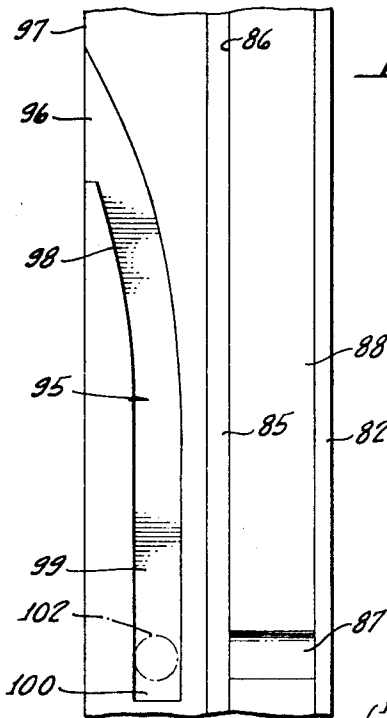


FIG. 14.

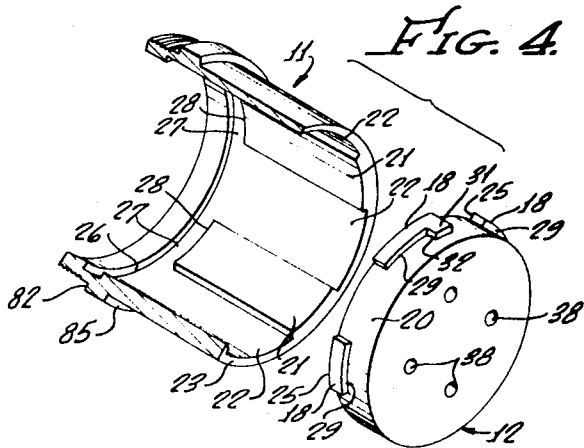


FIG. 4.

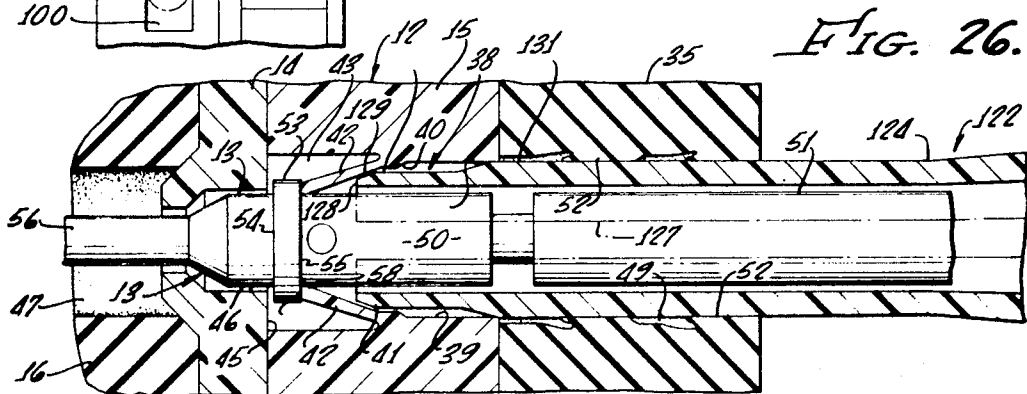


FIG. 26.

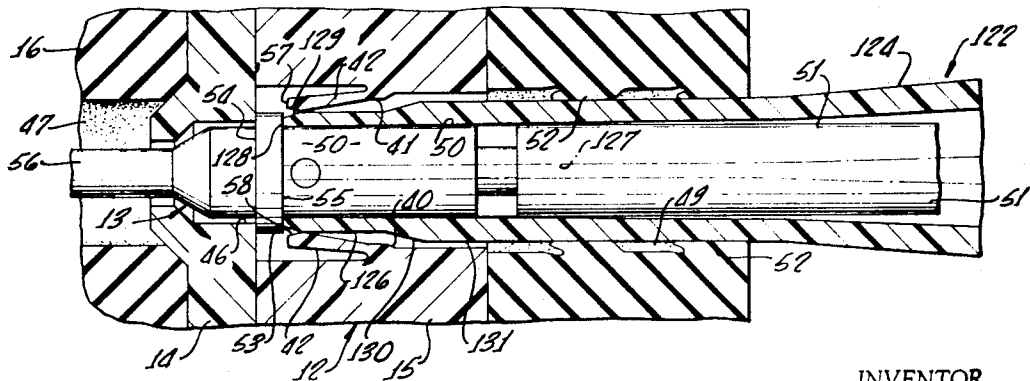


FIG. 27.

INVENTOR.
KENNETH M. CLARK
BY *James W. Carr*
W. H. Rosenberg
ATTORNEYS.

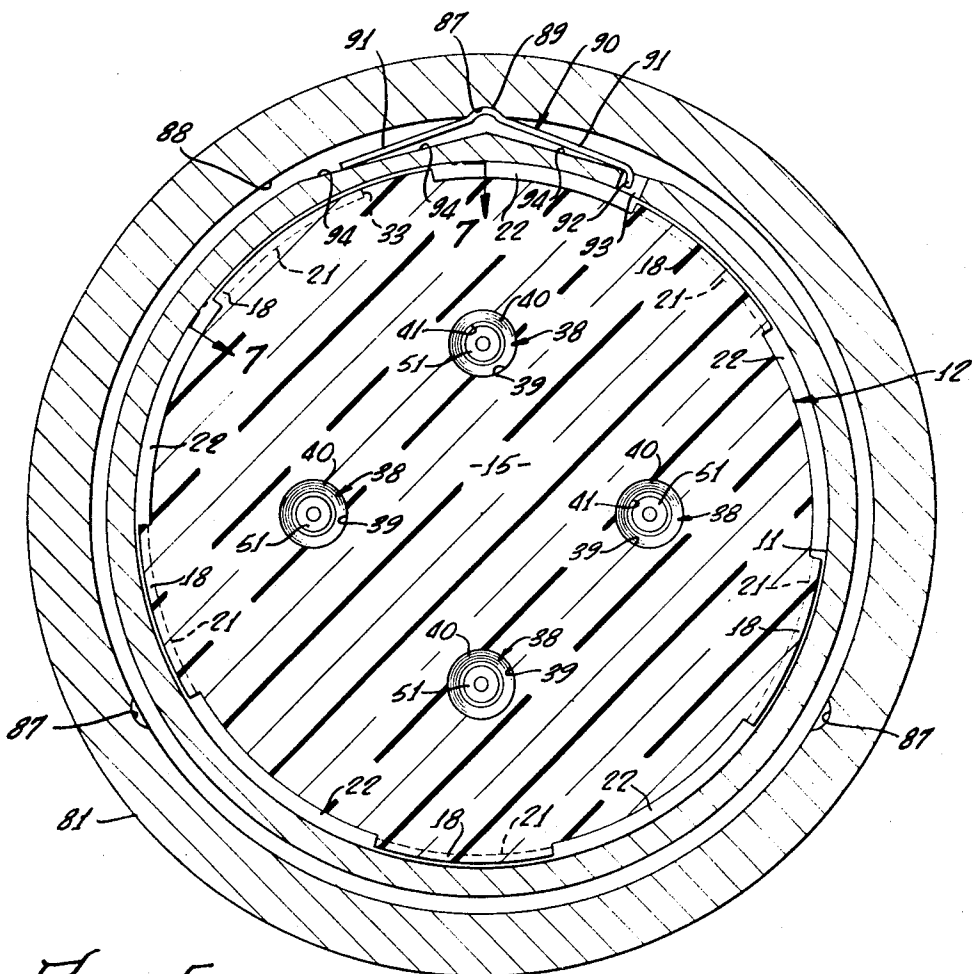


FIG. 5.

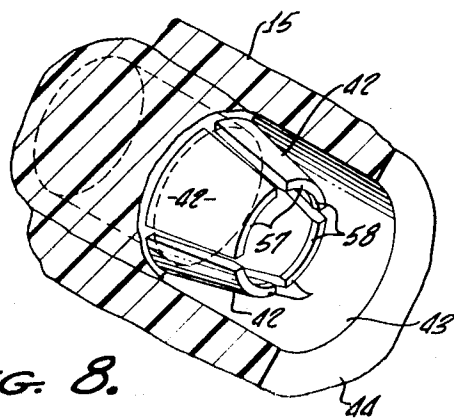


FIG. 8.

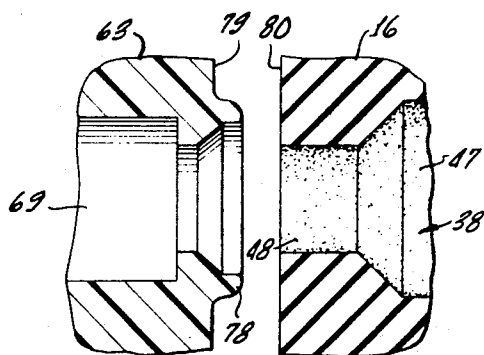


FIG. 13.

INVENTOR
KENNETH M. CLARK

BY *James H. Jones*
& H. H. H. H.
ATTORNEYS.

