United States Patent [19]

Pierce

[11] **3,708,780**

[45] **Jan. 2, 1973**

[54] MULTIPLE WIRE ELECTRICAL CONNECTOR

[75] Inventor: **Robert G. Pierce**, Downey, Calif.

[73] Assignee: **Microdot Inc.**, South Pasadena, Calif.

[22] Filed: **Feb. 11, 1970**

[21] Appl. No.: **9,125**

Related U.S. Application Data

[63] Continuation of Ser. No. 663,894, Aug. 28, 1967, abandoned.

[52] **U.S. Cl.**.....**339/176,** 339/217 S

[51] **Int. Cl.**.....**H01v 13/50**

[58] **Field of Search**.....339/89, 91, 176, 217 S

[56] **References Cited**

UNITED STATES PATENTS

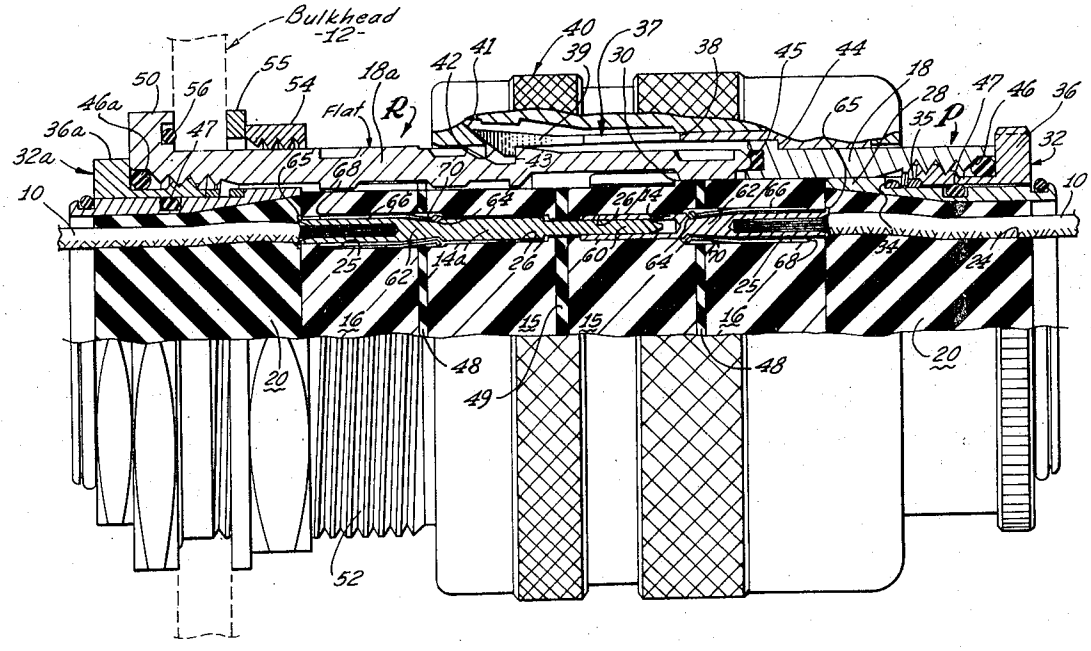
3,394,339	7/1968	Gaskievicz et al.	339/217 S
3,478,305	11/1969	Chirumbolo	339/217 S
3,327,282	6/1967	Krolak	339/217 S

Primary Examiner—Peter M. Caun
Attorney—Smyth, Roston and Pavitt

[57] **ABSTRACT**

A connector assembly incorporating a plurality of contact elements on the ends of a corresponding plurality of wires for mating with a similar complementary connector assembly includes insulating means forming a plurality of longitudinal passages to confine and retain the plurality of contact elements, the insulating means being divided into a rear section and a separate front section. The rear section has rear entrances to the longitudinal passages that are large enough to clear the contact elements and means cooperates with the front section to lock the contact elements in the longitudinal passages in response to assembling of the front section to the rear section. This arrangement permits the plurality of contact elements with the wires attached thereto to be inserted into the longitudinal passages of the insulating means from the rear thereby to avoid the necessity of threading the wires through the rear section of the insulating means before attaching the contact elements to the wires.

