

[54] **LOW COST SEALED CONNECTOR**

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[22] Filed: **July 20, 1973**

[21] Appl. No.: **381,267**

[52] U.S. Cl. **339/60 R; 339/91 R**

[51] Int. Cl. **H01r 13/52**

[58] Field of Search **339/59-61, 339/91, 94**

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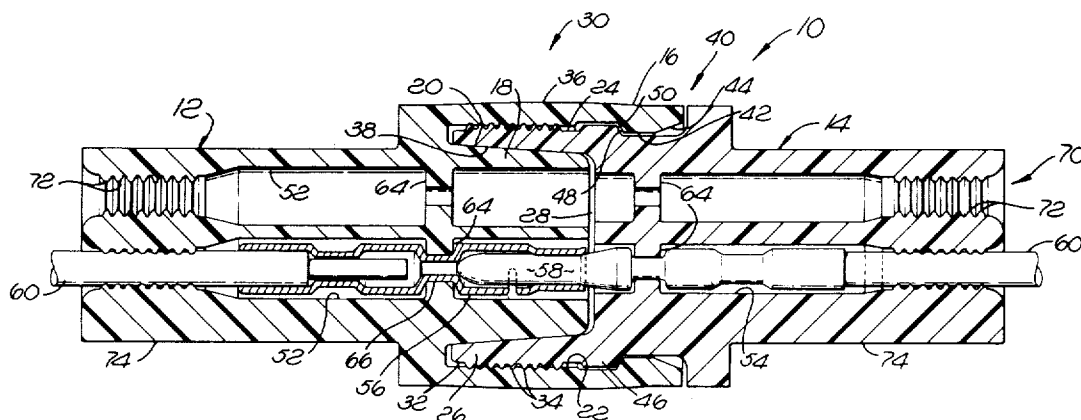