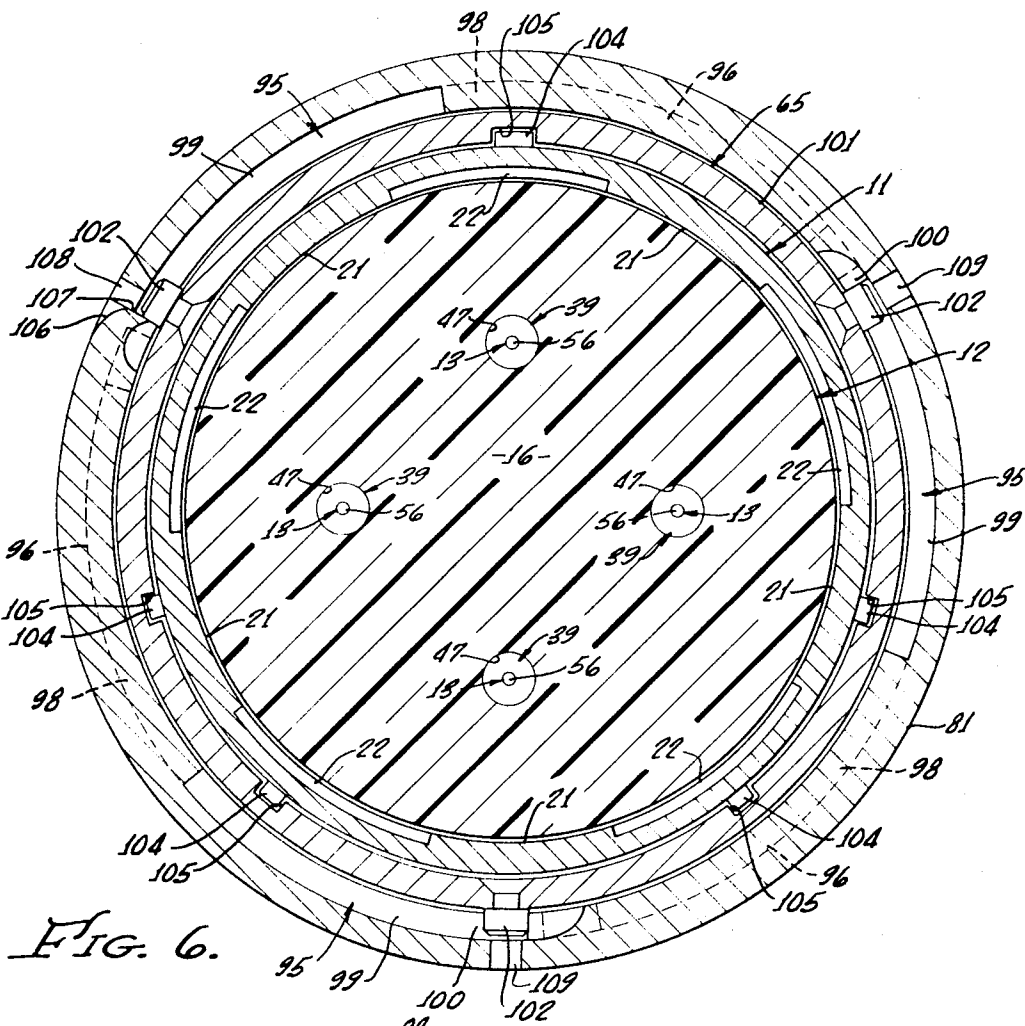


FIG. 6.

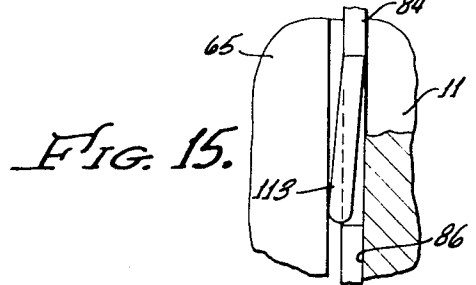


FIG. 15.

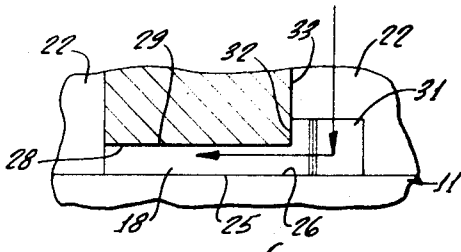


FIG. 7.

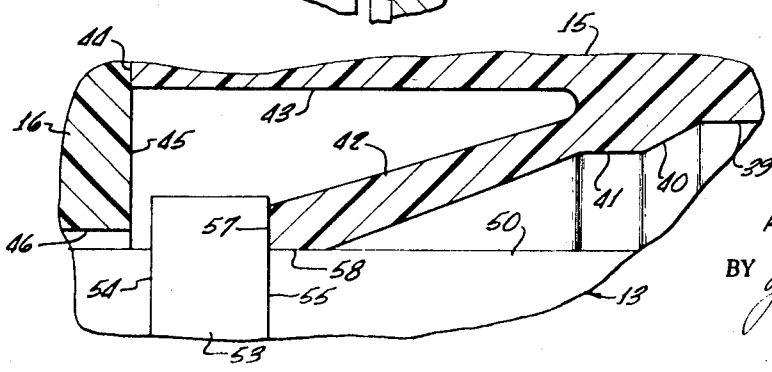


FIG. 10.

INVENTOR.
KENNETH M. CLARK
BY *[Signature]*
F. J. O'Brien -
ATTORNEYS.

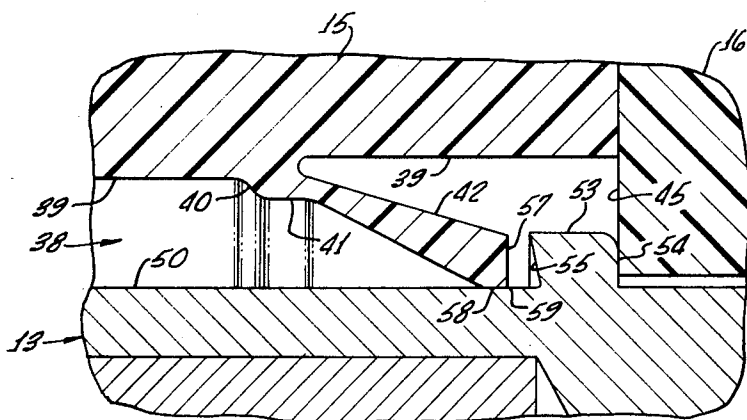


FIG. 11.

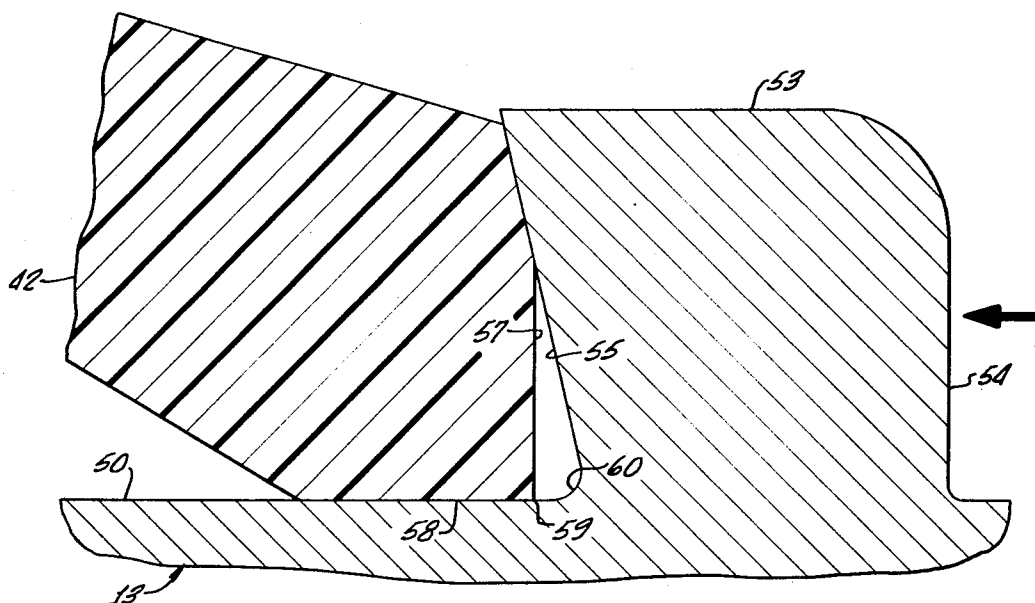


FIG. 12.

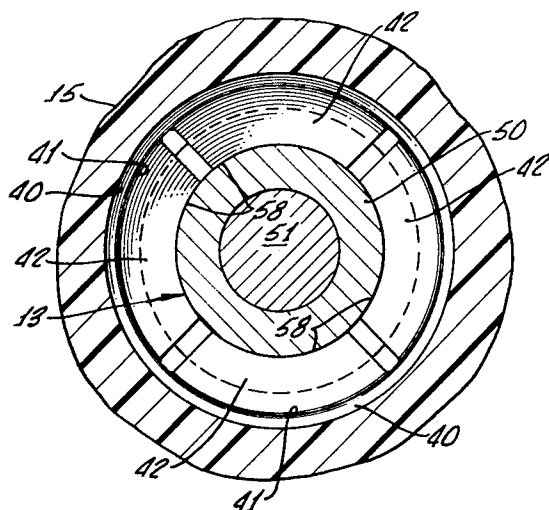
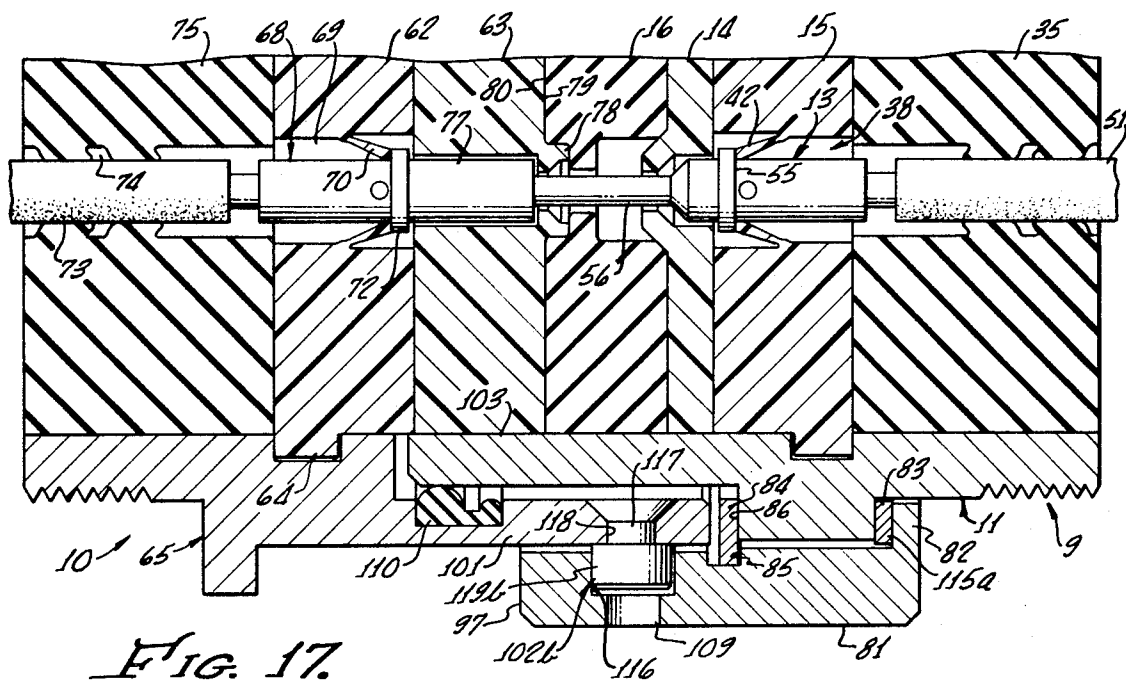
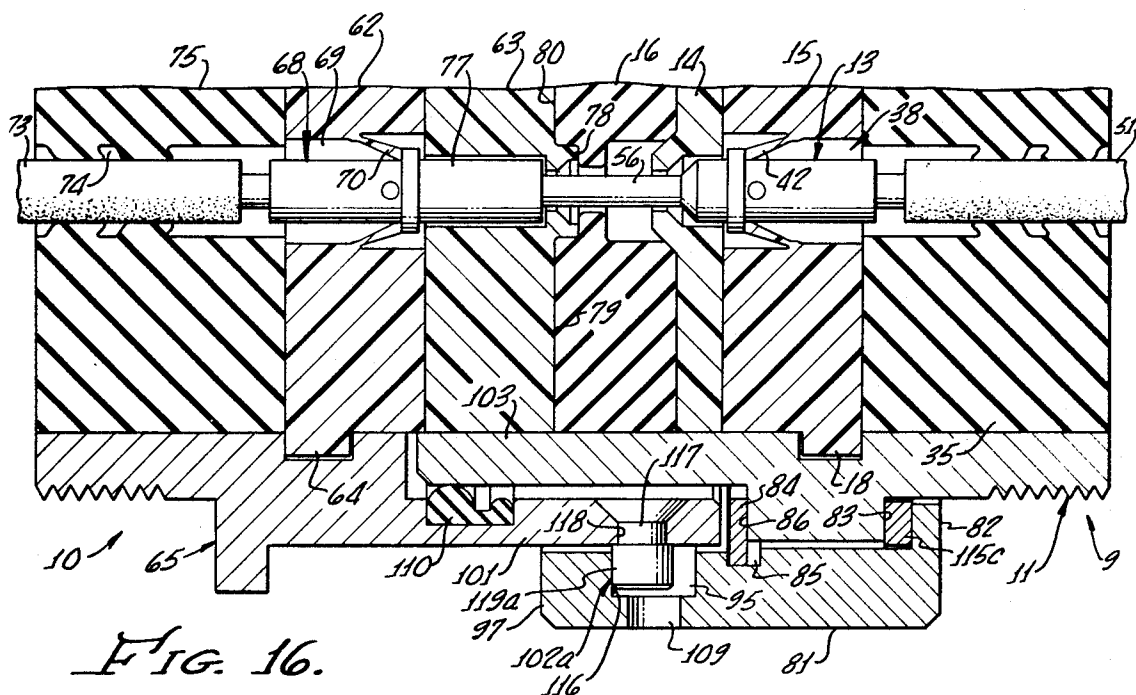


