United States Patent [19]

Clark

[11] **3,824,670**

[45] **July 23, 1974**

[54] **CONTACT INSERTION AND REMOVAL TOOL**

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

[22] Filed: **Apr. 4, 1973**

[21] Appl. No.: **347,849**

Related U.S. Application Data

[60] Division of Ser. No. 167,317, July 29, 1971, Pat. No. 3,727,172, which is a continuation-in-part of Ser. No. 83,782, Oct. 26, 1970, abandoned.

[52] **U.S. Cl.** ..... **29/203 H**

[51] **Int. Cl.** **H01r 43/00**

[58] **Field of Search** ..... 29/203 R, 203 HT, 203 HC, 29/203 HM

[56] **References Cited**

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3,110,093	11/1963	Johnson	29/203 H
3,325,884	6/1967	Blight et al.	29/203 H
3,382,558	5/1968	Lutz et al.	29/203 H

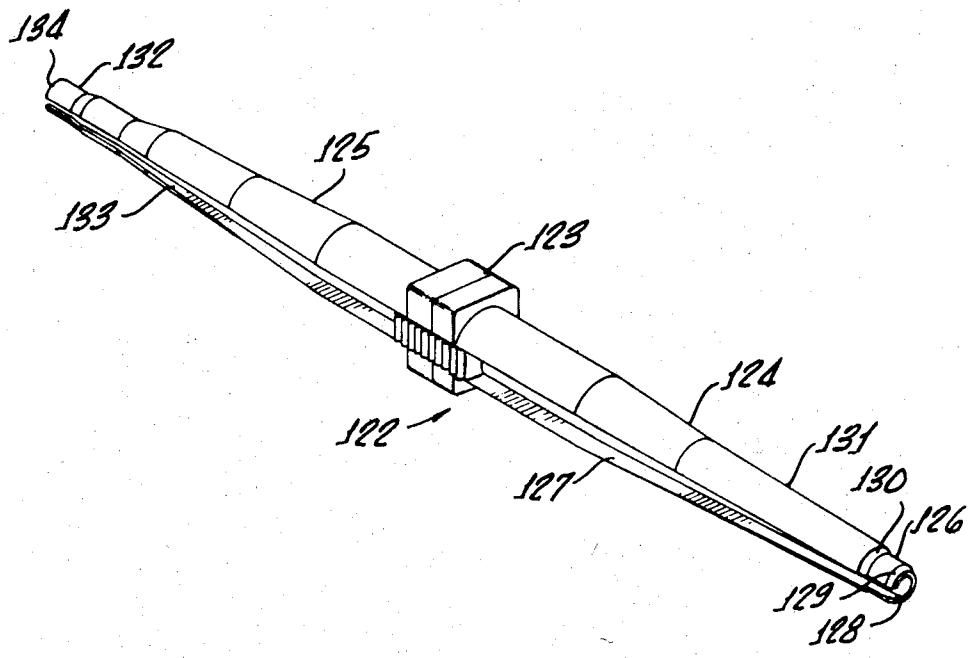
Primary Examiner—Thomas H. Eager

Attorney, Agent, or Firm—Richard F. Carr

[57] **ABSTRACT**

A tool for installing and removing contacts in an electrical connector that includes an insert having 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 the 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.

7 Claims, 21 Drawing Figures



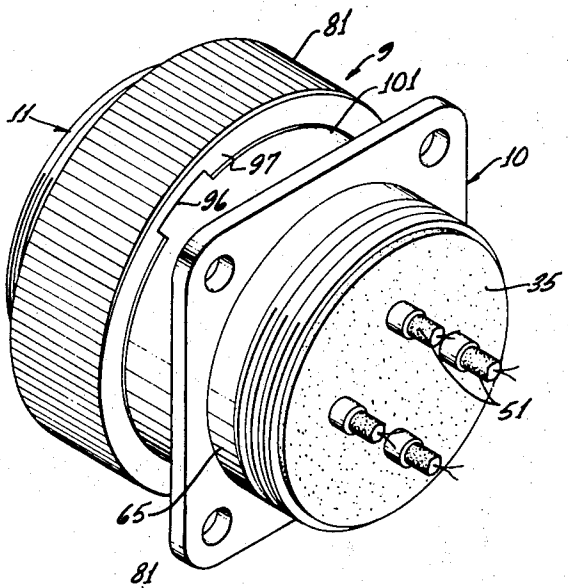


FIG. 1.