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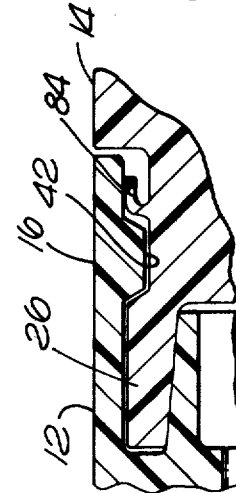
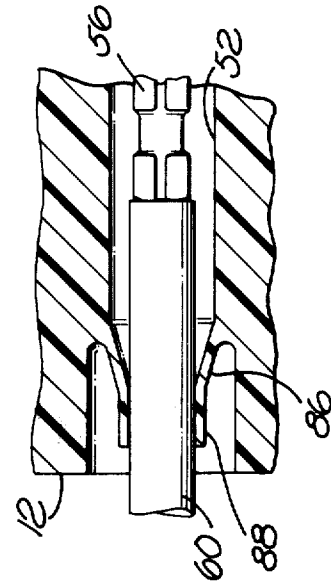
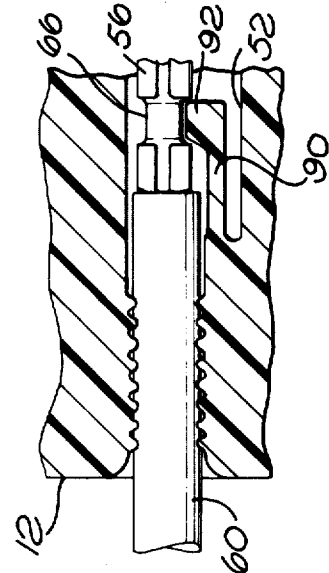
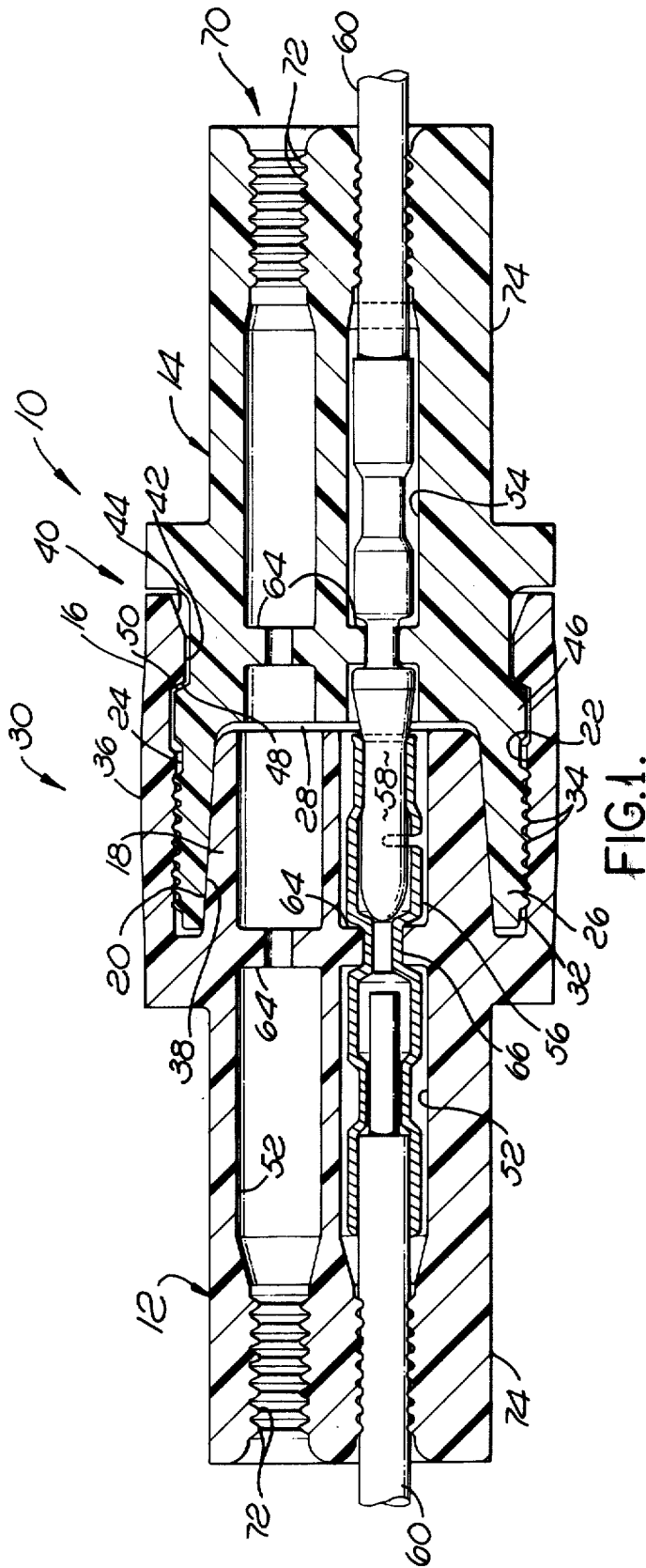
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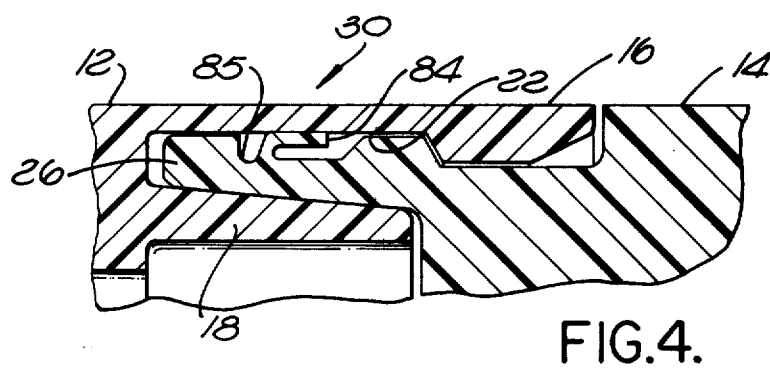
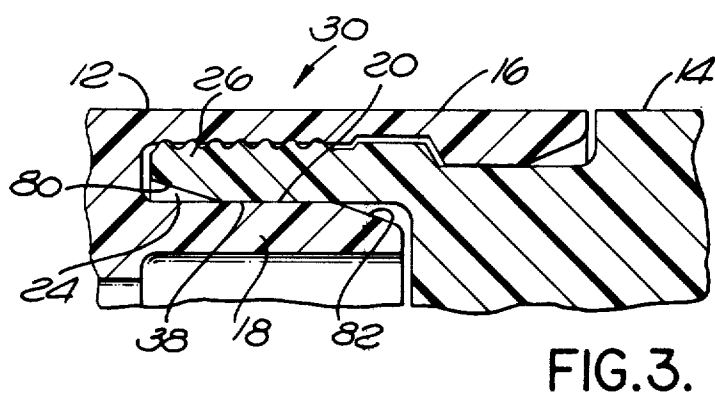
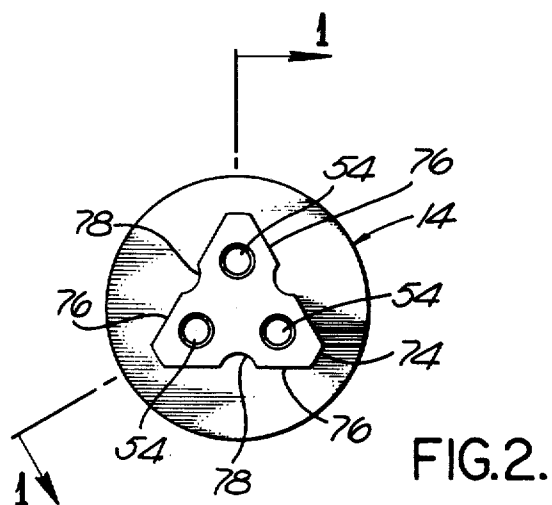
[57] **ABSTRACT**