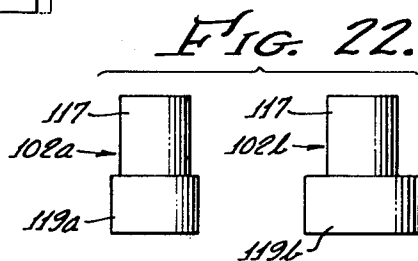
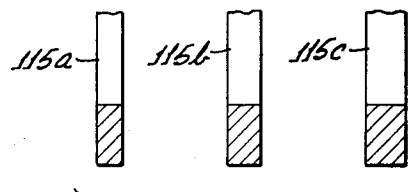
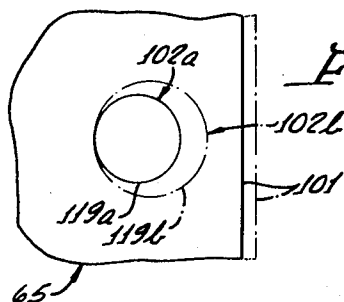
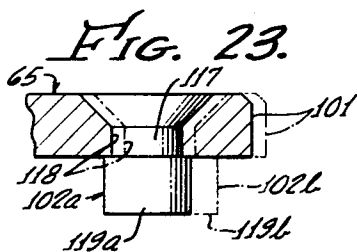
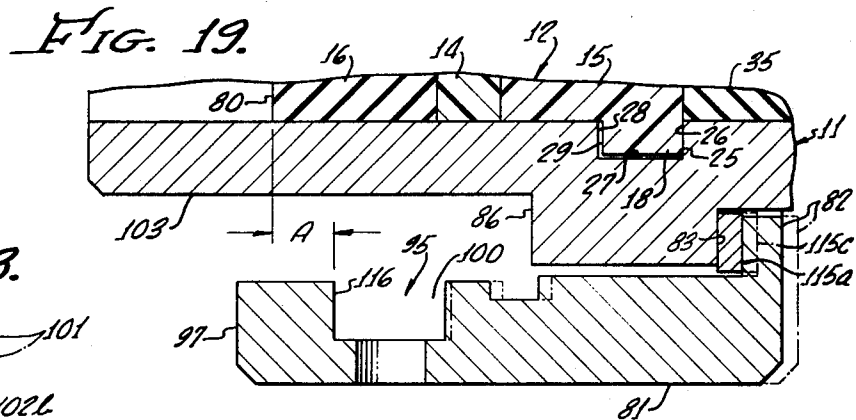
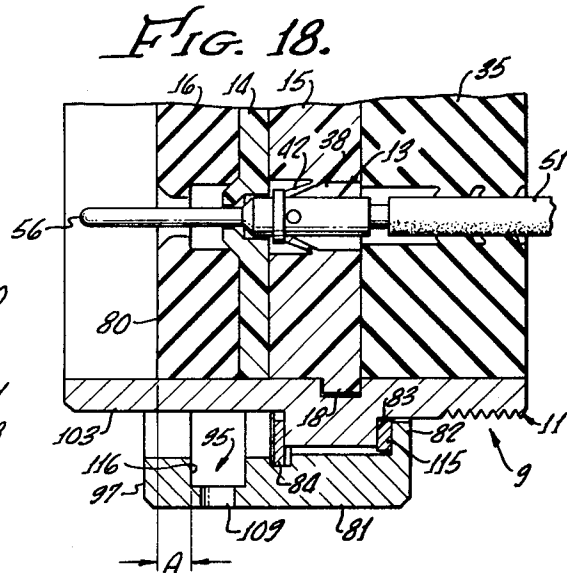
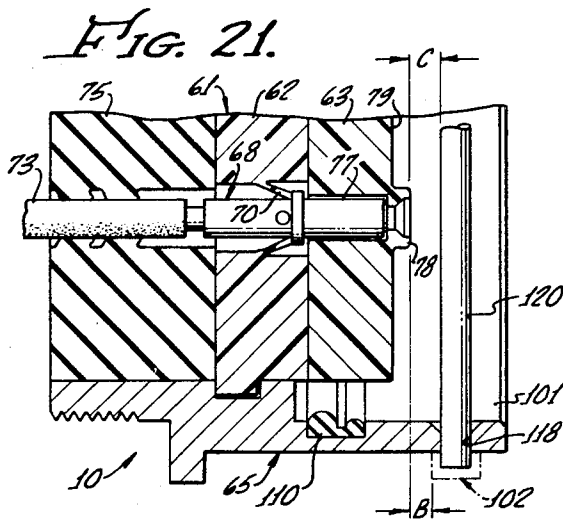
FIG. 9.

INVENTOR.
KENNETH M. CLARK
BY *James H. Carr*
E. Rotherberg
ATTORNEYS.



INVENTOR.
KENNETH M. CLARK

BY *James H. Carr*
F. R. Schenberg
ATTORNEYS.



INVENTOR.
KENNETH M. CLARK

BY *Janowitz, Carr & Rothberg*
ATTORNEYS.

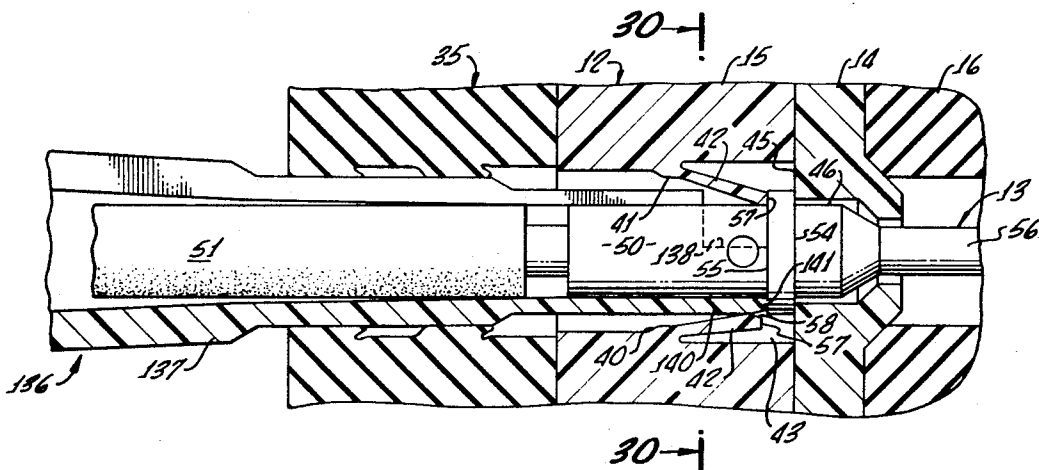
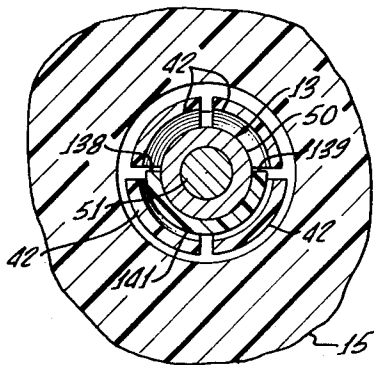
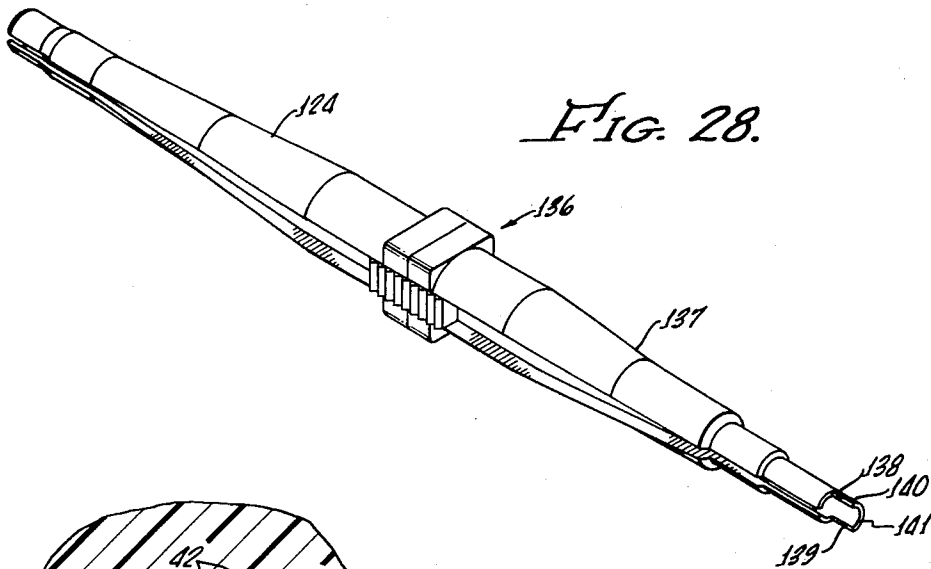


FIG. 29.