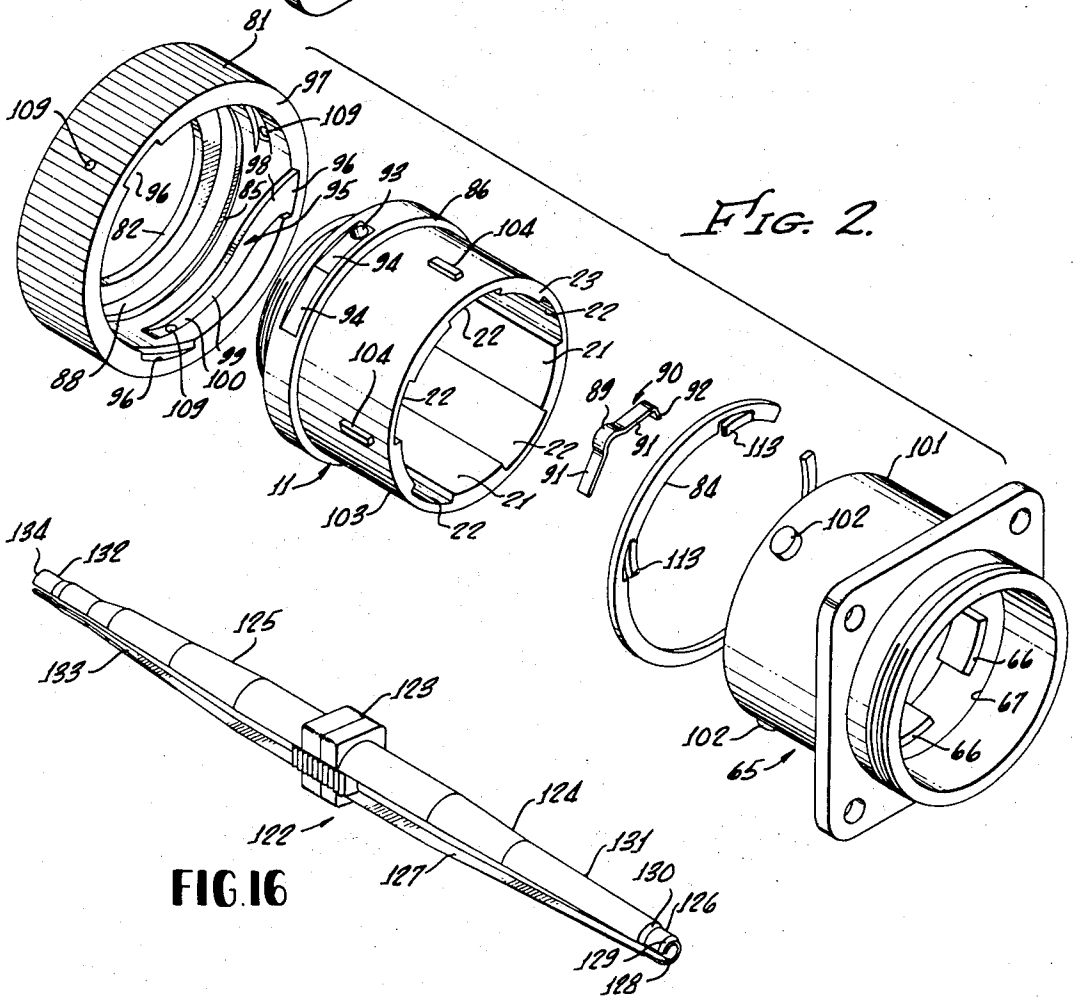


FIG. 2.