33 Claims, 9 Drawing Figures



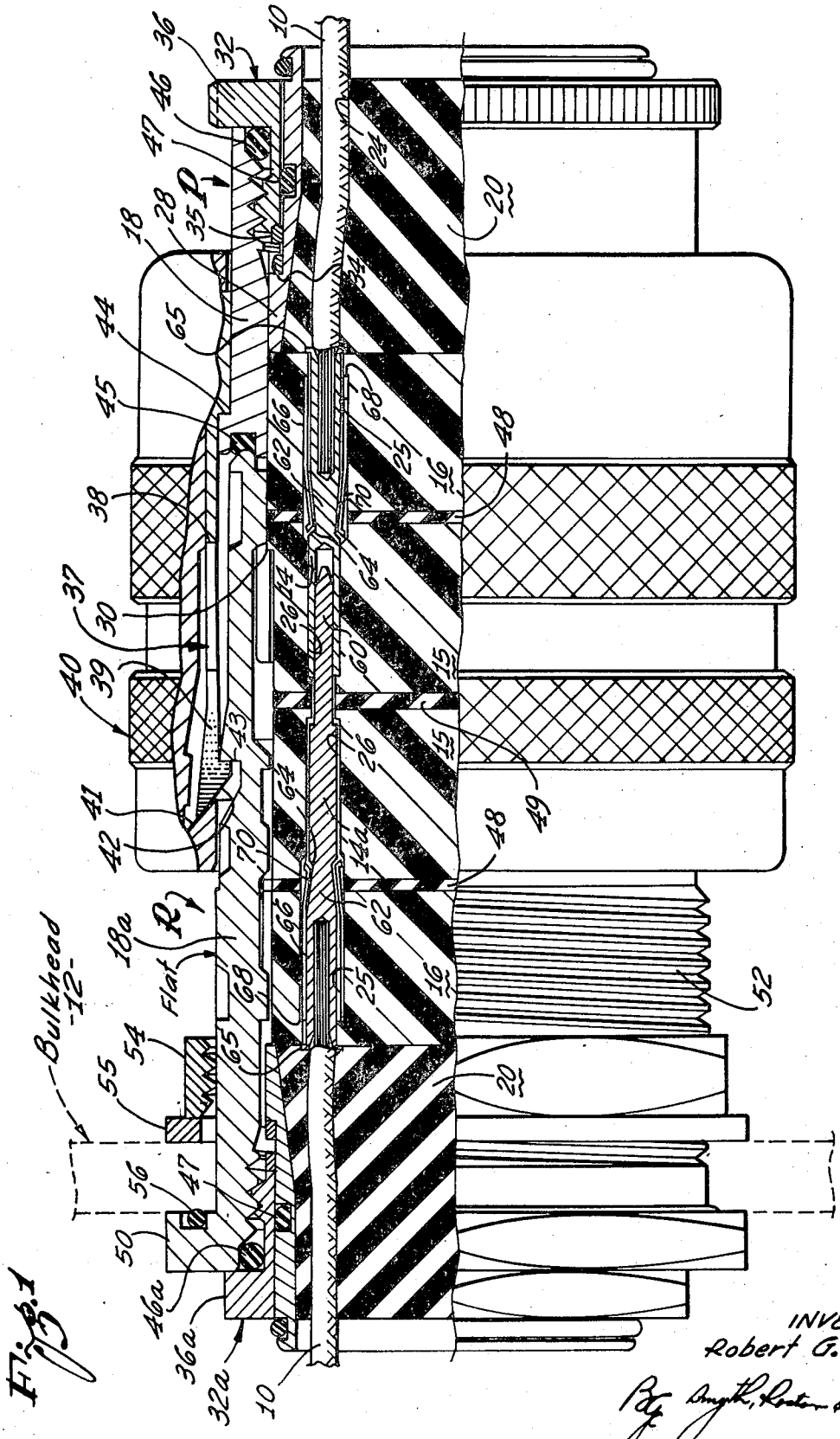

Bulkhead
Flat
INVENTOR:
Robert G. Pierce
By Smyth, Roston & Pavitt
ATTORNEYS

Fig. 1

Fig. 2

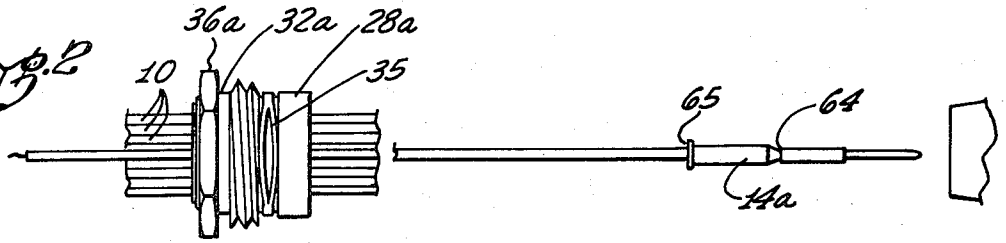


Fig. 3

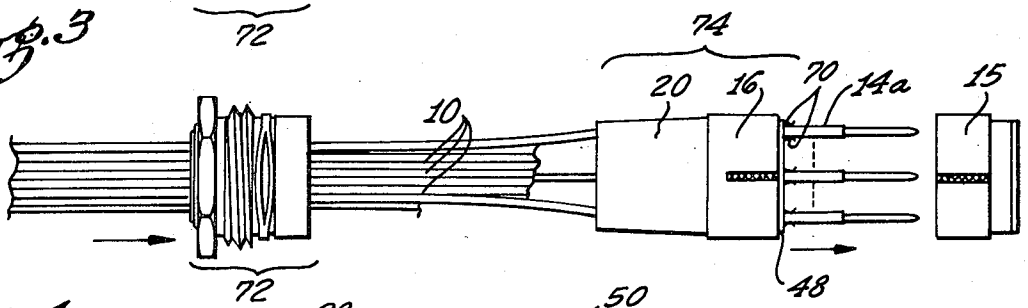


Fig. 4

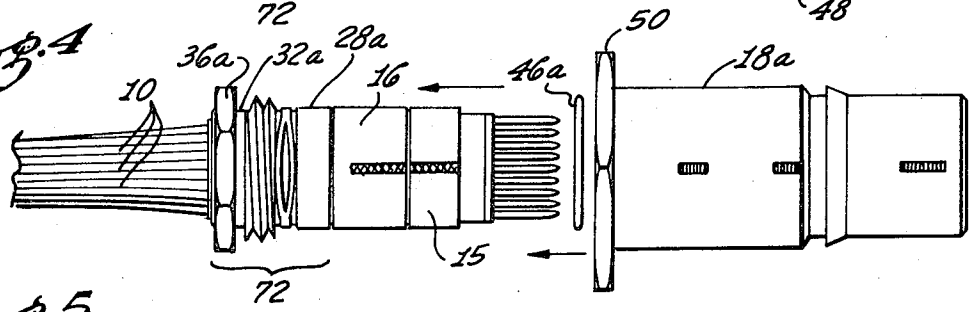


Fig. 5

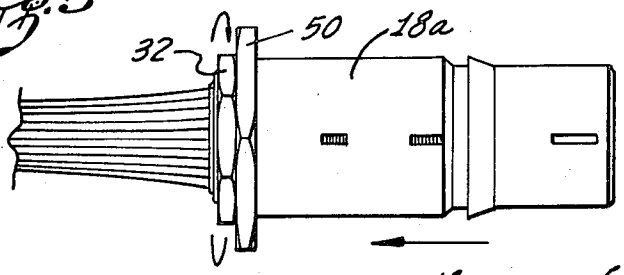
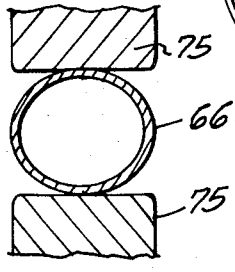
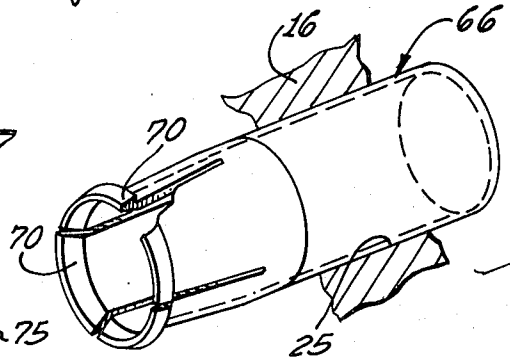