INVENTOR.
KENNETH M. CLARK
BY *James W. Carr*
Robert Rosenberg
ATTORNEYS.

ELECTRICAL CONNECTOR

REFERENCE TO RELATED APPLICATION

This is a continuation-in-part of my copending patent application Ser. No. 83,782, filed Oct. 26, 1970, for Electrical Connector, now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to electrical connectors.

2. The Prior Art

Electrical connectors conventionally include a plug and receptacle, each of which has an insert of dielectric material provided with multiple openings within which the electrical contacts are retained. The insert is introduced from the rearward end into a metallic shell, where it is held against an abutment by means of a nut. The nut is subject to loosening during service, so that there is no positive assurance of retention of the insert. Such loosening of the nut will allow the insert to move rearwardly even when the plug and receptacle are coupled, and can result in the separation of the contacts and the interruption of their electrical circuits. Also, this arrangement for retaining the insert wastes space within the shell, adding to the size of the connector.

Some connectors provide for rear insertion and release of the electrical contacts, a desirable feature facilitating the assembly and servicing of the connector. In these connectors, each contact opening includes a rearwardly facing shoulder. There is, in addition, a metal retaining clip that fits within the opening, having a split outer sleeve portion received between shoulders defined by a circumferential recess in the wall of the opening, while spring fingers incline forwardly and inwardly from the sleeve portion of the retainer clip. The contact includes an annular enlargement that defines forwardly and rearwardly facing shoulders. The contact is held in the insert of the connector by positioning its forwardly facing shoulder adjacent the rearwardly facing shoulder of the insert and the rearward shoulder of the contact against the ends of the spring fingers of the retaining clip. U.S. Pat. No. 3,158,424 provides an illustration of this contact retention system.

The necessity for utilizing a separate retainer clip for each contact adds considerably to the number of parts incorporated in the connector. This increases the expense of the connector as well as the required assembly time. The possibility is always present of an improper installation of a retainer clip (such as positioning it backwards), which will prevent it from correctly retaining the contact. The retainer clips also are fragile and very difficult to handle, particularly when used for connectors of small sizes.

In the past, it was proposed to use integral fingers on the dielectric insert to engage the rearward shoulder of the contact, instead of providing a separate metal retaining clip. This design had an insert that was in two sections bonded together. The connection of the insert sections was made around the periphery of the insert assembly, while interiorly the rearward radial face of the forward insert element was spaced from the forward face of the rearward insert element. This left an open cavity extending the entire interior transverse dimension of the insert unit. Thus, there was a connection between the adjacent contact openings, and the

openings were not continuous from front to rear, but interrupted by the cavity. The integral retention fingers projected forwardly from the forward face of the rearward insert element into the interior cavity, stopping short of the rearward face of the forward insert section. This provided the means for holding the contacts in place, with the fingers engaging the rearward contact shoulders, and the rearward face of the forward insert engaging the forward contact shoulders.

This design had certain disadvantages and was not successful commercially. The open cavity within the insert meant that the danger existed that a contact could become misaligned and cocked so that it engaged the adjacent contact to result in a short circuit. Also, a probe or other tool inserted into the connector could move from one contact opening to the adjacent one through the open cavity space, raising further risk of bending or damaging the contacts or misaligning them so that they would not mate properly or could result in a short circuit. Any moisture that found its way into the insert could travel to all of the contact openings rather than being confined to only one as where the contact openings are separated. Furthermore, the inserts of these connectors were made of nylon, which absorbed moisture and lost its strength when exposed to water, and could not withstand elevated temperatures.

Particularly in the design of a relatively small connector with integral plastic fingers, a severe problem arises in making the plastic fingers adequately strong to resist the rearward forces imposed on the contact without buckling and breaking. The retention fingers are loaded as columns, and, because their outer ends are free for engagement with the contact shoulder, they ordinarily lack stability. This, in turn, reduces the loading that they can withstand before buckling. Also, retention fingers of conventional configuration are loaded eccentrically to their neutral column centers, increasing the tendency to buckle under load. The relatively thin fingers additionally are subject to possible failure in shear or may break from an inability to flex properly.

Smaller connector sizes also have created problems in the manufacture of the tools used for insertion and removal of the contacts. These tools conventionally have been split tubular members of plastic material having ends adapted to engage the rearward contact shoulders, as described in U.S. Pat. No. 3,110,093. It is difficult to mold these tools to a tubular form when the diameter is reduced sufficiently to allow the tool to make proper engagement with contacts of the smaller sizes.

In order to secure the plug and receptacle of the connector together, a bayonet coupling mechanism frequently is used. This may include pins projecting radially outwardly from the shell of one of the sections of the connector, which are adapted to enter grooves in a coupling ring provided on the other section of the connector. The grooves have entrance portions at the forward end of the coupling ring, from which the grooves extend inwardly, terminating in recesses that extend back toward the forward end of the coupling ring. The pins enter the bayonet grooves as the connector is moved toward the mated position, moving to the inner ends of the grooves as the coupling ring is rotated. The coupling ring is engaged by a spring bias-

ing it axially so that the bayonet pins are moved into the recesses at the ends of the bayonet grooves upon the termination of the rotation of the coupling ring. The spring force holding the pins in the recesses acts as a detent that retains the coupling ring against inadvertent rotation.

This arrangement means that the plug and receptacle are moved toward each other a distance beyond their normal mated position before the pins are allowed to enter the recesses at the ends of the bayonet grooves. As the pins are moved into the recesses, there is a slight separational movement of the connector plug and receptacle. Also, it is possible for the coupling ring detent spring to be overcome by an outward pull on the two sections of the connector. This can allow some separation of the plug and receptacle so that the contacts move relative to each other toward an unmated position. Therefore, in order to assure electrical continuity through the connector under all conditions, the pin and socket contacts must be made sufficiently long to permit some relative movement between them without causing disengagement. Consequently, the connector must be made large enough to accommodate the longer contacts, despite continued requirements for reduction in the size and weight of electrical connectors.

At the forward faces of the plug and receptacle of the connector, it is necessary to seal at each contact opening to guard against entry of moisture or other foreign matter. This has been accomplished successfully by the use of a rigid forward face on the insert of one connector section, provided with a tapered axial recess at each of the openings. The mating connector section has a forward insert face of resilient elastomeric material with an oversized projection around each opening adapted to wedge into each tapered recess to provide a seal. This has been a very effective way of preventing entry of moisture. However, occasionally the elastomeric element will come into contact with oil, which causes it to swell. This makes the projecting portions larger and, hence, more difficult to force into the tapered recesses in the forward face of the mating connector section. When this occurs, more force is required in shifting the connector to the mated position because of the resistance afforded by the swollen projections around the many contact openings.

SUMMARY OF THE INVENTION

The present invention provides an improved electrical connector which overcomes the difficulties outlined above. In this connector, the insert is held in the shell by immovable abutments rather than a nut so that the insert will not become loosened while the connector is in service. This is accomplished by including spaced longitudinal grooves in the inner circumferential surface of the shell, which extend rearwardly from the forward end to an annular shoulder adjacent the rearward end. Circumferential recesses communicate with the longitudinal grooves and define additional abutments adjacent the annular shoulder. Lugs project outwardly from the insert and slide through the longitudinal grooves as the unit is assembled by moving the insert into the shell from the forward end. When the lugs have reached the annular shoulder, the insert is rotated to position the lugs in the circumferential recesses

between the shoulder and the abutments. A suitable connection, such as bonding, holds the insert against reverse rotation.

This construction means that the inserts cannot move rearwardly past the annular shoulder, so that the inserts are held positively under vibrational and other loads imposed during use. Once the connector has been coupled, the inserts will remain fixed and cannot move so as to disengage the contacts. Also, by assembling the insert from the forward end, more available space is provided inside the shell, increasing the number of contacts that may be included in a connector of a given size. Virtually the entire interior dimension of the plug shell can be used in retaining contacts, allowing the receptacle shell, where excess space necessarily is present, to accommodate a comparably increased number of contacts.

Within the insert, which is made of a moisture- and temperature-resistant plastic, are integral resilient fingers in each of the contact openings. These fingers project inwardly from the circumferential wall of the opening rather than extending into an open cavity. Thus, the contact openings are continuous from the forward to the rearward end of the insert, and the openings are isolated from each other. Better assurance of contact alignment and positioning is obtained in this manner. A dielectric barrier is provided between all adjacent contacts. Also, moisture or other foreign matter will not travel throughout the interior of the insert if it should enter one of the contact openings. The insert is made in two portions bonded together forwardly of the ends of the retention fingers. This positions the bond line away from the bases of the fingers so that nothing will be squeezed out during the bonding in an area that could interfere with the fingers.

The forward ends of the fingers are made thicker than the bases of the fingers, and provided with radial edges to engage the contact shoulders. The finger ends also include inner surfaces that are cylindrical segments to complementarily engage the barrels of the contacts. This stabilizes the ends of the fingers to increase their column strength. The larger cross-sectional area at the finger ends provides greater strength and load-carrying capacity both in bending and in shear. The thinner base portions of the fingers have requisite flexibility to allow contact insertion and removal without suffering damage.

The metal contact retained by the integral plastic fingers generally resembles those of conventional type. However, its rearward shoulder is not radial but, instead, is undercut. This gives it a frustoconical configuration as it tapers toward the forward end of the contact.

This combination provides substantially improved strength for the integral plastic retaining fingers so that they may be used satisfactorily even in small-sized connectors, and a separate metal clip is not required. The undercut shoulder has the effect of stabilizing the free end of the finger so that the finger's column strength is enhanced significantly. Increased stability also is realized from the complementary engagement of the cylindrical segmental surface of the finger with the periphery of the contact. The undercut shoulder helps keep the cylindrical segmental surface properly engaged with the contact surface to increase the stability

of the finger. The stabilizing effect is improved by the fact that the plastic of the finger is softer than the metal of the contact, so that the finger at its radial surface becomes distorted and the contact becomes, in effect, embedded in it. The undercut shoulder also keeps the inner corner of the finger end away from the fillet that necessarily is produced in machining the contact at the location between the rearward shoulder and the cylindrical barrel of the contact. With a radial contact shoulder, the corner of the finger will strike the fillet, which acts as a cam directing the finger outwardly toward a position where it disengages the shoulder. This situation is avoided where the shoulder is undercut, without sacrificing strength or recessing of the finger end. While achieving these beneficial effects, the connector with the integral plastic fingers of this invention at the same time is readily producible by molding.