FIG. 16

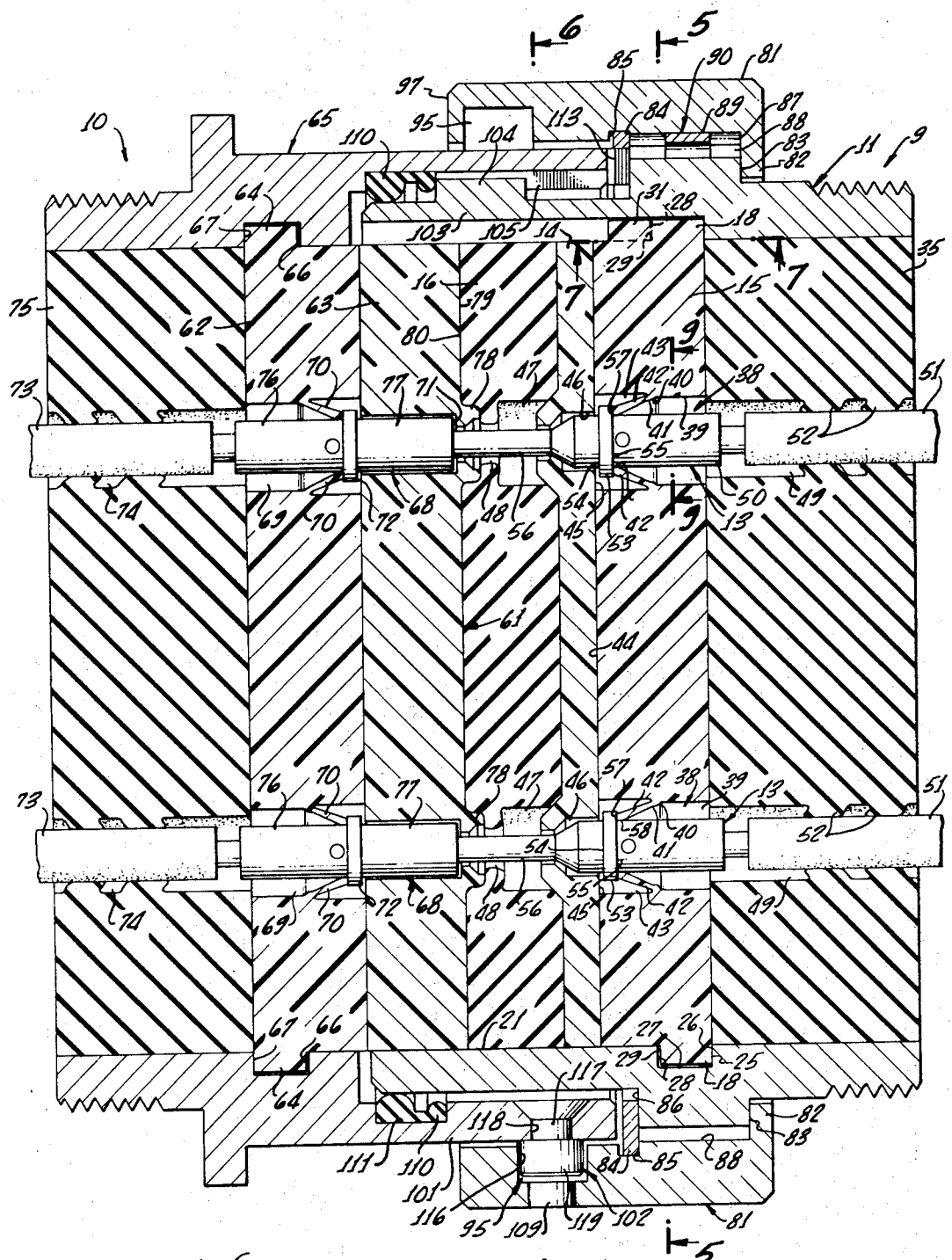


FIG. 3.

FIG. 14.

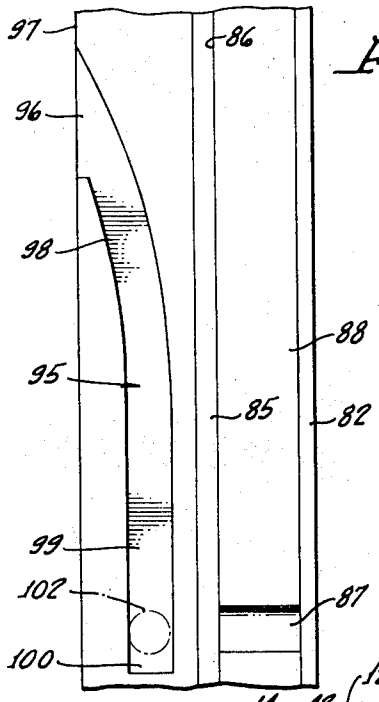


FIG. 4.