Fig. 7





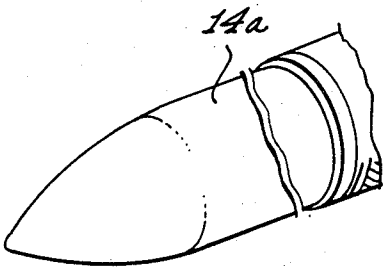


Fig. 6

INVENTOR:
Robert G. Pierce

By

ATTORNEYS

Fig. 8

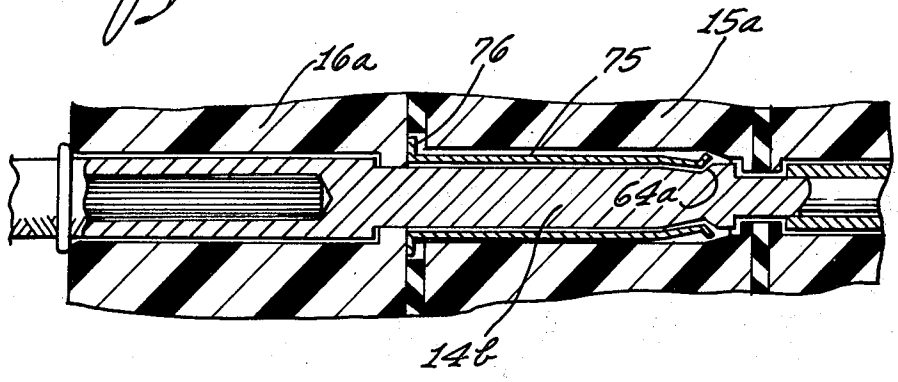
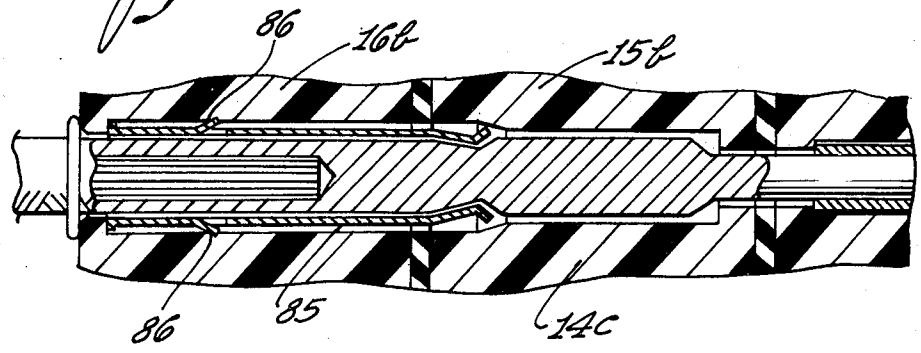


Fig. 9



INVENTOR:
Robert G. Pierce

By Smyth, Roston & Pavitt
ATTORNEYS

MULTIPLE WIRE ELECTRICAL CONNECTOR

This is a continuation of application Ser. No. 663,894 filed Aug. 28, 1967 (now abandoned.

BACKGROUND OF THE INVENTION

The present invention refers to an electrical connector assembly of the general type disclosed in the Jensen et al. U.S. Pat. No. 3,266,009, which assembly incorporates a plurality of either pin contact elements or socket contact elements on the ends of corresponding wires. A cylindrical housing of the connector assembly encloses an elastomeric grommet together with an adjacent insulating means that is divided into a rear insulating section and a separate abutting front insulating section. In the assembled connector the grommet resiliently embraces the individual wires and a plurality of longitudinal passages formed by the two sections of the insulating means captivates the individual contact elements.

It is characteristic of such a connector assembly as heretofore constructed that the entrances to the contact-confining longitudinal passages through the rear end of the rear insulating section are smaller in cross section than the contact elements for the purpose of confining the contact elements and preventing withdrawal of the contact elements by pulling force on the wires. Since the rear entrances are smaller than the contact elements, all of the wires must of necessity be individually threaded through the grommet and through the rear insulating section prior to the mounting of the contact elements on the individual wires.

One consequence of this necessity is that the assembly procedure is time consuming. Another consequence of the prior art assembly procedure is that it precludes the economies that may be achieved by attaching all of the wires to the contact elements in advance of the assembly procedure. A still further disadvantage attributable in part to the necessity for delaying the mounting of the contact elements on the ends of the wires is that the final assembly procedure involves putting together a relatively large number of individual parts instead of a relatively small number of sub-assemblies.

The present invention avoids these disadvantages by making it possible to mount the contact elements on the ends of the wires in advance of the assembly procedure and by making it possible to insert the contact elements on the ends of the wires into the rear entrances of the longitudinal passages in the insulating means of the connector. The present invention also provides unique sub-assemblies that greatly reduce the number of parts that must be handled in the assembly procedure.

SUMMARY OF THE INVENTION

Avoiding the necessity of pushing the wires through the rear insulating section before mounting the contact elements on the wires is solved by two provisions, first, making the rear entrances to the rear insulating section large enough for the contact elements to pass therethrough into the longitudinal passages and, second, by further providing special locking sleeves that have the capability of locking the contact elements in the longitudinal passages in response to the assembling the front insulating section to the rear insulating section. These two provisions make possible an

economical and time saving assembly procedure in which the contact elements are crimped or otherwise attached to the wires in advance of the assembly procedure.

In the preferred practice of the invention the final assembly of a connector is simplified by preparing sub-assemblies in advance not only to save time in the final assembly but also to reduce the number of parts that must be handled in the final assembly.

One sub-assembly, of course, consists of the numerous wires with the contact elements crimped thereon. The most important sub-assembly, however, consists of the rear insulating section with the soft elastomeric grommet bonded to the rear face thereof, the numerous longitudinal passages of the grommet being in register with the corresponding longitudinal passages of the rear insulating section and with locking sleeves mounted in the passages of the rear insulating section and protruding forwardly therefrom. These two sub-assemblies are united in the fabrication procedure by simply inserting the contact elements into the grommet and employing the wires that are connected to the contact elements to push the contact elements forward through the grommet to limit positions in the rear insulating section at which positions the corresponding locking sleeves snap into engagement with the contact elements.

One of the problems solved by the invention is how to mount the locking sleeves in the rear insulation section in a manner that will prevent the locking sleeves from being unseated and displaced forwardly by the insertion of the contact elements therethrough. It has been found that the locking sleeves may be adequately anchored in place at this early stage in the assembly procedure by simply dimensioning the locking sleeves for forced fit in the longitudinal bores or passages of the rear insulating section. Unfortunately, however, the bores through the rigid plastic member are so close together that the numerous stresses caused by the forced fit of the locking sleeves too often results in structural failure of the insulating section either during the course of assembly or during the service life of the connector.

The invention teaches that this problem may be solved by using thin walled locking sleeves, by making the locking sleeves of minimum diameter within the permissible tolerance and by deforming the locking sleeves to out of round configuration for the purpose of forced fit in the bores. Destructive forces are avoided because the confined thin walled sleeves exert only moderate radial pressure and the radial pressure is confined to one diameter of each bore with the diameters at random orientation among the bores.