Each contact opening includes a rearward portion of relatively large diameter, which connects through an inwardly tapering part to a forward portion of smaller diameter adjacent where the fingers project inwardly. This permits the removal tool to be made with a relatively wide slot and an end portion having an exterior diameter sufficient only to enter the rearward portion of the opening in the insert. Inwardly, the tool includes a tapered shoulder connecting to a portion of large exterior transverse dimension. As the tool is moved forwardly in the opening, the reaction between the tool and the wall of the opening closes up the longitudinal slot, causing the tool to become reduced in diameter so that it can enter the forward part of the opening. It then can pry the fingers away from the contact shoulder for removal of the contact. Upon removal, the tool engages the fingers forwardly of their connecting points so that there is a finite portion of each finger that is allowed to bend immediately to avoid breakage. For the installation tool, the end part may be relieved circumferentially so that not all the fingers will be engaged by the tool. This insures engagement of the contact shoulder by at least one finger so that the contact will be held in place when the tool is removed.

The resilient elastomeric gasket on the forward face of the insert of one of the connector sections is radial and without any forward projections. The other rigid forward face on the insert of the mating connector section has only an annular ridge or bead around each of the contact openings. This ridge engages the flat gasket face when the connector is mated to effect a seal around each of the openings. The sealing arrangement, therefore, does not depend upon the wedging of a projection on the gasket in an opening in the mating part, and, therefore, is little affected by swelling due to the presence of oils. This obviates the difficulty in mating the connector as the required axial force does not become too large.

The coupling mechanism provides a secure bayonet connection, but does not depend upon the bayonet pins and grooves to provide the detent that holds the coupling ring against inadvertent rotation. Instead, there is a separate detent for this purpose. Consequently, the grooves in the coupling ring are made circumferential in their inner portions, falling entirely in a radial plane and with no recesses at their inner ends for receiving the bayonet pins. Thus, when the coupling is moved to its mated position, the maximum relative

axial movement of the plug and receptacle takes place as the bayonet pins enter the inner groove portions. Also, the coupling ring is axially fixed relative to the plug shell, unlike prior designs in which the coupling ring could be moved by overcoming a spring force. Once the connector has been coupled, the plug and receptacle are permitted no relative movement, so that outward forces on the connector sections cannot cause separation of the pins and sockets. Hence, the pins and sockets may be made quite short because there is no overtravel as the connector is mated, nor will the contacts be moved apart once the coupling has been engaged. This allows the connector to be made smaller and lighter than prior designs.

With no spring in the coupling mechanism, tolerances must be controlled so that the insert faces engage with a proper amount of compression. For the plug, a spacer washer is used to position the coupling ring axially so that the forward edge of the bayonet groove is a predetermined distance from the forward face of the plug insert. Measurements are taken so that a washer of proper thickness may be selected to accomplish the correct spacing between the groove and the insert. For the receptacle, the distance between the opening for the bayonet pin and the forward face of the receptacle insert is measured. Then, a bayonet pin is selected of a diameter such that its rearward surface is a predetermined distance from the forward surface of the insert.

The detent for the coupling ring is provided by a leaf spring which is held by the plug shell and has a central portion which is adapted to enter a recess in the inner circumferential surface of the coupling ring. This occurs when the coupling ring has been rotated to where the bayonet pins are properly positioned at the inner ends of the grooves. The spring is cammed out of the recess for reverse movement in the unmating of the connector.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of an electrical connector made in accordance with this invention;

FIG. 2 is an exploded perspective view of certain portions of the connector, including in particular the parts used for coupling the plug and receptacle;

FIG. 3 is an enlarged longitudinal sectional view of the connector in the mated position;

FIG. 4 is an exploded perspective view, partially broken away, of the plug insert and shell;

FIG. 5 is a transverse sectional view taken along line 5—5 of FIG. 3;

FIG. 6 is a transverse sectional view taken along line 6—6 of FIG. 3;

FIG. 7 is a fragmentary sectional view taken along line 7—7 of FIG. 5;

FIG. 8 is a fragmentary enlarged perspective view of one portion of the plug insert assembly, illustrating the contact retention fingers;

FIG. 9 is a fragmentary transverse sectional view taken along line 9—9 of FIG. 3;

FIG. 10 is an enlarged fragmentary view illustrating the details of the finger shape and its engagement with the contact;

FIG. 11 is a fragmentary longitudinal sectional view showing the retention finger spaced from the contact shoulder when the contact is shifted forwardly;

FIG. 12 is a further enlarged fragmentary view illustrating the engagement between the retention finger and the contact shoulder, with the contact under rearward load;

FIG. 13 is an enlarged fragmentary longitudinal sectional view of the forward portions of the inserts of the plug and receptacle, shown slightly separated and illustrating the sealing arrangement for the openings;

FIG. 14 is a fragmentary flat pattern of the inside of the coupling ring, showing one of the bayonet grooves;

FIG. 15 is an enlarged fragmentary sectional view, taken along line 15—15 of FIG. 3, illustrating the engagement of the spring tab on the snap ring and the forward end of the receptacle shell;

FIG. 16 is a fragmentary longitudinal sectional view of the connector incorporating one size of bayonet pin and spacer washer used in adjusting tolerances to assure proper engagement at the forward surfaces of the connector inserts;

FIG. 17 is a view similar to FIG. 16, but with different sizes of bayonet pin and spacer washer;

FIG. 18 is a fragmentary longitudinal sectional view of the plug showing the critical dimension between the edge of the bayonet groove and the forward face of the insert;

FIG. 19 is an enlarged fragmentary sectional view showing how the spacer washer controls the dimension between the edge of the bayonet groove and the insert face in different tolerance conditions;

FIG. 20 is a fragmentary transverse sectional view of a group of three different sized spacer washers, one of which is to be selected in properly spacing the forward edge of the bayonet groove;

FIG. 21 is a fragmentary longitudinal sectional view of the receptacle illustrating the manner of measuring to obtain the dimension from the opening for the bayonet pin to the forward face of the insert;

FIG. 22 is a side elevational view of two bayonet pins having outer ends of different sizes;

FIG. 23 is a fragmentary longitudinal sectional view of the receptacle shell and bayonet pin showing how different sizes of bayonet pins may be used in different situations to in both cases position the rearward edge of the pin at the same location;

FIG. 24 is a fragmentary elevational view of the receptacle shell and bayonet pin of FIG. 23;

FIG. 25 is a perspective view of the contact insertion and removal tool;

FIG. 26 is an enlarged fragmentary longitudinal sectional view showing the tool of FIG. 25 as it is introduced into a cavity in the insert for contact removal;

FIG. 27 is a view similar to FIG. 26, but with the tool pushed all the way into the cavity for freeing the contact retention fingers from the rearward contact shoulder;

FIG. 28 is a perspective view illustrating a modified form of the contact insertion tool;

FIG. 29 is an enlarged fragmentary longitudinal sectional view illustrating the operation of the insertion tool of FIG. 28; and

FIG. 30 is a transverse sectional view taken on line 30—30 of FIG. 29;

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Illustrated in the drawing is a multiple pin and socket connector that includes a plug 9 and a receptacle 10. The general arrangement for retaining the contacts is the same in the plug and receptacle. In the embodiment illustrated, the pin contacts are in the plug and the socket contacts in the receptacle, although this may be reversed if desired. The plug 9 includes a plug shell 11, which is a generally tubular metal member of circular cross section. Within the shell 11 is an insert assembly 12 that serves to retain and hold a plurality of pin contacts 13. The insert assembly 12 includes disks 14 and 15 of a substantially rigid plastic. A suitable material for these members, because of its strength and temperature-resistance, is a polyarylsulfone marked under the trademark "Astrel" 360 plastic by Chemical Division, 3M Company, 3M Center, St. Paul, Minnesota. The disks 14 and 15 are suitably bonded together at their mating radial faces. At the forward end of the insert assembly 12 is bonded a gasket disk 16 of a resilient elastomeric material, such as silicone rubber.

The insert assembly 12 is retained in the plug shell 11 by means of interengaging castellations on the insert assembly and the plug shell. For this purpose, there are circumferentially extending lugs 18 that project outwardly from the periphery of the rearward disk 15, as seen in FIG. 4. In the embodiment illustrated, there are five of the lugs 18. The circumferential surface 20 from which the lugs 18 project is substantially complementary to the inner surface 21 of the plug shell 11. The slots 22 are made sufficiently wide to permit the insert assembly 12 to be introduced into the plug shell 11 by being slid inwardly from the forward end 23 of the plug shell, with the lugs 18 passing through the slots 22. The insert assembly 12 is moved into the plug shell until the rearward radial edges 25 of the lugs 18 are brought into engagement with an annular shoulder 26 at the rearward portion of the plug shell.

Circumferential slots 27 are formed at the rearward portion of the inner surface 21 of the plug shell 11, and are of widths substantially equal to the widths of the lugs 18. This provides circumferentially extending shoulders 28 spaced opposite from the annular shoulders 26 of the plug shell. The shoulders 26 and 28 are spaced apart a distance corresponding to the dimensions of the lugs 18 longitudinally of the insert assembly 12. This allows the insert assembly 12 to be rotated after the rearward edges 25 of the lugs 18 have been brought into engagement with the annular shoulder 26. The rotation of the insert assembly brings the lugs 18 in back of the circumferential shoulders 28 and into the circumferential slots 27. This positions the forward edges 29 of the lugs adjacent the circumferential shoulders 28 so that the radial shoulders 26 and 28 of the plug shell 11 hold the insert assembly 12 against longitudinal movement relative to the plug shell.

One of the lugs 18 may include a longitudinally forwardly projecting portion 31 having a side edge 32 which is brought into engagement with the side edge 33 of one of the longitudinal slots 22 in the plug shell for thereby limiting the rotational movement of the insert assembly 12 (see FIGS. 4 and 7). When the forward projection is provided, it assures that the insert assembly 12 assumes the proper rotational alignment

relative to the plug shell. After being properly positioned in the plug shell 11, the insert assembly is locked in place so as to prevent it from being given reverse rotation. This may be accomplished by bonding the insert assembly to the plug shell.

With the insert assembly positioned in this manner, a rearward sealing element 35 made of a resilient elastomer, such as silicone rubber, is bonded to the rearward radial face of the insert assembly and to the rearward portions of the inner circumferential wall 21 of the plug shell.

The pin contacts 13 are received in spaced parallel openings 38 formed in the insert assembly 12. The openings 38 are continuous from the front to the rear of the insert assembly 12, and are separated from each other so that there is no communication from one opening 38 to the other. The connector is designed so that a large number of the pin contacts 13 may be retained in close adjacency, but, for clarity of illustration, only a relatively few such contacts are shown in the drawing.