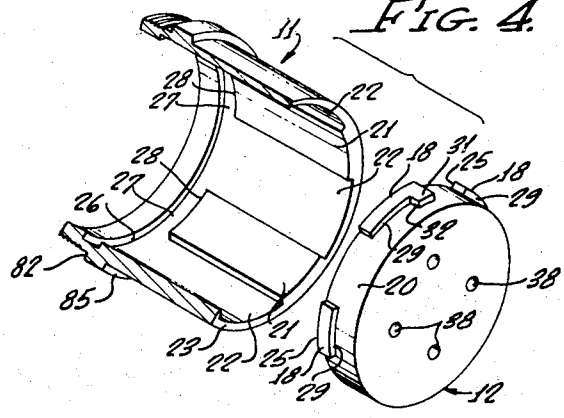


FIG. 17

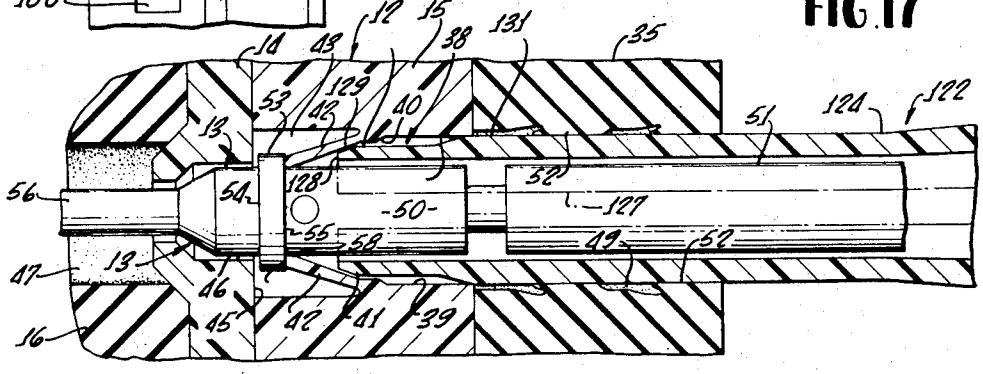
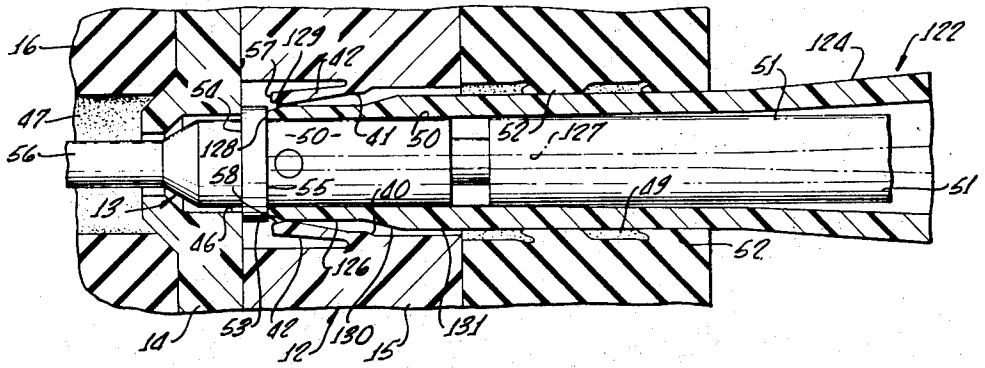


FIG. 18



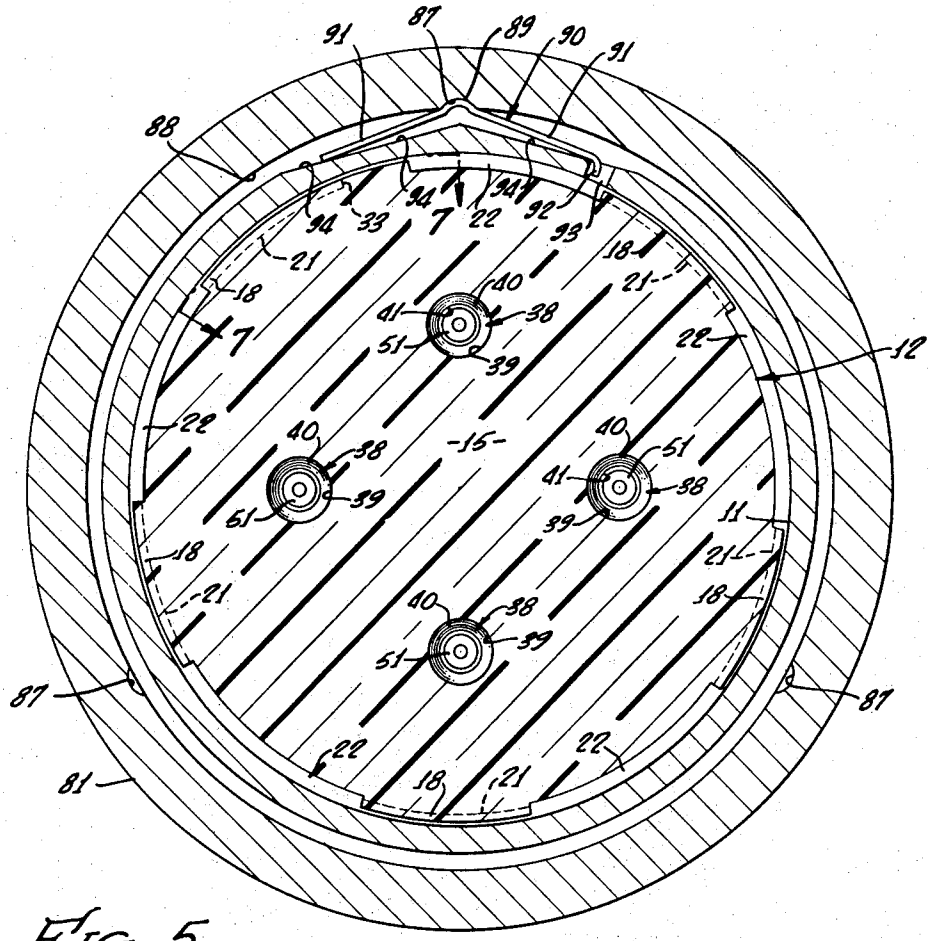


FIG. 5.