The frictionally anchored locking sleeves have locking fingers that resiliently flex radially outward to admit contact elements and then snap into engagement with locking shoulders of the contact elements when the contact elements reach their limit positions. Subsequently the forward insulating section is telescoped over the numerous projecting contact elements and moved into abutment with the rear insulating section, the front insulating section then confining the locking fingers of the locking sleeves against releasing flexure and thus effectively locking the contact elements against longitudinal displacement in either direction

out of their assembled positions. Forward displacement of an installed contact element is prevented by the fact that a radial flange at the rear end of the contact element abuts the rear face of the rear insulating section. Rearward displacement of an installed contact element is blocked because the locking fingers of the surrounding locking sleeve are confined in engagement with the contact element and because the rear end of the locking sleeve abuts an inner shoulder of the surrounding insulating section.

The various features and advantages of the invention may be understood from the following detailed description and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, which are to be regarded as merely illustrative:

FIG. 1 is an enlarged view partly in side elevation and partly in longitudinal section showing a receptacle assembly and a mating plug assembly embodying the teachings of the invention;

FIG. 2 is a side elevational view on a smaller scale relating to the receptacle assembly and showing a retaining nut sub-assembly backed onto a bundle of wires and showing the bundle of wires with contact elements thereon poised for insertion into a sub-assembly that comprises a grommet and a rear insulating section bonded thereto;

FIG. 3 is a similar view illustrating the step of employing the wires to push the contact elements into and through the grommet sub-assembly, the view showing the forward insulating section poised for assembly to the rear insulating section;

FIG. 4 is a similar view with the two insulating sections brought together and with an O-ring and a housing shell poised for the next step in the fabrication procedure;

FIG. 5 is a side elevational view of the completed receptacle assembly;

FIG. 6 is a perspective view on a greatly enlarged scale showing a locking sleeve in a bore of the rear insulating section of the receptacle assembly and showing a contact element poised for insertion into the locking sleeve;

FIG. 7 is a diagrammatic view illustrating the step of deforming a thin-walled locking sleeve to out-of-round configuration for the purpose of providing a forced fit of the locking sleeve in a bore of the rear insulating section;

FIG. 8 is a fragmentary sectional view similar to FIG. 1 showing a modification of the means for locking an installed contact element; and

FIG. 9 is a similar view illustrating another modification of the locking means.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the presently preferred embodiment of the invention shown in the drawings, a plug assembly, generally indicated by the letter P, mates with a receptacle assembly, generally designated by the letter R. Both of the two connector assemblies are illustrated as mounted on bundles of insulation covered wires **10** and the receptacle assembly R is illustrated as adapted to be fixedly mounted on a bulkhead **12**.

The plug assembly P, which will be described first, includes a plurality of contact elements which, in this instance, are socket contacts **14** which are closely spaced in the plug assembly. All of the socket contacts **14** are encased by insulating means made in two separate sections, namely, a front insulating section **15** and a rear insulating section **16**. In this example both of these insulating sections are rigid bodies made of diallyl phthalate with embedded glass fibers.

The insulating means comprising the two insulating sections **15** and **16** is encased by a cylindrical housing shell **18** and suitable sealing means is provided to close the rear end of the housing shell in sealing contact with the insulation covered wires **10**. In the construction shown, the sealing means includes a relatively soft resilient grommet **20** which has suitable longitudinal passages **24** to receive the insulation covered wires **10**, which passages register with corresponding passages **25** in the rear insulating section **16**, the passages **25** registering, in turn, with corresponding passages **26** in the front insulating section **15**. It will be noted that each of the socket contacts **14** extends through a passage **25** of the rear insulating section **16** and a corresponding passage **26** of the front insulating section **15**. The grommet **20** is made of a suitable elastomer such as silicone rubber having a relatively low Shore hardness.

The grommet **20** is constricted by a surrounding follower sleeve **28** that abuts the rear insulating section **16**, the follower sleeve forcing and tightening the two insulating sections longitudinally against a rearwardly facing inner circumferential shoulder **30** of the housing shell **18**. The follower sleeve **28** is retained by retaining means in the form of a retaining nut **32** acting against a rearwardly facing outer circumferential shoulder **34** of the follower sleeve, the shoulder being formed by a peripheral portion of the follower sleeve that telescopes snugly into the housing shell **18**.

The retaining nut **32** acts on the outer shoulder **34** through the medium of a suitable annular spring **35** that surrounds the follower sleeve. As shown in FIG. 2, the annular spring may be in the form of a circular band of thin spring metal that is circumferentially slitted with the resilient slit portions spread apart axially.

As shown in FIG. 1, the retaining nut **32** has an external screw thread in engagement with an internal screw thread of the housing shell **18** and has a heavy knurled radial flange **36** that is tightened firmly against the rear end of the housing shell **18**.

The housing shell **18** is embraced by a cylindrical locking spring, generally designated **37**, in abutment against a circumferential shoulder **38** of the housing shell, the locking spring being longitudinally slotted to form a circumferential series of forwardly extending hook-shaped locking fingers **39**. The locking spring **37** is, in turn, slidingly embraced by a coupling ring **40** which is formed on its leading end with an inner circumferential cam **41** for cooperation with overhanging cam surfaces **42** of the respective locking fingers. The locking fingers **37** are biased radially inward for releasable engagement with a circumferential shoulder **43** of the housing shell **18a** of the receptacle assembly R and normally the cam surfaces **42** of the locking fingers press against the circumferential cam **41** of the coupling ring **40** to hold the coupling ring at a normal forward position at which an inward circumferential

shoulder 44 of the coupling ring abuts the rear end of the locking spring. The coupling ring 40 may be shifted longitudinally rearward from its normal position by manual force to cause the cam 41 to act on the cam surfaces 42 of the locking fingers 37 to lift the locking fingers to released positions.

The plug assembly P incorporates suitable provisions to make it fluid tight. For this purpose the housing shell 18 is formed with a forwardly facing groove to seat an elastomeric ring 45 that is compressed between the plug assembly P and the receptacle assembly R. An additional O-ring 46 forms a seal between the housing shell 18 and the retaining nut 32. In addition a sealing ring 47 is effective between the locking nut 32 and the follower sleeve 28. Further sealing provisions include an elastomeric wafer 48 that is interposed between the two insulating sections 15 and 16 and preferably is bonded to section 16. An elastomeric wafer 49 is also interposed between the confronting ends of the plug assembly P and the receptacle assembly R, and preferably is bonded to section 15 of receptacle assembly R.