Each opening 38 includes a relatively wide-diameter portion 39 at the rearward end of the plastic disk 15 which, through a frustoconical portion 40, tapers forwardly to a portion 41 of smaller diameter. A plurality of fingers 42 extends radially inwardly and axially forwardly from the portion 41 of the opening 38 into the continuation 43 of the opening 38 in the member 15. This positions the fingers 42 inwardly and radially opposite the circumferential wall of the portion 43 of the opening 38. The fingers 42 are shorter than the section 43 of the opening, so that their forward ends are inward of the forward radial face 44 of the member 15. There are four of the fingers 42 in the example shown, as illustrated in FIG. 8. The fingers 42 are rounded transversely so that collectively they define a generally frustoconical shape with narrow spaces between adjacent fingers. While the plastic member 15 is relatively hard and rigid, the fingers 42 are thin and, therefore, resilient. A radial shoulder is formed by the rearward face 45 of the member 14 where the diameter of the opening decreases at portion 46. In the gasket member 16, the opening has a relatively wide-diameter portion 47 at the rearward end and a smaller-diameter portion 48 at the forward end.

An opening 49 in the rearward sealing member 35 communicates with each of the openings 38.

The pin contacts 13 may be of conventional construction, including hollow, longitudinally elongated barrel portions 50 at their rearward ends, which receive the ends of wires 51 from which the insulation has been stripped. The contact barrels 50 are crimped to the wires 51 to form a mechanical and electrical connection. The wires 51 enter the openings 38 through the openings 49 in the rearward member 35, being engaged by annular sealing beads 52 formed on the circumference of the opening 49.

Forwardly of the barrel portion 50, each contact 13 includes a part 53 of enlarged diameter which defines forward and rearward shoulders 54 and 55, respectively. Beyond the forward shoulder 54, the contact narrows to a projecting pin portion 56 that is adapted to enter the socket contact. When installed in the opening 38, the forward shoulder 54 of the contact is adjacent the rearwardly facing shoulder defined by the rearward

face 45 of the insert 14, which thereby prevents forward movement of the contact 13.

In this manner, the contact is positioned within the insert assembly and securely retained. With the use of the integral fingers 42, it is unnecessary to provide any auxiliary metal clip for retaining the contact, as in conventional connector construction. This simplifies the manufacture of the connector and lowers its cost. The danger of an improperly installed retainer clip is obviated. With the fingers 42 being entirely received in the section 43 of the opening 38, which locates them rearwardly of the forward face 44 of the disk 15, the bonding together of the inserts 14 and 15 will not adversely affect the fingers. In other words, the fingers are remote from the bond line so that any excess bonding material squeezed out at the joint will not interfere with the movement of the fingers.

As best seen in the enlarged illustration of FIG. 10, the fingers 42 are thicker in cross section at their forward ends than they are at their points of attachment to the insert 15, being tapered gradually in thickness to the rear. Also, each finger has a substantially radial forward end surface 57 which connects at a right angle to an inner end surface 58, which is a cylindrical segment generally complementary to the barrel 50 of the contact 13. When the finger 42 engages the contact 13, the radial end surface 57 fits behind the rearward shoulder 55 of the contact, while the inner end surface 58 of the finger rests upon the barrel 50 adjacent the shoulder 55.

The rearward transverse shoulder 55 of the contact 13 does not fall within a radial plane. Instead, it is inclined toward the forward end of the contact. Consequently, the shoulder 55 is undercut, being defined by a frustum of a cone. Desirable results are achieved when the shoulder 55 is inclined at around 12° relative to a radial plane. When the contact 13 is subjected to a force pushing it toward the rear, the undercut shoulder configuration and the inner finger surfaces 58 contribute greatly to the amount of force which can be absorbed before the retention fingers 42 will fail.

With the arrangement of this invention, the fingers 42, loaded as columns, receive the forces on them near the neutral centers of the columns, minimizing the tendency to buckle. The plastic of the fingers 42, being softer than the metal of the contact 13, becomes distorted where it engages the radially outer portion of the shoulder 55, as illustrated in particular in the enlarged view of FIG. 12. This has the effect of embedding the shoulder in the outer ends of the plastic fingers 42, stabilizing the finger ends. This increases the column strength of the fingers 42 because a column can withstand more loading if its ends are stabilized.

An additional stabilizing effect is realized because of the arcuate inner surfaces 58 of the fingers 42 substantially complementarily engaging the periphery of the barrel 50 of the contact adjacent the base of the shoulder 55. This helps to anchor the free ends of the fingers. The inclined configuration of the shoulder 55 results in a force component on the fingers 42 helping to hold the surfaces 58 tightly against the circumference of the barrel 50 to enhance the column stabilizing effect.

The greater wall thickness of the fingers at their outer ends adds to their strength in shear and in bend-

ing. The bending strength resists the buckling of the fingers under load.

Another advantage comes from the fact that the inner corner 59 of the finger 42, between the end surface 57 and the inner surface 58, becomes spaced rearwardly from the fillet 60, which necessarily is formed between the shoulder 55 and the barrel 50 when the contact 13 is machined. When there is a straight radial shoulder, the inner corners of the retention fingers will engage the fillet at the base of the shoulder. This deflects the fingers outwardly, thereby tending to cam the fingers out of engagement with the shoulder. The undercut shoulder 55 permits the finger to clear the fillet 60 without requiring a recess in the finger and without sacrifice in the strength of the fingers.

The insert assembly 61 for the receptacle 10 includes a plastic disk 62 that is similar to the member 15. To it is bonded or otherwise suitably secured a forward cover disk 63. The members 62 and 63 also may be made of "Astrel" 360 plastic. Outwardly projecting lugs 64 on the disk 62 correspond to the lugs 18 on the member 15. The lugs 64 secure the insert assembly 61 to the receptacle shell 65 in the same way that the lugs 18 attach the insert assembly 12 in the plug shell 11. The insert assembly 61 is introduced into the receptacle shell 65 by passing the lugs 64 through axial grooves in the inner surface of the receptacle shell 65, whereupon subsequent rotation of the insert assembly 61 places the lugs 64 between opposed forward and rearward shoulders 66 and 67, respectively, in the receptacle shell. This holds the disk 62 and the cover element 63 within the receptacle.

The socket contacts 68 are retained in continuous separate openings 69 in the insert assembly of the receptacle, positioned against axial rearward movement by integral fingers 70 that project forwardly and inwardly from the insert disk 62. A shoulder 71 on the insert member 63, where the opening 69 reduces in width, is adjacent the forward end of the contact 68 and precludes forward movement of the contact. The fingers 70 are engageable with the rearward edge of the annular enlargement 72 on the socket contact. A wire 73 extends inwardly through an opening 74 in the rearward sealing member 75 of the receptacle 10 for each of the socket contacts 68. The end portions of the wires 73 are stripped of insulation and connected by crimping to the rearward barrel ends 76 of the socket contacts 68. When the forward ends 77 of the socket contacts receive the projecting pin portions 56 of the pin contacts 13 upon the mating of the connector, circuits are completed between the wires 51 and 73.

A rounded annular bead 78 projects outwardly from the forward radial face 79 of the cover disk 63 of the receptacle insert around each of the openings 69. The bead 78 is engaged by the flat forward face 80 of the gasket 16 of the plug 9 when the connector is in the assembled position. Consequently, the bead 78 displaces the resilient material of the gasket 16 and an efficient moisture seal is produced. This type of seal does not rely upon the entry of a projecting part of the resilient elastomer into a recess in the hard plastic of the mating part as in some prior-art designs. Unlike the previous designs, swelling of the gasket 16 from attack of fluids will not appreciably interfere with the mating of the connector so that the axial force required will not vary significantly under those conditions.

The mechanism for securing the plug and receptacle together in the mated position includes a coupling ring 81 that circumscribes the plug shell 11. The rearward end of the coupling ring includes a radially inwardly extending flange 82 in back of a rearwardly facing shoulder 83 on the plug shell. A snap ring 84 fits in an annular recess 85 in the intermediate portion of the inner circumferential wall of the coupling ring 81. The snap ring 84 is positioned in front of a forwardly facing radial shoulder 86 on the plug shell 11, cooperating with the flange 82 in retaining the coupling ring 81 on the plug shell 11. This allows the coupling ring 81 to rotate relative to the plug shell 11, but relative axial movement is prevented.

Intermediate the snap ring 84 and the flange 82, the coupling ring 81 is provided with three short, arcuate, longitudinally extending recesses 87 in its inner surface 88 (see FIGS. 2 and 5). These recesses are adapted to receive the outer rounded portion 89 of a leaf spring 90. The latter member has normally straight legs 91 terminating in an inwardly bent end 92 which is received within a radial opening 93 in the periphery of the plug shell. This holds the spring 90 to the plug shell 11. Adjacent the legs 91 of the spring 90 are flat chordal surfaces 94 which provide a clearance for permitting flexure of the spring 90.

By this construction, the coupling ring 81 can be rotated relative to the plug shell 11, but there is a detent action tending to prevent relative rotation when the portion 89 of the spring 90 enters a recess 87. This retaining force may be overcome by applying adequate torque to the coupling ring to cam the rounded spring portion 89 out of the recess 87, compressing the spring inwardly and allowing the spring portion 89 to slide along the circumferential surface 88 of the coupling ring intermediate the recesses 87.

Forwardly of the snap ring 84, three bayonet grooves 95 are formed in the inner circumferential surface 88 of the coupling ring. Each groove 95 includes a wide entrance opening 96 at the forward end 97 of the coupling ring, from which there extends an inclined portion 98 of the groove, leading to a circumferential inner part 99 of the groove. The axis of the latter portion of the bayonet groove 95, as best seen in FIGS. 2 and 14, falls entirely within a radial plane as there is no recess for the bayonet pin at the inner end 100 of the groove.

The receptacle shell 65 includes a forward portion 101 of enlarged diameter which provides a clearance around the insert assembly 61. At the end of the forward portion 101 of the receptacle shell are three radially outwardly projecting bayonet pins 102.

When the electrical connector is to be mated, the forward end portion 103 of the plug shell 11 enters the forward portion 101 of the receptacle shell 65, fitting in the clearance space around the insert assembly 61 of the receptacle. Keys 104 on the plug shell fit in keyways 105 in the receptacle shell, assuring the proper rotational alignment of the plug and receptacle. With the keys in the keyways, the detent spring, when in a recess 87 in the coupling ring, positions the coupling ring so that the entrances 96 of the bayonet grooves 95 are aligned with the bayonet pins 102. Therefore, the bayonet pins 102 are brought to the entrances 96 of the bayonet grooves 95 in the coupling ring 81 as the plug and receptacle are advanced axially

toward each other. Subsequent rotation of the coupling ring 81 moves the bayonet pins 102 through the inclined portions 98 of the grooves 95 and into the circumferential portions 99, drawing the plug and receptacle into the fully mated position. The coupling ring 81 is turned until the pins 102 are adjacent the inner ends 100 of the grooves 95, which occurs as the outer portion 89 of the spring 90 enters a detent recess 87 in the coupling ring.