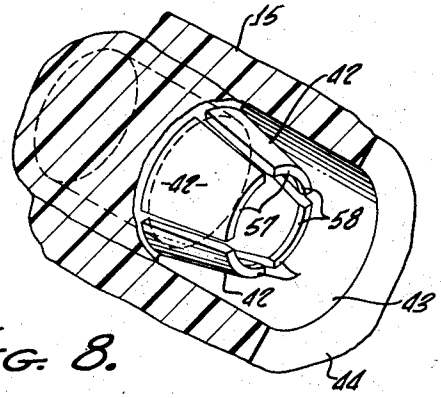


FIG. 8.

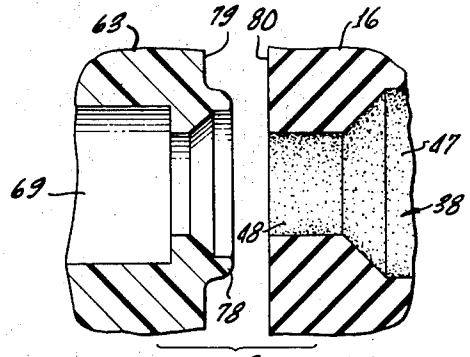


FIG. 13.

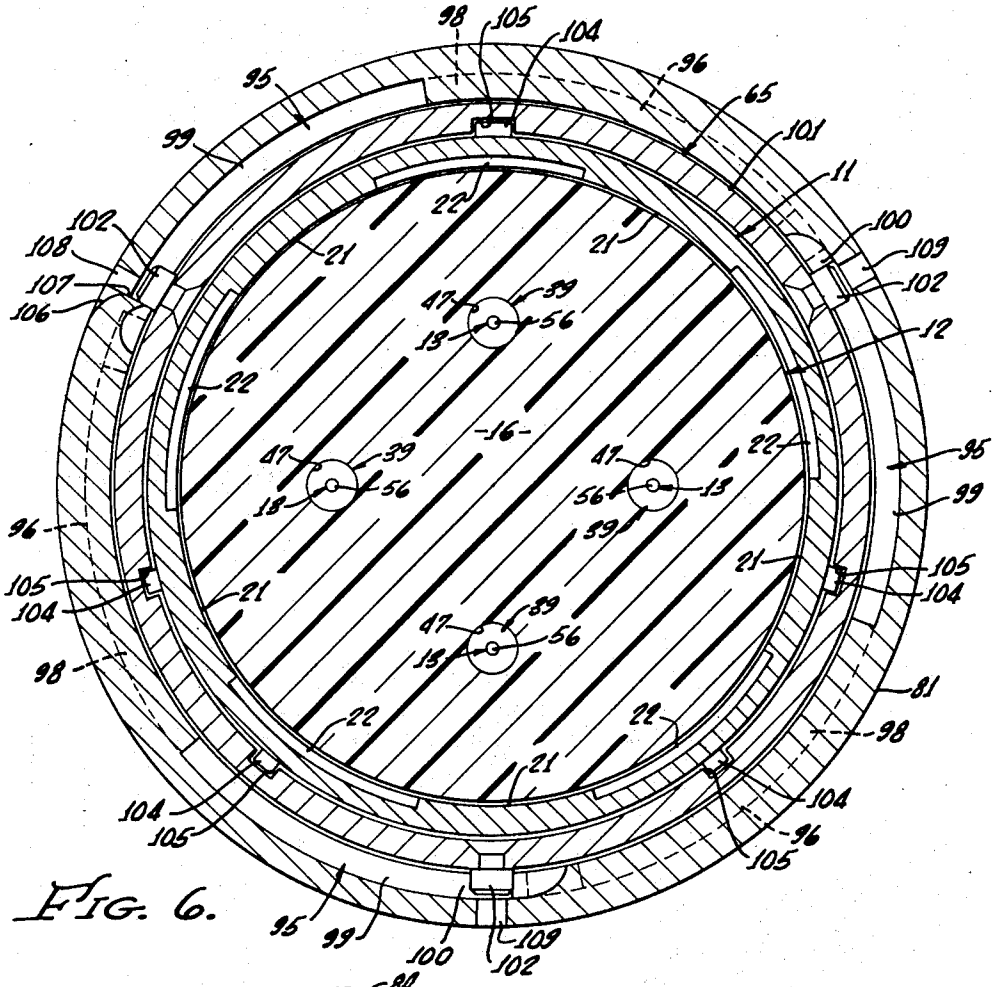


FIG. 6.

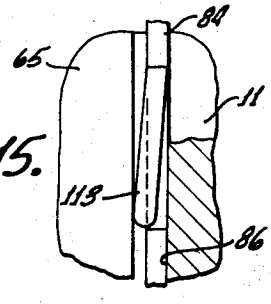


FIG. 15.

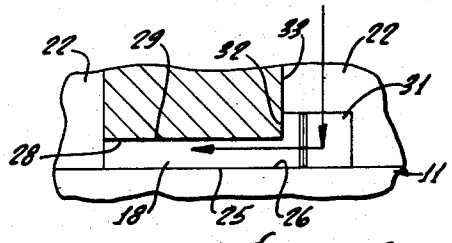


FIG. 7.