The construction of the receptacle assembly R is similar to the construction of the plug assembly P as indicated by the use of corresponding numerals to indicate corresponding parts.

It will be noted that the housing shell 18*a* of the receptacle assembly R has a radial flange 50 of hexagonal circumferential configuration to engage one side of the bulkhead 12 and has an external screw thread 52 to receive a lock nut 54 to cooperate with a flat washer 55 for engaging the other side of the bulkhead. The radial flange 50 may be grooved to seat an O-ring 56 for sealing engagement with the bulkhead.

The retaining unit 32*a* of the receptacle assembly R has a hexagonal radial flange 36*a* backed against the hexagonal radial flange 50 of the housing shell 18a, with the juncture sealed by an O-ring 46*a*.

The housing shell 18*a* of the receptacle assembly R telescopes over the front and rear insulating sections 15 and 16 of the plug assembly P. The housing shell 18*a* of the receptacle assembly R makes pressure abutment against the sealing ring 45 when the locking fingers 39 of the plug assembly P are in locking engagement with the previously mentioned circumferential shoulder 43 of the housing shell 18*a* as shown in FIG. 1.

The receptacle assembly R incorporates contact elements 14a which are pin contacts with forward pin portions 60 that are dimensioned for insertion into corresponding sockets of the socket contacts 14 of the plug assembly P.

Each contact element 14 of the plug assembly P and each contact element 14*a* of the receptacle assembly R has an intermediate reduced neck portion 62 that is tapered to form a rearwardly directed sloping circumferential shoulder 64 and the rear end of the contact element is formed with a radial flange 65. When a contact element 14 or 14*a* is installed its rear flange 65 abuts the rear face of the corresponding rear insulating section 16 to prevent forward axial movement of the contact element and the forward portion of the installed contact element extends into the adjacent front insulating section 15.

Rearward axial movement of an installed contact element 14 or 14*a*, i.e. withdrawal of the contact element from the corresponding rear insulating section 16 is prevented by a thin walled metal locking sleeve 66 that surrounds the contact element with the rear end of the locking sleeve in abutment with an inner circumferential shoulder 68 that is formed in the corresponding passage 25 of the rear insulating section. The forward end portion of the locking sleeve 66 is longitudinally slotted to form a plurality of resilient locking fingers 70 (FIG. 6) that abut the circumferential shoulder 64 of an installed contact element.

As may be seen in FIG. 1, the rear portion of each passage 26 of a front insulating section 15 is slightly enlarged to clear the locking fingers 70 but is not enlarged enough to permit the locking fingers to flex radially out of engagement with the circumferential shoulder 64 of the contact element. It is apparent, however, that if a front insulating section 15 is separated from the corresponding rear insulating section 16, the locking fingers 70 of the locking sleeves 66 in the rear insulating section are free to flex radially out of engagement with the locking shoulders 64 of the contact elements.

A feature of the invention is the concept of making up a number of sub-assemblies in advance of a final assembly procedure. FIGS. 2 – 5, for example, show how sub-assemblies are brought together in the final assembly of the receptacle assembly R.

FIG. 2 indicates how one such sub-assembly may comprise a bundle of the insulation covered wires 10 with pin contact elements 14*a* crimped onto the leading ends of the wires. FIG. 2 also shows what may be termed a retaining nut sub-assembly, generally designated 72, which comprises a retaining nut 32*a*, a cylindrical spring 35 and a follower sleeve 28*a*. It will be noted in FIG. 2 that the retaining nut sub-assembly 72 encloses the bundle of wires 10 rearwardly of the pin contacts 14*a*.

A second sub-assembly, generally designated 74 in FIG. 3, comprises a rear insulating section 16 with a grommet 20 bonded thereto in a unitary manner. Each of the previously mentioned passages 25 in the rear insulating section 16 is occupied by a corresponding locking sleeve 66, the locking fingers 70 of the locking sleeves extending forwardly beyond the front end of the rear insulating section.

A primary feature of the invention is that, because of the particular construction of the sub-assembly 74, it is possible to insert the contact elements 14*a* into and through the rear end of the sub-assembly 74, thus making it possible to mount the contact elements on the ends of the wires 10 in advance instead of waiting until the wires have been threaded through the sub-assembly.

FIG. 3 shows how the contact elements 14*a* protrude forward beyond the sub-assembly 74 when the contact elements are installed in the sub-assembly. Each of the contact elements 14*a* is shoved into and through the sub-assembly 74 by means of the corresponding wire 10 until the rear radial flange 65 of the contact element abuts the rear face of the rear insulating section 16. At the same time, the locking fingers 70 of the corresponding locking sleeve snap into engagement with the circumferential locking shoulder 64 of the contact element to lock the contact element against withdrawal from the sub-assembly.

To make it possible to insert the contact elements **14***a* into and through the sub-assembly **74** in this manner, the locking sleeves **66** must be effectively anchored in the rear insulating section **16** to keep the locking sleeves from being dragged out of the rear insulating section by frictional contact with the advancing contact elements. For quick assembly of the locking sleeves **66** to a rear insulating section **16** it is desirable to dimension the locking sleeves for forced fit in the passages **25** of the rear insulating section. It has been found, however, that dimensioning the locking sleeve **66** for forced fit in a conventional manner is impractical because of the tolerances involved. Inevitably some of the locking sleeves that are so dimensioned create excessive stresses in the rear insulating section because the passages **25** of the rear insulating section are so closely spaced that only thin walls of the rear insulating section separate the passages. As a consequence, numerous cracks and failures develop in the thin wills of a rear insulating section **20** if the locking sleeves **66** therein are dimensioned for forced fit in the usual manner.

The present embodiments of the invention solves this problem by employing locking sleeves **66** with relatively thin walls, by further making the locking sleeves undersized in diameter relative to the passages **25**, and, finally, by distorting the locking sleeves to out-of-round configuration. FIG. **7** shows how a locking sleeve **66** is placed for this purpose between a pair of jaws **75** and then the jaws are moved slightly towards each other to deform the locking sleeve beyond its elastic limit, thereby to give the locking sleeve a permanent oval configuration having a major transverse axis larger than the diameter of a passage **25** in a rear insulating section **16**. The deformed locking sleeves **66** fit sufficiently tightly in the passages **25** but do not cause failure of the structure of the rear insulating section because the locking sleeve has such a thin wall and because the locking sleeve exerts pressure against only two diametrically opposite regions of a passage **25**. It is to be further noted that the major cross-sectional axes of the various locking sleeves **66** are at random orientation in the various passages **25**.