A low cost sealed electrical connector in which the mating plug and receptacle connector members are each formed of a unitary body of elastic pliant molded material in which mating contacts are mounted in aligned contact passages. The receptacle connector member is formed with a resiliently radially expandable sleeve which slidably receives a forwardly extending annular section of the plug connector member. Such annular section defines a cavity which slidably receives a central projection formed on the receptacle connector member. Either a deformable lip or a plurality of ribs are formed on the outer surface of the plug annular section which have an interference fit with the inner surface of the sleeve thereby providing a primary interfacial seal therebetween. The projection on the receptacle provides mechanical support for the plug annular section and also is in sealing engagement therewith so as to provide a secondary seal. A lip seal or sealing ribs are formed on the wall of each contact passage to provide a rear seal for the insulated wire which is connected to the contact mounted in the passage.

11 Claims, 7 Drawing Figures







LOW COST SEALED CONNECTOR

BACKGROUND OF THE INVENTION

This invention relates generally to an electrical connector and, more particularly, to a low cost sealed electrical connector suitable for use, for example, in automotive vehicles.

DESCRIPTION OF THE PRIOR ART

There are generally two different types of electrical connectors, namely, sealed and unsealed. The term, sealed, as used herein refers to the ability of a connector, that is, the mated plug and receptacle members, to prevent the intrusion of moisture or other contaminants into the area of the connector containing the electrical contacts.

There are presently available a number of electrical connectors which are of the sealed type. However, methods to achieve sealing in these connectors are expensive and have functional limitations which render the connectors unacceptable for some applications. In one form of such a sealed electrical connector, an elastomeric sealing member is faced on each end of the respective parts of the connector. The central sealing member is referred to in the art as an interfacial seal. To function, this seal must be held in a compressed condition against the mating surfaces of the connector parts. This requires some form of positive coupling or latching between such parts which adds to the cost of the connector. Loss of this pressure between the parts will allow moisture entry into the connector.