A positive stop is provided in one of the bayonet grooves to prevent rotation of the coupling ring 81 past the detent position when the connector is mated. This is accomplished by bending inwardly a small section 106 of the circumferential wall of the coupling ring, presenting an abutment surface 107 in the bayonet groove where it can be contacted by the bayonet pin at the termination of the rotation of the coupling ring 81 (see FIG. 6). This location corresponds to the positioning of the outer portion 89 of the detent spring 90 in a detent receptacle 87. An opening 108 is formed in the wall of the coupling ring adjacent the stop 107, while two additional openings 109 in the coupling ring are spaced 120° from the opening 108. This permits visual exterior inspection of the connector when in the mated position to ascertain whether or not the bayonet pins 102 have moved a sufficient distance into the bayonet grooves 95. When the ends of the pins 102 (which may be painted) can be seen through the openings 108 and 109, it is known that the bayonet pins are in the inner portions of the bayonet slots and that the plug and receptacle are coupled properly.

By this arrangement, the plug and receptacle are advanced axially toward each other the maximum distance when the bayonet pins are adjacent the ends 100 of the grooves 95 that receive them. No outward movement occurs as the connection is made, and, when the bayonet pins 102 reach the circumferential portions 99 of the grooves 95, the parts are held in their position of full maximum engagement. Even though subjected to a separating force, no relative movement of the plug and receptacle can take place, so that electrical continuity through the contacts is assured. The bayonet pins 102 are held against the forward sides of the bayonet grooves 95 when separating forces are imposed, while the coupling ring 81 is prevented from movement axially by the engagement of the flange 82 with the rearwardly facing shoulder 83 of the plug shell 11. This provides a solid connection of the parts.

When the connector is in the fully mated position, the forward outer periphery of the forward end of the plug shell 11 engages an annular seal 110. The latter member is held in an annular groove 111 in the receptacle shell 65 by bonding.

In some instances, the snap ring 84 may be provided with forwardly projecting tabs 113 that are brought into engagement with the end of the forward portion 101 of the receptacle shell 65 when the connector is mated (see FIG. 15). This puts a desirable tension on the coupled plug and receptacle, eliminating any clearance in the coupling mechanism. This also makes an electrical connection between the plug shell 11 and the receptacle shell 65.

The plug and receptacle are disconnected by reverse rotation of the coupling ring 81 to free the bayonet pins 102 from the bayonet grooves 95. As this is accom-

plished, the detent spring 90 is forced out of one detent recess 87, and its central part 89 slides along the surface 88 of the coupling ring 81 to the next detent recess 87. In the latter detent position, the bayonet pins 102 have reached the entrances 96 to the grooves 95 and the plug and receptacle may be pulled apart axially.

When the connector is mated, the plug 9 and the receptacle 11 are held together by the reaction of the rearward surfaces of the bayonet pins 102 against the forward edges of the bayonet grooves 95. This causes the forward faces of the inserts in the plug and receptacle to be brought into interengagement and held under compression. When assembled properly, the sealing bead 78 engages and becomes embedded in the forward face 80 of the resilient insert 16 around the mating pin and socket contacts. It is important that the bead 78 of the forward cover disk 63 and the forward face 80 of the insert 16 assume the proper relative position when the connector is mated. If they are advanced toward each other an inadequate distance, the bead 78 will not bear against the gasket disk with sufficient force to form a seal. Too much movement of one insert toward the other will cause overcompression at the mating connector surfaces, making it difficult to mate the plug and receptacle. While some variation is not harmful, manufacturing tolerances can build up so that either objectionable condition can exist.

In conventional connector design, where there is a spring in the coupling mechanism, dimensional variations of this sort are not important because the movement permitted by the spring will allow for tolerances and keep the mating faces under proper compression. With the present invention, however, there is no spring in the coupling mechanism, and tolerance buildup requires a different solution. This is accomplished by controlling the positions of the working surfaces of the bayonet grooves and the bayonet pins relative to the forward surfaces of their respective insert assemblies. Each is controlled separately to a predetermined dimensional range.

For the coupling ring 81, tolerance control is effected by means of a spacer washer 115 which fits between the abutments defined by the rearward flange 82 of the coupling ring 81 and the shoulder 83 on the shell 11 (see FIGS. 16-20). By selecting a spacer washer 115 of proper axial dimension, the distance A (indicated in FIG. 18) between the forward edge 116 of the bayonet groove 95 and the forward face 80 of the gasket insert 16 can be held within acceptable limits. Normally, in a carefully manufactured connector, the distance A can be controlled adequately by having available only a limited number of sizes of the spacer washers 115. Three such washers, such as the washers 115a, 115b and 115c shown in FIG. 20 will suffice.

In the assembly procedure, the coupling ring 81 is positioned on the shell 11 with one thickness of washer, selected by estimation or arbitrarily, positioned between the flange 82 and the shoulder 83. The distance A then is measured. Obviously, if the selected washer causes the distance A to fall within the proper range, nothing more need be done. However, if the distance A is over or under the specified range, the originally chosen washer is replaced by one of a thickness such that the distance A will be brought to within proper limits. Simple addition or subtraction will

establish the choice of spacer washer. A thicker washer will move the forward edge 116 of the groove 95 closer to the surface 80, and a thinner washer will increase the distance between the forward edge 116 and the surface 80.

In the receptacle 10, it is necessary to maintain the correct distance B between the rearward working surfaces of the bayonet pins 102 and the forward edge of the bead 78 (see FIG. 21). This is accomplished by providing bayonet pins 102 with different diameters at their exposed portions, permitting selection of a bayonet pin of proper size. This may be a choice from among two pins, such as the pins 102a and 102b illustrated in FIG. 22. In each instance, the shank portion 117 is the same and can fit complementarily in the opening 118 in the shell 65. However, the enlarged outer parts 119a and 119b, which are adapted to fit in the bayonet groove 95, are of different diameters.

In selecting the proper bayonet pin, the distance C is measured from the rearward edge of the opening 118 in the receptacle shell 65 to the forward edge of the bead 78. With this distance being known, it is possible then to select the bayonet pin having its outer part 119a or 119b dimensioned so as to result in a distance B within accepted limits. Obviously, when the distance C is at a minimum, the bayonet pin with the smaller outer end 119a is selected, while larger distances C require the bayonet pin having end 119b.

Because the opening 118 and the forward face 79 of the receptacle insert are radial with respect to the connector, the distance C may be found by first inserting a rod 120 through the opening. The rod 120 is extended inwardly parallel to the forward face 79 of the insert 63. A measurement can be made without difficulty between the rearward edge of the rod 120 and the forward edge of the sealing bead 78. This is the same dimension as that between the rearward edge of the opening 118 and the bead 78, which is the distance C.

The integral forwardly inclined fingers 42 in the plug 9 and similar fingers 70 in the receptacle 10, for holding the contacts 13 and 68, make possible desirable rear insertion and release of the contacts. In other words, the contact may be both installed and removed from the rearward ends of the plug and receptacle. Installation and removal of the contacts for such connectors ordinarily are accomplished by a tool that includes a split plastic tubular element which fits around the barrel of the contact and engages the rearward contact shoulder as the contact is installed and removed. However, when the contacts are extremely small in size, it is difficult to mold a tubular tool that will be sufficiently small in diameter to engage the contact properly for insertion and removal.

With the present invention, the tool may be constructed as shown in FIGS. 25, 26 and 27, where the end of the tool defines somewhat less than a complete circle and, therefore, is not difficult to form. The contact insertion and removal tool 122 of FIG. 25 is made of a deflectable but generally rigid plastic material. It includes a central part 123 from which extend a portion 124 for contact removal and a portion 125 for contact insertion. The forward portion 126 of the removal end 124 of the tool is arcuate in cross section, but defines less than a complete annulus by having a relatively wide longitudinal slot 127 extending from the outer end 128

of the tool. A shallow beveled surface 129 adjacent the outer end of the tool reduces the transverse dimension and wall thickness at that location. Inwardly of the end 128, the exterior of the tool increases in diameter at a tapered shoulder 130 to a wider portion 131.

The forward portion 126 of the tool 122 has a lateral dimension which permits it to enter into the rearward portion 39 of the opening 38 where the contact 13 is held, as seen in FIG. 26. However, the lateral dimension of the tool inwardly of the tapered shoulder 130 is greater than the diameter of the portion 39 of the opening. Continued axial advancement of the tool into the opening 38, therefore, causes the tapered shoulder 130 to enter the opening section 39, acting as a cam to compress the forward portion of the tool, reducing the width of the slot 127. When the wider portion 131 of the tool reaches the portion 39 of the opening, as shown in FIG. 26, the forward end portion 126 becomes reduced to a lateral dimension which is less than the diameter of the portion 41 of the opening adjacent the fingers 42. When the tool is compressed in this manner, it can be moved underneath the fingers 42 as it is advanced axially.

When the forward end of the tool reaches the fingers 42, its reduced width causes it to engage the fingers beyond their points of attachment to the insert 15. The bevel 129 on the tool also gives it a reduced width at its end and helps move the place of engagement between the tool and the fingers forwardly. In other words, the tool does not initially contact the fingers at their bases, but at an intermediate location between their ends. As a result, there is a finite length of each finger rearwardly of where the tool engages it. This provides a length of the finger that can flex immediately as the tool bends it outwardly. Engagement at the base of the finger, however, would leave no adjacent portion to bend and there would be danger of breaking the finger as the tool pried it outwardly.

The wall thickness of the removal portion 124 of the tool at its forward portion 126 is sufficient to deflect the fingers 42 outwardly a distance that will cause them to clear the rearward shoulder 55 of the contact 13. The bevel 129 serves the additional purpose of reducing the tool thickness, so that the fingers will not be bent too far outwardly to cause interference with the wall 43. With the fingers 42 spread apart, the wire 51 and tool 122 are gripped and pulled outwardly, removing the contact 13 from the opening 38.

As a consequence of the convergence of the tool in the opening 38, the tool may be formed to a relatively large lateral dimension and given a wide slot because the wall of the opening in the insert compresses the tool laterally to give it the proper dimension at the forward portion of the opening where the fingers are to be deflected.

The insertion tool portion 125 is generally similar to the removal tool section 124, having a forward arcuate portion 132 provided with a relatively wide slot 133. In installing a contact, the insertion tool 125 is fitted around the barrel 50 of the contact 13 so that its end 134 engages the rearward shoulder 55 of the contact. The tool is moved into the opening 38 with the contact 13, becoming compressed so that the forward end of the tool enters the smaller-diameter portion 41 of the opening 38 and the width of the slot 133 is diminished.

The forward shoulder 54 of the contact cams the resilient fingers 42 outwardly as the contact enters the forward portion of the opening 38, allowing the fingers to slide over the enlarged portion 53 of the contact and the rearward shoulder 55 to move past the finger ends 57. Then, the insertion tool 125 is pulled outwardly, leaving the contact 13 in its place within the insert of the connector.