FIG. **3** shows a front insulating section **15** poised for assembly against the sub-assembly **74**. An elastomeric wafer **49** is bonded to the front insulating section as shown.

FIG. **4** shows the front insulating section **15** abutting the rear insulating section **16**, thereby effectively confining the various locking fingers **70** of the locking sleeves **66** to lock the contact elements **14***a* against axial withdrawal from the sub-assembly **74**. FIG. **4** also shows the previously mentioned O-ring **46***a* poised in position for movement of the O-ring onto the sub-assembly **72** against the radial flange **36***a* thereof. FIG. **4** further shows the housing shell **18***a* of the receptacle assembly R poised in position to telescope over the previously assembled parts.

FIG. **5** shows the housing shell **18***a* telescoped over the previously described parts with the retaining nut **32** tightened against the radial flange **50** of the housing shell to compress the interposed O-ring **46***a*.

It will be appreciated that the task of final assembly is greatly simplified by providing a sub-assembly. It may be further appreciated that the final assembly is facilitated by the feature of the construction which permits the wires **10** with the contact elements mounted thereon to be inserted into a sub-assembly **74** from the rear end thereof.

It is apparent from an inspection of FIG. **1** that a locking sleeve **66** can contract to its normal minimum diameter only if the fingers of the locking sleeve register with the neck **62** of the contact element. If any contact element is not shoved far enough forward in a rear insulating section **16** to permit the locking fingers **70** of a locking sleeve **66** in the rear insulating section to contract, the expanded fingers of the locking sleeve will block the desired subsequent rearward abutment of the front insulating section **15** against the rear insulating section. Thus, if any single contact element is not pushed forward to its desired final position in a rear insulating section, the person assemblying the structure would be apprized of the fact by the subsequent difficulty encountered in trying to seat the front insulating section against the rear insulating section. No damage would be caused by this difficulty.

If a contact element is far rearward of its normal position in the rear insulating section, it would be possible to back the front insulating section against the rear insulating section, but in the case of a plug assembly P, the result would be a blank hole that would be quite apparent when the plug assembly is viewed in front elevation. In the case of a receptacle assembly R, the blank hole would not be so obvious but nevertheless would be apparent on close inspection.

It is important to note that the resilient locking sleeves **66** have thin cylindrical walls and that no room is required for radial expansion of the locking fingers either in the front insulating section or rear insulating section. Consequently the passages in the two insulating sections need be only slightly larger in diameter than the contact elements. The importance of this feature is that the passages through the insulating sections may be of relatively small diameter to permit the contact elements to be pushed relatively close together.

Initially, i.e. before the front insulating section **15** is placed in its assembled position contiguous to the back insulating section **16**, the locking sleeves **66** serve as detent means to engage the contact elements to hold the contact elements effectively in their assembled positions. Thus once a contact element is advanced into engagement with the resilient fingers of the corresponding locking sleeve, the contact element may be ignored thereafter while the remaining contact elements are maneuvered into the assembled positions. Since the locking sleeves only yieldingly engage the contact elements at this time, however, any contact element may be readily withdrawn and replaced if desired. An important feature of the invention is that the locking fingers of the locking sleeves are fully visible at this time for ready inspection.

It is to be noted that the circumferential locking shoulder **64** of a contact element is a sloping shoulder as distinguished from a steep or abrupt shoulder and that the outer ends of the locking fingers **70** are bent outward. Consequently when the locking fingers are not confined by the front insulating section, a wire **10** may be pulled to withdraw a contact element from the back insulating section **16**, the sloping circumferential shoulder of the contact element acting on the bent ends

of the locking fingers to cam the locking fingers outward to release the contact element.

Since the moving of the front insulating section to its assembled position confines the locking fingers of the locking sleeve and thus positively locks the contact elements in their assembled positions, the detent means are, in effect converted into locking means in response to the correct positioning of the front insulating section.

At any time desired, the front insulating section may be moved forward relative to the rear insulating section or the rear insulating section may be moved rearward relative to the front insulating section to convert the locking means back into the detent means. Thus while the plug P is mated with the receptacle R, the retaining nut **32** of the plug may be loosened to permit retraction of the rear insulating section **16** of the plug from the associated front insulating section **15** and then any defective socket contact element of the plug may be quickly and easily replaced through the grommet **20** and through the rear insulating section of the plug.

In a typical embodiment of the invention, the diameter of the passages or bores in the front insulating sections **15** and the rear insulating sections **16** is 0.0665 inch plus or minus 0.002 inch. Thus, the diameter of the passages ranges from 0.0063 to 0.0067 inch. A locking sleeve **66** is made with a nominal diameter of 0.0660 inch with the same tolerance of plus or minus 0.002 inch to range in diameter from 0.0658 inch to 0.0662 inch and, of course, the locking sleeve is permanently deformed to out-of-round configuration to fit tightly in any diameter between 0.0063 inch and 0.0067 inch. Preferably, the locking sleeves are made of quarter hard-heat treated beryllium copper.

The force required to insert or withdraw a contact element in the absence of a front insulating section **15** does not exceed 1½ pounds. After a front insulating section is assembled to a rear insulating section, however, the contact elements are so effectively locked in place that a wire **10** will break before the wire can be pulled hard enough to withdraw the contact element thereon.

FIG. **8** illustrating a modification of the invention shows a locking sleeve **75** mounted in a front insulating section **15*a*** with a rear flange **76** of the locking sleeve backed against and bonded to the front surface of an adjacent rear insulating section **16*a***. The locking sleeve engages a circumferential shoulder **64*a*** of a contact element **14*b*** to prevent withdrawal of the contact element.

FIG. **9** illustrating another modification shows how a locking sleeve **85** mounted in a rear insulating section **16*b*** and a cooperating front insulating section **15*b*** may be lanced and thus formed with forwardly directed tongues or teeth **86** that dig into the material of the rear insulating section to prevent forward displacement of the locking sleeve in the absence of the front insulating section. The locking sleeve **85** prevents withdrawal of a cooperating contact element **14*c*** in the usual manner. Obviously, the constructions shown in FIGS. **8** and **9** make it unnecessary to dimension a locking sleeve for a forced fit in an insulating section.

My description in specific detail of the presently preferred embodiments of the invention will suggest various changes, substitutions and other departures from my disclosure within the spirit and scope of the appended claims.