In another form of a sealed connector, the entire body of the connector is formed of a plastic material. Typically, the central or interfacial seal for the connector is provided by the sealing engagement of a forward cylindrical portion of the plug with a cylindrical recess formed in the forward end of the receptacle connector member of the connector. In addition the rear seal, that is, the seal between the contact passage and the contact, is provided simply by an interference fit between the mating cylindrical surfaces of the parts. A connector of this particular form is described in U.S. Pat. No. 3,601,760. Such a connector however is not capable of entirely preventing the intrusion of moisture or other contaminants over a wide variety of temperature and environmental conditions as encountered in automotive vehicles. It is also known in the art to provide rubber grommets in connectors in which resilient sealing ribs are formed in the contact passages extending through the grommets. Other rear sealing techniques are also known. For example, as disclosed in co-pending application of John E. Barr, Ser. No. 298,416, filed Oct. 17, 1972, entitled "Low Cost Sealed Connector and Method of Making Same", assigned to the assignee of the present application, a radially deformable collet is forced into an annular space between an insulated wire joined to a contact and the wall of the contact passage in the connector insulator to provide a rear seal. The interfacial or central seal for this connector is provided separately for each contact pair in the form of a projection having ribs thereon which have an interference fit with the walls of a recess formed in the mating connector member. While all the aforementioned techniques have been known and utilized, still no connector has yet been devised which adequately prevents the intrusion of moisture or other contaminants into the interior thereof and which is sufficiently

low in cost to be practical from an economic standpoint for use on automotive vehicles. It is the purpose of the present invention to provide such a connector.

SUMMARY OF THE INVENTION

It is the principal object of the present invention to provide an improved low cost sealed electrical connector.

According to the principal aspect of the present invention, there is provided a low cost sealed electrical connector in which the mating plug and receptacle connector members each comprises a unitary body of elastic pliant material with electrical contacts mounted in aligned passages in the bodies. The receptacle connector member embodies a resiliently radially expandable forwardly extending sleeve portion which slidably receives an annular section which extends forwardly from the plug connector member. Annular sealing means is integrally formed on one of the connector members extending radially between the sleeve portion of the receptacle connector member and the annular section of the plug connector member. A projection is formed on the receptacle connector member which extends into the cavity defined by the annular section of the plug connector member. This projection provides a relatively rigid mechanical support for such annular section thus assuring that an effective primary interfacial seal is provided between the mated parts. In addition, the projection on the receptacle connector member is in sealing engagement with the wall of the cavity in the plug connector member so that a secondary seal is formed in series with the primary seal, thereby assuring that contaminants and moisture external of the connector will not intrude into the central interior area of the connector containing the electrical contacts. Rear seals for the insulated wires connected to the contacts are provided by either a plurality of ribs or a radially extending lip integrally formed on the wall of each contact passage. A connector embodying the aforementioned interfacial and rear seals has been found to be air and moisture tight over a wide variety of temperature and environmental conditions. In addition, the connector bodies may be molded as unitary parts thereby minimizing manufacturing and assembly costs.

Other aspects and advantages of the invention will become more readily appreciated by reference to the following detailed description when considered in connection with the accompanying drawings in which like reference numerals designate like or corresponding parts throughout the various views.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partial longitudinal sectional view taken along line 1—1 of FIG. 2 showing mated receptacle and plug members of a connector embodying the features of the present invention;

FIG. 2 is an end view of the plug connector member illustrated in FIG. 1;

FIG. 3 is a fragmentary sectional view showing a modified form of the interfacial seal of the invention;

FIG. 4 is a fragmentary sectional view showing another alternative form of the interfacial seal of the invention;

FIG. 5 is a fragmentary sectional view showing still a further form of the interfacial seal of the invention;

FIG. 6 is a fragmentary sectional view showing an alternative form of a rear seal which may be utilized in the connector of the invention; and

FIG. 7 is a fragmentary sectional view illustrating a modified form of a contact retention element in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference is now made to the drawings in detail, particularly FIGS. 1 and 2, which illustrate a preferred form of the electrical connector of the present invention, generally indicated 10. The connector comprises mated receptacle and plug members 12 and 14, respectively. Except for the contacts mounted therein, each connector member consists of a unitary mass of molded elastic pliant material which is chemically resistant to hostile environments and varying temperature conditions.

Any thermoplastic elastomer, such as polyurethane polyester, for example could be utilized as the material of the plug and receptacle connector members. It will be appreciated, however, that other elastomers could be utilized if they possess the required characteristics of resiliency, flexibility and softness to produce effective seals when configured in accordance with the present invention, as will be described later herein.