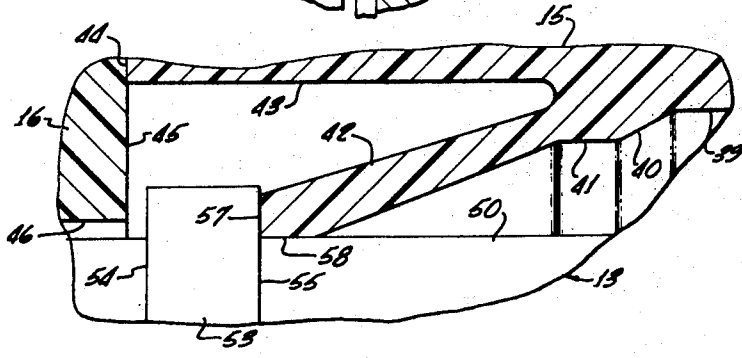


FIG. 10.

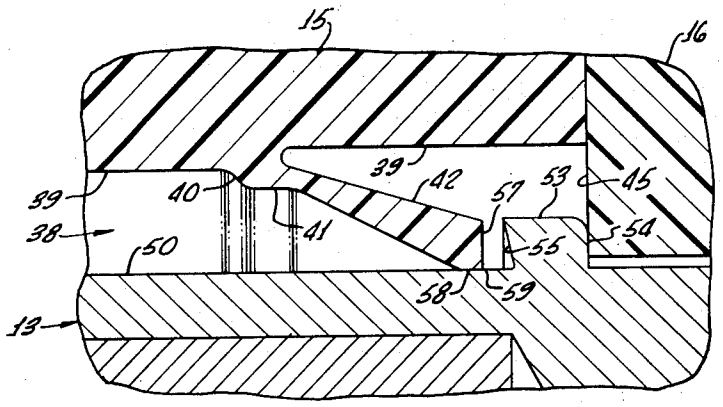


FIG. 11.

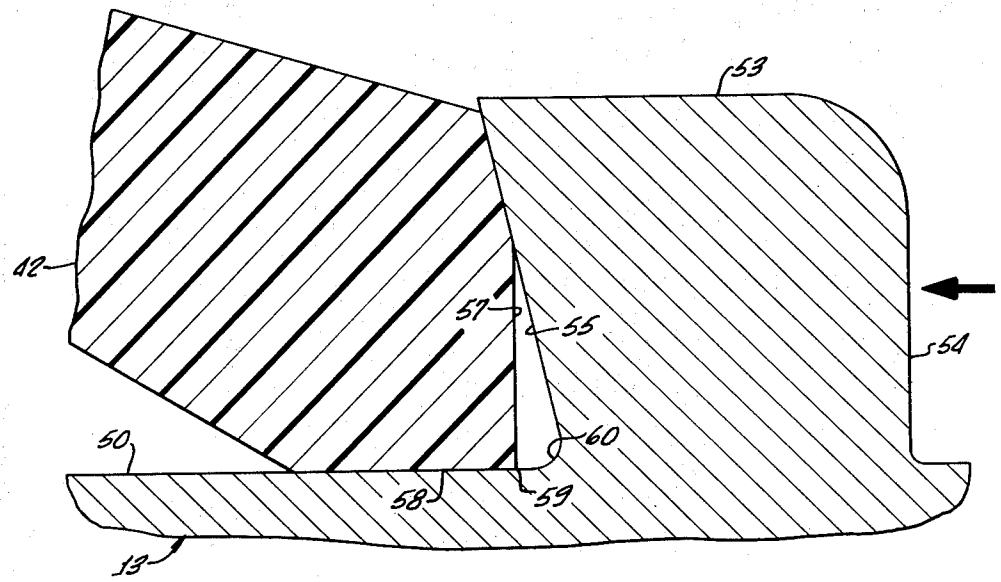


FIG. 12.

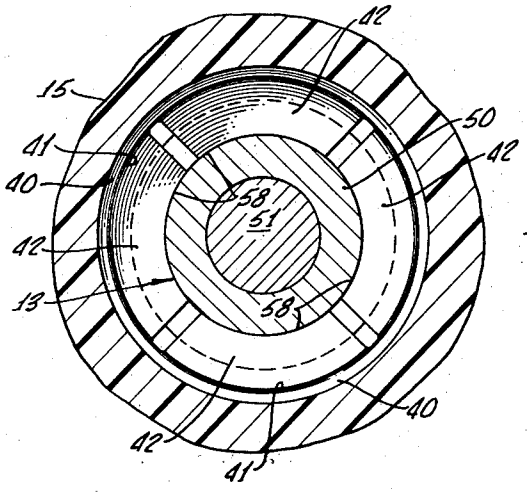


FIG. 9.