I claim:

1. In a connector assembly incorporating a plurality of contact elements on the ends of corresponding conductors for mating with a complementary connector assembly incorporating complementary contact elements wherein the connector assembly includes a housing shell confining insulating means, with the insulating means, in turn, forming a plurality of passages confining said plurality of contact elements, wherein the improvement comprises:

a front insulating section and a rear insulating section in contiguous relationship with portions thereof defining said passages;

said rear insulating section forming rear entrances to the passages large enough to permit the contact elements with the conductors attached thereto to be inserted through the rear insulating section when the front insulating section is separated from the rear insulating section,

said contact elements being peripherally recessed to form reduced neck portions that provide rearwardly directed locking shoulders;

resilient sleeves anchored to said rear insulating section and extending forward therefrom to engage the contact elements respectively,

said resilient sleeves having first portions and forward resilient fingers extending from the first portions and biased in their free state radially inwardly of the sleeves to enter said neck portions of the contact elements and to provide yielding engagement with said locking shoulders of the contact elements to resist rearward retraction of the contact elements,

said first portions of the resilient sleeves being disposed in the passages in the rear insulating section and said rearwardly directed shoulders of the contact elements and the forward ends of said fingers being normally in the passages of said front insulating section and the passages of the front insulating section being dimensioned in cross section to confine the fingers only to their inwardly biased position in contiguous relationship with said rearwardly directed shoulders of the contact elements thereby to positively lock the contact elements in their normal positions,

whereby with the front insulating section spaced from the forward end of the rear insulating section, the contact elements may be inserted through the rear insulating section and beyond into engagement with said fingers and then the front insulating section may be assembled to the rear insulating section to confine the fingers and thus lock the contact elements in their assembled positions; and

said fingers and rearwardly directed shoulders being shaped to cooperate for cam action to flex the fingers outward to release the contact elements in response to axial withdrawal force on the contact elements.

2. An improvement as set forth in claim **1** in which said locking sleeves and rearwardly facing shoulders are shaped to cooperate for cam action to flex the locking sleeves outward to release the contacts in response to axial withdrawal force on the contacts.

3. An improvement as set forth in claim 1 in which said locking shoulders of the contact elements are sloping shoulders to cam the resilient fingers out of engagement therewith in response to rearward retraction of the contact elements when the resilient fingers therein are not confined by the front insulating section.

4. An improvement as set forth in claim 3 in which the outer ends of the resilient fingers are turned outward less than 90° from the longitudinal axes of the passages to facilitate the cam action of the locking shoulders on the fingers.

5. An improvement as set forth in claim 1 in which the resilient sleeves are normally positioned in the portions of said passages that are in the rear insulating section;

in which the resilient sleeves have circumferentially continuous cylindrical walls, said cylindrical walls having an unrestrained non circular cross-sectional configuration of greater cross dimension than the cross sections of said portions of the passages whereby the locking sleeves are constricted by said portions of the passages for frictional resistance to forward displacement of the resilient sleeves by insertion by the contacts into the sleeves,

said sleeves being made of thin material to avoid destructive outward pressure of the sleeves on the surrounding passage walls.

6. An improvement as set forth in claim 5 in which the resilient sleeves are mounted in the passages in the rear insulating section and the sleeves have at least one forwardly and outwardly directed tongue at the forward ends of the forward resilient fingers.

7. In a connector assembly incorporating a plurality of contact elements on the ends of corresponding conductors for mating with a complementary connector assembly incorporating complementary contact elements wherein the connector assembly includes a housing shell,

wherein the improvement comprises:

a front insulating section and a rear insulating section defining insulating means, the front insulating section and the rear insulating section having a plurality of passages for receiving and confining said plurality of contact elements;

the rear entrance portions of said passages formed by the rear insulating section being shaped and dimensioned to clear the contact elements thereby to permit the contact elements to be installed by insertion into the passages from the rear end of the rear insulating section;

said contact elements having forwardly facing shoulders;

said insulating means having rearwardly facing shoulders cooperative with the forwardly facing shoulders of said contact elements to limit the forward movement of the contact elements in said passages;

said rearward section of said insulating means providing forwardly facing shoulders in said passages;

said contact elements having rearwardly facing peripheral shoulders in said passages located forwardly of said forwardly facing shoulders of the passages; and

locking sleeves surrounding the contact elements in said passages with forward portions of the locking sleeves abutting the rearwardly facing shoulders of the contact elements and with rear portions of the locking sleeves abutting the forwardly facing shoulders of the passages to prevent rearward withdrawal of the contact elements from the passages,

said forward portions of the locking sleeves being biased in their free state radially inwardly to abut said rearwardly facing shoulders and being radially expansible upon the exertion of a force to permit said rearwardly facing shoulders of the contact elements to pass forwardly through the locking sleeves,

the passages in said front insulating section, at the assembled position of the front insulating section and the locking sleeves, embracing the forward portions of the installed locking sleeves to prevent radial expansion of the forward portions of the locking sleeves from their inwardly biased position in contiguous relationship to the rearwardly facing shoulders of the contact elements, and

the fingers and the rearwardly facing shoulders being shaped to cooperate for cam action to flex the fingers outward to release the contacts in response to axial withdrawal force on the contacts.

8. An improvement as set forth in claim 7 in which said rearwardly facing shoulders of the insulating means are formed by the rear end of the rear insulating section.

9. An improvement as set forth in claim 2 in which the rear ends of the contact elements are flanged to abut the rear end of the rear insulating section when the contact elements are correctly positioned.

10. An improvement set forth in claim 7 in which the outer ends of the locking sleeves are turned outward to facilitate the cam action.

11. An improvement as set forth in claim 10 in which the portions of the passages in the front insulating section into which the sleeves extend are of uniform cross section and said turned ends of the fingers define a larger cross section than the uniform cross section when the fingers are in their release positions.

12. In a connector assembly incorporating a plurality of contact elements on the ends of corresponding conductors for mating with a complementary connector assembly incorporating complementary contact elements wherein the connector assembly includes a housing shell, the contact elements having rearwardly directed shoulders, wherein

the improvement to permit the plurality of contact elements with the conductors attached thereto to be inserted into the rear of the rear insulating section thereby to avoid the necessity of threading the conductors through the rear insulating section prior to attachment of the contact elements to the conductors,

insulating means divided into a plurality of sections positioned in end to end relationship and including at least a front insulating section and a rear insulating section;

said rear insulating section having a plurality of passages and the passages having rear entrances large enough to permit the contact elements with

the conductors attached thereto to be inserted through the passages in the rear insulating section to their assembled positions when the front insulating section is separated from the rear insulating section;

the front insulating section having passages to permit the contact elements with the conductors attached thereto to be inserted through the passages,

detent means carried by the rear insulating section and having forward portions yieldingly biased inwardly in their free state to engage the contact elements to effectively hold the contact elements in their assembled positions after the contact elements have been advanced through the rear insulating section to their assembled positions with the front insulating section spaced from the rear insulating section; and

the passages in the front insulating section having dimensions to accommodate the detent means at the forward end only in the radially inwardly biased position;

the forward portions of the detent means and the rearwardly directed shoulders being shaped to cooperate for cam action to flex the fingers outward to release the contacts in response to axial withdrawal force on the contacts.