The receptacle connector member 12 is formed with a resiliently radially expandable forwardly extending cylindrical sleeve 16. A central forwardly extending projection 18 is also formed on the receptacle connector member 12 inside the sleeve 16. The outer surface 20 of the projection 18 is spaced from the inner cylindrical surface 22 of the sleeve to define therebetween an annular recess 24.

The plug connector member 14 is formed with a forwardly extending annular section 26 which provides a central cavity 28. When the receptacle and plug connector members are mated, as illustrated in FIG. 1, the projection 18 is slidably received within the cavity 28 and the annular section 26 is slidably received in the annular recess 24.

An interfacial seal, generally designated 30, is provided between the cylindrical inner surface 22 of the sleeve 16 and the cylindrical outer surface 32 of the annular section 26 of the plug connector member. In the preferred embodiment of the invention, the interfacial seal comprises a plurality of annular ribs 34 integrally formed on the annular section 26 of the plug connector member. The ribs extend from the cylindrical outer surface 32 of the plug radially toward the cylindrical inner surface 22 of the sleeve 16. The ribs are dimensioned so as to have an interference fit with the sleeve 16. Compressive deformation of the ribs, in intimate contact with the smooth cylindrical inner surface of 22 of the sleeve 16, causes an elastic deformation of the sleeve, as well as a slight bulging of the outer surface of the sleeve as indicated at 36. The compressive deformation of the ribs and elastic deformation of the sleeve 16 results in an air and moisture tight primary labyrinth seal between the plug and the receptacle connector members. Since the projection 18 on the receptacle connector member underlies this seal, it provides a relatively rigid support for maintaining sealing engagement between the ribs 34 and the sleeve 16. Preferably the outer surface 20 of the projection 18 has a frusto-conical configuration which mates with the wall 38 of

the cavity 28 in the plug connector member that has a like frusto-conical configuration. The mating frusto-conical surfaces 20 and 38 tend to create a wedging action between the annular section 26 and the projection 18 when the plug connector member is mated with the receptacle connector member thereby enhancing the sealing engagement of the ribs 34 with the inner surface 22 of the sleeve 16. In addition, the engagement of the mating frusto-conical surfaces 20 and 38 produces a secondary seal in series with the primary seal provided by the ribs 34 thus assuring that air, moisture or other contaminants do not enter the interior of the connector.

Latching means, generally designated 40, is integrally formed on the two connector members for releasable holding the same together. Such latching means comprises an integral, radially inwardly extending flange 42 formed on the sleeve 16 adjacent to its outer end. The sleeve is beveled at its inner surface to provide a frusto-conical lead surface 44 which facilitates insertion of the annular section 26 of the plug connector member into the receptacle connector member. A radially outwardly extending flange 46 is formed on the plug connector member. This flange is positioned behind the flange 42 when the connector members are mated. The flange 42 provides a rearwardly facing inclined surface 48. A similarly inclined rearwardly facing surface 50 is formed on the flange 46 adjacent to the surface 48. Since the sleeve 16 is resiliently radially expandable, when the plug connector member is initially mated with the receptacle connector member, the flange 42 will ride over the surface of the ribs 38 and the flange 46 until it passes the inclined surface 50 whereupon the flange will contract thereby latching the two connector members together. To separate the connector members, the members are pulled axially apart whereupon the flange 42 will expand radially outwardly due to the engagement of the inclined surface 48 on flange 42 with the inclined surface 50 on flange 46 whereby the latching means is uncoupled thus allowing full disengagement of the connector members. It will be appreciated that due to the resiliency of the sleeve 16, the ribs 34 may be shifted axially with respect thereto during the engaging and disengaging of the connector members.

It is noted that the forward portions of the plug and receptacle connector members are shaped so that the plug connector member fills nearly all the space within the receptacle connector member, namely the annular recess 24. Thus, when the two halves of the connector are mated, air contained within is caused to be expelled. Displacement of this air within the connector body produces a condition which results in a slightly greater than atmospheric pressure within the connector. This pressure resists ingress of moisture or air into the interior of the connector.