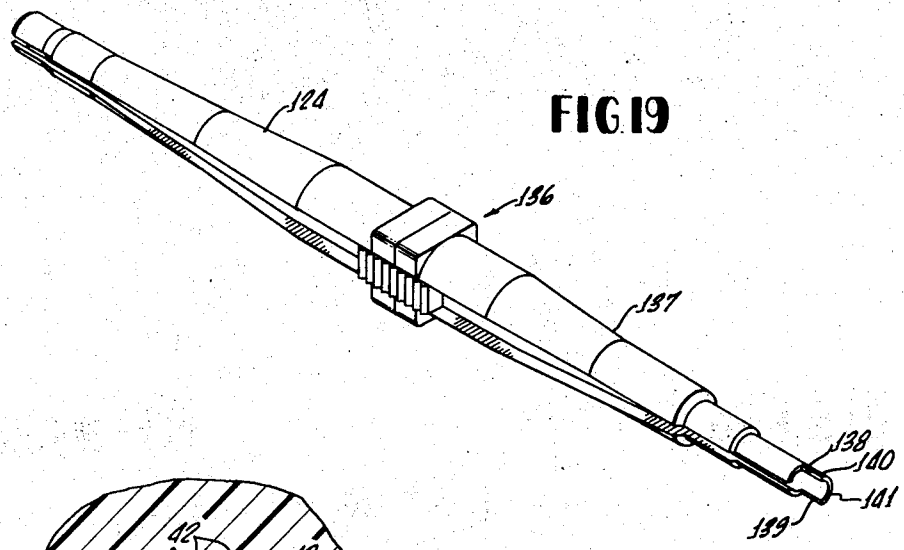


FIG 19

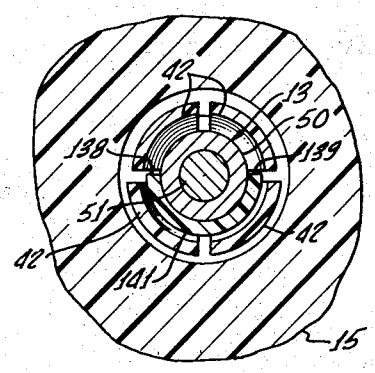


FIG 21

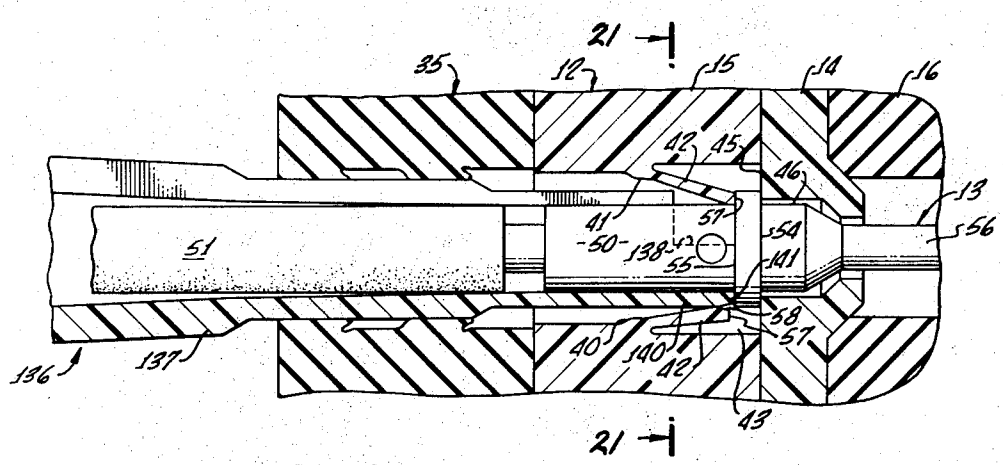


FIG 20

CONTACT INSERTION AND REMOVAL TOOL

REFERENCE TO RELATED APPLICATIONS

This is a division of my copending patent application Ser. No. 167,317, filed July 29, 1971, U.S. Pat. No. 3,727,172 for Electrical Connector, which is a continuation-in-part of application Ser. No. 83,782, filed Oct. 26, 1970, now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention:

This invention relates to tools for installation and removal of contacts of electrical connectors.

2. Description of Prior Art:

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.

The 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 shoulder, 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.

SUMMARY OF THE INVENTION

The present invention provides an improved tool for installation and removal of contacts in an electrical connector which overcomes the difficulties outlined above. With the insert of the plug and of the receptacle, which is made of a moisture- and temperature-resistant plastic, are integral resilient fingers in each of the contact openings. 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 provided 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.

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 to 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.