The installation and removal for the socket contacts 68 in the receptacle 10 are, of course, the same as described above for the pin contacts in the plug.

In smaller connectors, it becomes difficult to proportion the parts such that the installation portion of the tool will allow the finger ends to overlap the rearward shoulder 55 of the contact when the fingers are pried outwardly by the end of the tool. When the connector is miniaturized, the rearward shoulder 55 of the contact is quite small in the radial direction. Consequently, the wall thickness of the end of the tool must be very thin if it is to allow the ends of the retention fingers 42 to move inwardly sufficiently to engage the shoulder 55 as the tool inserts the contact. Of course, if the fingers 42 do not overlap the shoulder 55, the contact will not be held against rearward movement, and the tool cannot be removed without pulling the contact outwardly past the retention fingers. On the other hand, if the end wall of the tool is thin enough to allow the fingers 42 to move inwardly an adequate distance to engage the shoulder 55, the tool may have inadequate strength to push the contact into the connector.

The tool 136 shown in FIG. 28 solves this problem, allowing the wall thickness of the tool to be adequate for contact insertion, at the same time making certain that in all instances the contact will be held in the connector when the insertion tool is removed. The tool 136 of FIG. 28 uses the same removal portion 124 as in the embodiment of FIG. 25. The contact installation portion 137 differs from the prior embodiment primarily by being recessed circumferentially along the opposed edges 138 and 139 of the longitudinal slot at the outer end of the tool. This leaves an end part 140 defined by a cylindrical segment that is less than a semicylinder. Inwardly of the end part 140, the tool portion 137 resembles that of the installation tool portion 125 described above.

Upon inserting a contact, the radial end surface 141 of the tool portion 137 engages the rearward shoulder 55. Because of the large circumferential recess at the end of the tool, only part of the shoulder 55 is engaged by the end surface 141 of the tool, but there is adequate engagement to permit the tool to insert the contact. Also, as a result of the reduced lateral dimension of the end part 140, less than all four retention fingers 42 will be engaged by the end part 140 when the contact has been pushed to its final position (see FIGS. 29 and 30). The finger or fingers not engaged by the end portion 140 of the tool 137 are free to snap inwardly behind the shoulder 55 to hold the contact in place. The wall thickness of the section 140 may be such that the retention fingers 42 it engages are pried outwardly so that they clear the shoulder 55. This does not matter, however, because the fingers 42 that already engage the contact shoulder 55 where the end part is cut away hold the contact in the opening as the tool is removed. In assuring that at least one finger 42 will be cleared by

the tool and able to engage the contact shoulder 55, no matter what the relative rotational positions of the fingers and the tool, the end portion 140 may extend through an arc of around 155° when there are four closely spaced retention fingers as in the example shown.

The foregoing detailed description is to be clearly understood as given by way of illustration and example only, the spirit and scope of this invention being limited solely by the appended claims.

What is claimed is:

1. An electrical connector device comprising:

a body of dielectric material having a forward end and a rearward end,

said body having a plurality of spaced continuous openings therein extending through said body between said forward end and said rearward end,

each of said openings having a circumferential wall,

and an electrical contact in each of said openings, each of said contacts having

a first abutment adjacent said forward end and a second abutment adjacent said rearward end,

said body having a first abutment in each of said openings adjacent said first abutment of the contact therein for limiting the movement of said contact toward said forward end,

said body having integral resilient finger means in each of said openings inclined inwardly and forwardly from said circumferential wall,

said finger means having forward end portions spaced inwardly from and radially opposed to said circumferential wall, and adjacent and engageable with said second abutment of said contact for limiting movement of said contact toward said rearward end,

said body being in at least two pieces,

said pieces having mating faces transversely of and extending between said openings,

said pieces being held in interengagement along said mating faces,

said finger means being positioned rearwardly of said mating faces.

2. A device as recited in claim 1 in which said pieces are bonded together at said mating faces, and said finger means are integrally attached to said body at a location rearwardly of said mating faces.

3. An electrical connector device comprising:

a body of dielectric material having a forward end and a rearward end,

said body having a plurality of spaced continuous openings therein extending through said body between said forward end and said rearward end,

each of said openings having a circumferential wall,

and an electrical contact in each of said openings, each of said contacts having,

a first abutment adjacent said forward end and a second abutment adjacent said rearward end,

said body having a first abutment in each of said openings adjacent said first abutment of the contact therein for limiting the movement of said contact toward said forward end,

said body having integral resilient finger means in each of said openings inclined inwardly and forwardly from said circumferential wall,

said finger means having forward end portions spaced inwardly from and radially opposed to said circumferential wall, and adjacent and engageable with said second abutment of said contact for limiting movement of said contact toward said rearward end,

each of said openings including a relatively large-diameter rearward portion, and a relatively small-diameter portion forwardly of said relatively large-diameter portion,

said finger means projecting from a location forwardly of said relatively small-diameter portion.

4. A device as recited in claim 3 in which each of said openings includes a frustoconical portion intermediate said relatively large-diameter portion and said relatively small-diameter portion for thereby providing a tapering surface between said portions.

5. An electrical connector device comprising:

a body of dielectric material having a forward end and a rearward end,

said body having a plurality of spaced openings therein extending through said body between said forward end and said rearward end,

and an electrical contact in each of said openings,

each of said contacts having,

a first abutment adjacent said forward end and a second abutment adjacent said rearward end,

said body having a first abutment in each of said openings adjacent said first abutment of the contact therein for limiting the movement of said contact toward said forward end,

said body having integral resilient finger means inclined inwardly and forwardly with respect to said openings,

said finger means having forward end portions adjacent said second abutment of said contact for limiting movement of said contact toward said rearward end,

said finger means being thicker at said forward end portions than they are rearwardly of said forward end portions.

6. An electrical connector device comprising:

a body of dielectric material having a forward end and a rearward end,

said body having a plurality of spaced openings therein extending through said body between said forward end and said rearward end,

and an electrical contact in each of said openings,

each of said contacts having,

a first abutment adjacent said forward end,

a second abutment adjacent said rearward end,

and a longitudinally directed surface rearwardly of said second abutment,

said body having a first abutment in each of said openings adjacent said first abutment of the contact therein for limiting the movement of said contact toward said forward end,

said body having integral resilient finger means, said finger means including a plurality of individual fingers inclined inwardly and forwardly with respect to said openings,

each of said fingers having a forward end portion a first part of which is adjacent and engageable with said second abutment of said contact for limiting movement of said contact toward said rearward end, and a longitudinally extending second part of which engages said longitudinally directed surface for imparting stability to said finger.

7. A device as recited in claim 6 in which:

said longitudinally directed surface is substantially cylindrical,

and in which said second part of said forward end portion of each of said finger is a substantially cylindrical segment substantially complementarily engaging said longitudinally directed surface.

8. A device as recited in claim 7 in which said first part of said forward end portion is substantially radial.

9. A device as recited in claim 8 in which each of said fingers is thicker at said forward end portion than it is rearwardly of said forward end portion.

10. A device as recited in claim 8 in which each of said fingers tapers in thickness rearwardly from said forward end portion.

11. An electrical connector device comprising:

a body of dielectric material having a forward end and a rearward end,

said body having a plurality of spaced continuous openings therein extending through said body between said forward end and said rearward end,

each of said openings having a circumferential wall having a first portion of a first diameter, a second portion of a second and smaller diameter and a substantially radial shoulder interconnecting said first and second portions, and an electrical contact in each of said openings,

each of said contacts having a forwardly facing shoulder adjacent and opposed to said substantially radial shoulder of the opening in which it is received,

whereby said contacts are prevented from substantial movement forwardly relative to said body,

each of said contacts having a rearwardly facing shoulder,

said body having integral resilient finger means in each of said openings inclined inwardly and forwardly within said first portions of said circumferential walls,

said finger means having forward end portions adjacent said rearwardly facing shoulders of said contacts for preventing substantial movement of said contacts rearwardly relative to said body,

said body being in at least two pieces,

said second portions of said circumferential walls and said substantially radial shoulders being on one of said pieces,

said first portions of said circumferential walls and said finger means being on the other of said pieces.

12. A device as recited in claim 11 in which said pieces have mating surfaces extending radially between said openings intermediate the ends of said openings, said pieces being bonded together along said mating surfaces.

13. A device as recited in claim 12 in which said substantially radial shoulders are defined by continuations of said mating surface of said one piece.

14. A device as recited in claim 12 in which said finger means project forwardly from said other piece from a location rearwardly of said mating surface of said other piece.

15. A device as recited in claim 14 in which said finger means consist of four separate fingers, each of said contacts having a cylindrical barrel portion rearwardly of said rearwardly facing shoulder of said contact, said forward end portions being arcuate and substantially complementary to said barrel.

16. An electrical connector device comprising:

a plastic body having a forward end and a rearward end,

said body having at least one opening extending from said forward end to said rearward end,

said body having a plurality of integral fingers in said opening,

a first end of each of said fingers being attached to said body and the opposite end thereof being spaced inwardly of the wall of said opening,

said fingers being inclined forwardly and toward the longitudinal axis of said opening from said first ends thereof to said opposite ends thereof,

and an electrical contact of metallic material in said opening,

said contact having a rearwardly facing shoulder,

said opposite ends of said fingers being adjacent

said rearwardly facing shoulder for retaining

said contact against forces urging said contact

rearwardly,

said rearwardly facing shoulder being undercut.

17. A device as recited in claim 16 in which said rearwardly facing shoulder is defined by a frustum of a cone.

18. A device as recited in claim 16 in which said fingers are rounded transversely so as to collectively define a substantially frustoconical shape, said fingers being separated by relatively narrow spaces.

19. A device as recited in claim 16 in which there are four of said fingers.

20. A device as recited in claim 16 in which said opening has a greater diameter forwardly of said attachments of said fingers than rearwardly of said attachments.

21. A device as recited in claim 16 in which:

said opposite ends of said fingers have surfaces substantially radial relative to said contact,

said fingers being relatively softer than said contact, whereby said rearwardly facing shoulder can effect distortion of said surfaces.

22. A device as recited in claim 21 in which:

said fingers have additional surfaces adjacent and inwardly of said end surfaces thereof,

said additional surfaces being defined by substantially cylindrical segments,

said contact having a cylindrical periphery adjacent said rearwardly facing shoulder,

said cylindrical periphery being substantially complementarily engaged by said additional surfaces.

23. A device as recited in claim 22 in which:

said end surfaces connect substantially at right angles to said additional surfaces so as to provide a corner therebetween,

and in which said contact has a fillet between said rearwardly facing shoulder and said circumferential periphery,

said corners being spaced rearwardly of said fillet upon engagement of said end surfaces by said rearwardly facing shoulder.

24. A device as recited in claim 23 in which said fingers taper in wall thickness from said opposite ends to said first ends thereof.

* * * * *

40

45

50

55

60

65