The receptacle connector member 12 and plug connector member 14 are provided with a plurality of axially aligned longitudinally extending contact passages 52 and 54, respectively. Three such passages are shown in FIG. 2 for each connector member by way of example only. Obviously, a greater or smaller number of passages could be provided if desired. A socket contact 56 is positioned in each of the passages 52 while a pin contact 58 is positioned in each of the passages 54. In FIG. 1, one set of aligned passages 52 and 54 are shown without the contacts mounted therein to clarify the dis-

closure. Each contact terminates an insulated wire 60. In FIG. 1, the contacts are shown as being of the closed barrel type, the barrel being crimped onto the wire. The contact passages 52 in the receptacle connector member extend through the projection 18 while the contact passages 54 in the plug connector member open into the central cavity 28 of the plug connector member. The pin contacts 58 extend outwardly into the cavity for engagement with the socket contacts 56 when the connector members are mated. Thus, the mated contacts are disposed within the interior of the primary interfacial seal 30 and the secondary seal provided by the mating frusto-conical surfaces 20 and 38.

Means are integrally formed on the receptacle and plug connector members for retaining their respective contacts therein. Such means comprises a flange 64 which extends radially inwardly from the wall of each contact passage. Said flange is sufficiently resilient and pliant to allow a contact to pass therethrough when it is inserted through the rear of the contact passage. Each contact is formed with an annular recess 66. The depth of the recess 66 and the radial dimension of each flange 64 are such that the flange will have a snug fit in the recess to hold the contact against appreciable longitudinal movement relative to the connector member body.

A rear seal, generally designated 70, is provided between the rear portion of each contact passage in the connector members and the insulated wire 60 mounted therein. In FIG. 1, such rear seal comprises a plurality of radially inwardly extending deformable ribs 72 which are integral with the wall of the passage. These ribs are dimensioned so as to have an interference fit with the insulation covering on the wire 60 thereby producing an intimate mechanical contact and labyrinth seal between the insulated wire and the connector member body. As pressure increases on the one or either side of this seal, the pressure acts on the wire insulation and body material causing the wire insulation to plastically deform and the body elastomer to elastically conform with increasing pressure. This results in a tight seal between the wire insulation and connector body. Preferably the outer periphery of the ribs 34 and the inner periphery of the ribs 72 have a convexly curved configuration in longitudinal cross-section. This configuration of the sealing ribs has been found to provide a far more effective sealing engagement than with ribs which have a flat outer or inner perimeter as the case may be.

Preferably the rear sections 74 of the receptacle and plug connector members are molded so as to have a reduced cross-section as best seen in FIG. 2. The contact passages extend through the rear sections 74 of the connector body. Each such section is formed with three sides 76 disposed closely as possible to the walls of the passages to minimize the thickness of the body about the passages and thus provide a more resilient wall area around the passages for accommodating different size wires. Longitudinally extending grooves 78 are formed in the walls 76 between the passages to further enhance the flexibility of the material surrounding the passages.

From the foregoing, it is seen that by the present invention there is provided unitary connector members which have an interfacial seal, rear seals, latching arrangement and contact retention means all integrally formed thereon. Thus, all the necessary features required for an effective connector are provided in a pair

of unitary bodies of elastic pliant material. These bodies may be formed by conventional molding techniques. Therefore, it can be seen that the connector of the present invention may be manufactured at very low cost and with no assembly procedures required except the insertion of the contact terminated wires into the respective contact passages. Moreover, the latter procedure may be performed without the requirement of a special tool, and the contacts may be withdrawn from the connector members simply by pulling on the insulated wires, again without the requirement of a special tool for releasing the contact retention means.