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 viewing 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 perspective view of the contact insertion and removal tool;

FIG. 17 is an enlarged fragmentary longitudinal sectional view showing the tool of FIG. 16 as it is introduced into a cavity in the insert for contact removal;

FIG. 18 is a view similar to FIG. 17, but with the tool pushed all the way into the cavity for freeing the contact retention fingers from the rearward contact shoulder;

FIG. 19 is a perspective view illustrating a modified form of the contact insertion tool;

FIG. 20 is an enlarged fragmentary longitudinal sectional view illustrating the operation of the insertion tool of FIG. 19; and

FIG. 21 is a transverse sectional view taken on line 21—21 of FIG. 20.

DESCRIPTION OF THE PREFERRED EMBODIMENT

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 marketed under the trademark "Astrel" 360 plastic by Chemical Division, 3M Company, 3M Center, St. Paul, Minn. 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 ssubstantially 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 shoulder 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 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 **43** in the example shown, as illustrated in FIG. **8**. The fingers **42** are rounded transversely so that collectively they define a generally fructoconical 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 ia 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 **43** 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 bending. 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 **85** in its upper 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** is a plug and receptacle and 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 separating force, no relative movement of the plug and receptacle can take place, so that electrical continuity through the contacts is assumed. 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** with 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 accomplished, 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.

The integral forwardly inclined fingers **42** in the plug **9** and similar fingers **70** in the receptacle **10,** for holding the contact **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. **16, 17** and **18,** 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. **16** 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. **17.** 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 shouder **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. **17,** 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 may be very thin if it is to allow the ends of the retention fingers **42** to move inwardly sufficient 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 movmement, 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. **19** solves this problem, allowing the 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. **19** uses the same removal portion **124** as in the embodiment of FIG. **16.** 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. **20** and **21**). 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 change 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.

I claim:

1. In combination with an electrical connector device having a body of dielectric material having a forward end and a rearward end, said body having an opening extending between said forward and rearward ends and spring finger means inclined inwardly and forwardly from the periphery of said opening, and an electrical contact, said contact having a rearwardly facing shoulder for engagement by said finger means, an arrangement for inserting said contact into and removing said contact from said opening comprising

a first circumferential surface defining a first portion of said opening having a first diameter,

said spring finger means being inclined inwardly and forwardly from a position adjacent said first circumferential surface,

a second circumferential surface defining a second portion of said opening having a second and larger diameter,

said second circumferential surface being rearwardly of said first circumferential surface,

and a tubular member,

said tubular member being longitudinally split so as to provide opposed spaced longitudinal edges,

said tubular member having an end portion provided with an outer edge adapted to engage said shoulder of said contact,

said end portion having a lateral dimension such that it is adapted to enter said second portion of said opening,

said end portion being of greater lateral dimension than said first diameter,

said end portion being deflectable to compress the lateral dimension of said tubular member to allow said end portion to enter said first portion of the opening,

said tubular member having a second portion of greater lateral dimension than said end portion and said second diameter,

said second portion of said tubular member being movable into said second portion of said opening upon said forward movement of said tubular member,

and a surface interconnecting said end and second portions,

said interconnecting surface being engageable with said body at said second circumferential surface upon movement of said tubular member forwardly relative to said body for thereby so compressing the lateral dimension of said tubular member, said end and second portions of said tubular member and said first and second portions of said opening being proportioned such that said end portion is compressed to a lateral dimension less than that of said first diameter when said second portion of said tubular member is in said second portion of said opening,

whereby said end portion engages said finger means inwardly of the periphery of said opening.

2. A device as recited in claim **1** in which said outer edge includes a radially inwardly and axially outwardly tapered beveled surface.

3. A device as recited in claim **1** in which said interconnecting surface is substantially frustoconical.

4. In combination with an electrical connector device having a body of dielectric material having a forward end and a rearward end, said body having an opening extending between said forward and rearward ends, a plurality of spring fingers inclined inwardly and forwardly from the periphery of said opening, and an electrical contact, said contact having a rearwardly facing shoulder for engagement by said spring fingers, an arrangement for inserting said contact into said opening comprising

a generally tubular member,

said member being longitudinally split so as to provide spaced longitudinal edges,

said member having an end portion with an outer end surface adapted to engage said rearwardly facing shoulder for pushing said contact into said opening from said rearward end,

said longitudinal edges adjacent said end surface being spaced apart a distance such that upon pushing said contact in said opening said tubular member engages less than all of said spring fingers irrespective of the relative rotational positions of said member and said fingers,

whereby the ends of said spring fingers not engaged by said member are free to position themselves behind said rearward shoulder for holding said contact in said opening upon said insertion of said contact by said member.

5. A device as in claim **4** in which said distance said longitudinal edges are spaced apart adjacent said end surface is greater than the spacing between said longitudinal edges inwardly thereof, whereby said longitudinal edges are recessed circumferentially adjacent said end surface.

6. A device as recited in claim **5** in which said member where said edges are so recessed is defined by a substantially cylindrical segment which is less than a semicylinder.

7. A device as recited in claim **6** in which said substantially cylinder segment extends through an arc of around 155°.

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