A connector as illustrated in FIGS. 1 and 2 has been tested to determine its ability to withstand various temperatures and climatic conditions. One sample of the connector was temperature cycled 100 times by subjecting it alternately to -40°C for 1 hour followed by heating the connector to 105°C for 1 hour. The connector was immersed into water at the end of 11,18,80 and 100 cycles and was subjected to external pressurization of 10 psi. No leakage was evidenced at this pressure after this temperature cycling test. Also no electrical failure was observed. Another sample of the connector was immersed in a 6 inch head of 5% salt solution at room temperature for 504 hours. No leakage was evidenced and satisfactory electrical resistance was maintained. Another sample was immersed in a 4 foot head of 5% salt solution at room temperature for 164 hours. The connector was then pressure tested at 10 psi for 10 minutes. This sample also evidenced no leakage and satisfactory electrical resistance was maintained. Two samples of the connector were exposed at temperatures of 105°C for 100 hours and no leakage failure was exhibited in the rear seals of the connectors. Three further samples were exposed to temperatures of 75°C and 105°C for 120 hours and no leakage failures were observed in the interfacial seals of the connectors. An additional sample was exposed to oil vapor at 96°C for 200 hours and no leakage or electrical failures were observed. Thus, it is seen that the connector of the present invention is satisfactory for performance on automotive vehicles or the like wherein environmental conditions may be encountered which are similar to or less severe than the conditions created in the aforementioned tests.

Referring now to FIG. 3, there is shown an alternative form of the connector of the present invention. In this embodiment, the mating surfaces 38 and 20 on the plug connector member annular section 26 and projection 18, respectively, have a cylindrical rather than a frusto-conical configuration. The forward inner surface of the annular section 26 is beveled to provide a frusto-conical lead surface 80. The outer surface of the projection 18 is also beveled to provide a frusto-conical lead surface 82 which is complementary to the surface 80. The surfaces 80 and 82 cooperate to facilitate insertion of the annular section 26 of the plug connector member into the recess 24 in the receptacle connector member.

FIG. 4 shows another embodiment of the invention wherein the interfacial seal 30 is in the form of a lip seal rather than a labyrinth seal. The lip seal comprises a radially extending axially and radially resilient lip 84 integrally formed on the bottom of a recess 85 in the annular section 26 of the plug connector member. The length of this lip is greater than the distance between the bottom of the recess and the cylindrical surface 22

of the sleeve 16. Thus, when the connector members are mated, the outer portion of the lip is caused to be elastically deflected, bending rearwardly and assuming the position illustrated in FIG. 4. Sealing is effected by intimate mechanical contact and elastic deformation of the lip and the receptacle surfaces. Increased external pressure improves the seal effectiveness by forcing the lip more tightly against the surface 22. FIG. 5 illustrates a connector having a lip seal 84 like that illustrated in FIG. 4, except that the lip seal is positioned forward of the flange 42 on the sleeve 16 when the connector members are mated.

FIG. 6 illustrates a modified form of a rear seal which may be utilized in the present invention. The rear seal comprises an integral inwardly and rearwardly extending resilient lip 86 which terminates in a cylindrical radially expandable sleeve 88 concentrically disposed within the contact passage 52. The sleeve 88 is dimensioned to have an interference fit with the insulated wire 60 disposed in the passage. The seal effectiveness increases with increasing external pressure acting on the external surface of the sleeve 88 and lip 86. It is noted that the lip 86 must extend rearwardly rather than forwardly inasmuch as with the latter increasing external pressure would overcome the elastic forces causing the seal to leak. The contact 56 in the embodiment illustrated in FIG. 6 is shown as being an open barrel type contact. It is important that all the exposed edges of the crimp barrel of the contact 56, and of the contacts illustrated on in the other figures of the drawing, be smoothed as by deburring so that the rear seal 70 will not be scored when the contacts are inserted into the connector members, which might lead to possible leakage pathways.

FIG. 7 illustrates a modified form of a contact retention arrangement which may be utilized in the present invention. In this embodiment, a longitudinally extending radially resilient finger 90 is integrally formed with the wall of the contact passage 52. A radially inwardly extending flange element 92 is formed on the end of the finger 90. This flange element extends into the contact recess 66 to limit axial movement of the contact within the passage 52. It will be appreciated that due to the resiliency of the finger 90, the flange element 92 will be forced radially outwardly when the contact 56 is inserted into or withdrawn from the passage 52.

It will be appreciated that the various forms of interfacial and rear seals disclosed herein may be utilized in the connector of the present invention in any combination. For example, the rear lip seal illustrated in FIG. 6 could be used in place of the rear labyrinth seal in the connector illustrated in FIG. 1. In addition, either of the interfacial lip seals illustrated in FIGS. 4 and 5 may be substituted for the interfacial labyrinth seal in the connector illustrated in FIG. 1. Also, for example, either of the interfacial lip seals illustrated in FIGS. 4 and 5 could be added in combination with the labyrinth interfacial seal 30 in the connector illustrated FIG. 1. Other combinations and modifications will be apparent to those skilled in the art.

What is claimed is:

1. An electrical connector comprising:
mating plug and receptacle connector members each comprising a one-piece unitary elastic pliant body;
said receptacle connector member embodying a resiliently radially-expandable forwardly-extending sleeve portion and a central forwardly-extending

supporting projection spaced from said sleeve portion to define a generally annular recess therebetween, said sleeve portion having a generally cylindrical inner surface surrounding said projection;
said plug connector member embodying a forwardly-extending annular section slidably insertable into said annular recess, said projection providing a relatively rigid support for said annular section;
said annular section providing a central cavity slidably receiving said projection and having a generally cylindrical outer surface;
one of said cylindrical surfaces being smoothly continuous and substantially free of undulations throughout its length;
a plurality of longitudinally-spaced annular ribs integral with the other of said cylindrical surfaces, said ribs being adapted to be compressively deformed in a sealing interference fit with said smoothly continuous cylindrical surface to form a first seal having a plurality of sealing contacts over a length of said receptacle connector member defined by said longitudinally-spaced ribs;
said annular section having an inner surface adapted to mate in sealing engagement with a cooperating outer surface of said supporting projection to form a second seal underlying said first seal;
longitudinally extending aligned contact passages in said plug and receptacle connector members, said receptacle connector member contact passage extending through said projection and said plug connector member contact passage opening into said cavity;
a plurality of annular integral ribs on the wall of each of said passages adjacent to the rear thereof dimensioned to have an interference fit with an insulated wire terminating in a contact in the forward portion of said passage; and
means in each said passage for removably retaining a contact therein.

2. An electrical connector as set forth in claim 1 wherein:

the outer periphery of each said rib on said other cylindrical surface has a convexly curved configuration in longitudinal cross-section.

3. An electrical connector as set forth in claim 1 wherein:

said supporting projection and said annular section have mating frusto-conical surfaces.

4. An electrical connector as set forth in claim 1 wherein:

each said contact retaining means is integrally formed on the wall of each said passage.

5. An electrical connector as set forth in claim 1 wherein:

the inner periphery of said ribs on said contact passage walls have a convexly curved configuration in longitudinal cross-section.

6. An electrical connector as set forth in claim 1 wherein:

the outer surface of said supporting projection and the wall of said cavity are in sealing contact.

7. An electrical connector as set forth in claim 1 including:

latching means in addition to said ribs integrally formed on said plug and receptacle connector members for releasably holding said members in mating engagement.

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8. An electrical connector as set forth in claim 7 wherein:

said latching means comprises an inwardly extending flange on said receptacle connector member adjacent to the end of said sleeve defining a rearwardly facing surface and a rearwardly facing surface formed on said plug connector member behind said sealing means engageable with said surface on said receptacle connector member, said surfaces being inclined so that upon applying a disengaging force to said connector members said flange will expand radially outwardly.

9. An electrical connector as set forth in claim 1 including:

a contact mounted in each of said contact passages, each said contact being connected to an insulated wire extending through the rear of its correspond-

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ing contact passage; and
said annular ribs on the wall of each said contact passage sealingly engaging said insulated wire.

10. An electrical connector as set forth in claim 9 wherein:

each said contact is formed with an annular recess; and

each said contact retaining means extends into the annular recess in its respective contact limiting longitudinal movement of said contact.

11. An electrical connector as set forth in claim 10 wherein:

each said contact retaining means comprises a radially inwardly extending annular flange being sufficiently resilient and pliant to allow said contact to pass therethrough.

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