13. An improvement as set forth in claim **12** in which said detent means and contact elements are shaped for release of the contact elements, prior to the positioning of the front insulating section, by cam action of the contact elements on the detent means in response to axial withdrawal force on the contact elements.

14. An improvement as set forth in claim **12** in which the contact elements have peripheral recesses and the locking means comprise resilient detent elements biased to contract radially into engagement with said peripheral recesses whereby an incorrectly positioned contact element expands the corresponding locking means; and

in which the passages in the front insulating section are dimensioned to clear the contracted detent elements but not the expanded detent elements whereby a detent element that is expanded by an incorrectly positioned contact element blocks correct positioning of the front insulating section to call attention to the incorrect positioning of the contact element.

15. An improvement as set forth in claim **14** in which the passages in the front insulating section are shaped and dimensioned to confine the locking means in their contracted state at the assembled position of the front insulating section thereby to lock the contact elements in their correct positions.

16. An improvement as set forth in claim **12** in which said detent means are mounted in the passages in the rear insulating section;

in which each detent means has a portion with a continuous cylindrical wall; and

in which the unrestricted configuration of said cylindrical wall is out of round with a cross-sectional dimension exceeding the cross-sectional dimension of the passage in which it is mounted whereby the cylindrical wall is compressed by the passage for frictional retention of the detent element in the passage.

17. An improvement as set forth in claim **16** in which the unrestricted configuration of said cylindrical wall of each detent means is oval so that each installed detent means exerts radially outward pressure against the surrounding passage along a given diameter of the passage; and

in which the detent means are positioned at random in the rear insulating section with respect to the orientation of said diameter.

18. In a connector assembly for providing electrical continuity with the ends of a plurality of conductors,

a plurality of contact elements constructed to be attached to the ends of the individual conductors in the plurality, the contact elements having forwardly facing shoulders and having rearwardly facing shoulders,

first insulating means having a plurality of passages for individually confining the contact elements in the plurality and having at least one shoulder in each of the passages,

second insulating means having a forward disposition relative to the first insulating means and having a plurality of passages with a configuration for individually confining the contact elements in the plurality and providing for the insertion of the contact elements, with the conductors attached to the contact elements, through the rear ends of the passages, and having a plurality of shoulders for contiguous disposition with the forwardly facing shoulders of the contact elements,

means including a housing shell for confining the first and second insulating means in contiguous relationship to each other,

locking sleeves surrounding the contact elements in the passages of the first insulating means and the rearward portions of the passages in the second insulating means, said locking sleeves having additional portions inwardly biased in their free state to abut the rearwardly facing shoulders of the contact elements and having rear portions abutting the shoulders in the first insulating means to prevent rearward withdrawal of the contact elements from the passages,

the additional portions of the locking sleeves being capable of outward expansion to provide for a passage of the rearwardly facing shoulders of the contact elements forwardly through the locking sleeves,

the first and second insulating means in their contiguous relationship confining the installed locking sleeves to prevent outward expansion of the additional portions of the locking sleeves out of engagement with the rearwardly facing shoulders of the contact elements, and

the additional portions of the locking sleeves and the rearwardly facing shoulders of the contact elements being shaped to cooperate for cam action to fix the additional portions outwardly to release the contact elements in response to axial withdrawal force on the contact elements.

19. In the connector assembly set forth in claim **18**,

the first and second insulating means being individually removable and the forward portions of the locking sleeves extending through the passages in the first insulating means to become exposed with the second insulating means removed.

20. In the connector assembly set forth in claim 19,
the rearwardly facing shoulders of the contact elements having a gradual taper inwardly with progressive positions toward the front of the contact elements; the taper and the additional portions of the locking sleeves combining in a cam action when the contact elements are displaced rearwardly; and the contact elements having a flange capable of engaging the first insulating means to lock the contact elements, in the assembled relationship with the locking sleeves, against forward movement in the passages of the first and second insulating means.

21. In the connector assembly set forth in claim 19 the locking sleeves being provided with a configuration relative to the passages for retention in the passages and for removal from the passages and for insertion into the passages without damaging the first and second insulating means and without the use of special tools.

22. The connector assembly defined in claim 18 wherein:
said inwardly biased additional portions of said locking sleeves are capable of being expanded radially outwardly in response to the rearward movement of said contact elements.

23. In a connector assembly for providing electrical continuity with the ends of a plurality of electrical conductors,
first insulating means defining a plurality of passages,
second insulating means defining a plurality of passages having a mating configuration with the first passages, the first insulating means being disposed rearwardly of and in contiguous relationship to the second insulating means,
a plurality of contact elements for individual connection with the ends of the electrical conductors, the contact elements having a configuration for insertion through the passages in the first and second insulating means from the rear ends of such passages, the contact elements being provided a particular portion having a configuration for a cam action, and
a plurality of detent means carried by the first insulating means and yieldingly biased inwardly in the free state at their forward ends to individually engage the particular portions of the contact elements,
the forward ends of the detent means being disposed at exposed positions at the front ends of the first insulating means with the second insulating means displaced from the first insulating means to facilitate the holding of the contact elements by the holding means,
the forward portions of the detent means and the particular portions of the contact elements being shaped to cooperate for cam action to release the contact elements in response to axial withdrawal force on the contact elements.

24. In the connector assembly set forth in claim 23
means including a housing shell for confining the first and second insulating means in contiguous relationship to each other.

25. In a connector assembly as set forth in claim 24,
the forward ends of the detent means and the particular portions of the contacts being shaped for release of the contacts by cam action of the contact element on the detent means in response to axial withdrawal force on the contacts.

26. In a connector assembly as set forth in claim 25,
the contacts having peripheral recesses and the detent means comprising at their forward ends resilient detent elements normally biased into engagement with the peripheral recesses whereby an incorrectly positioned contact expands the corresponding detent elements,
the passages in the second insulating means being dimensioned to clear the contracted detent elements but not the expanded detent elements whereby a detent element expanded by an incorrectly positioned contact blocks correct positioning of the contact element.

27. In a connector assembly as set forth in claim 26 wherein the passages in the second insulating means are shaped and dimensioned to confine the detent elements in their contracted state with the first and second insulating means in contiguous relationship and with the contacts properly positioned in the passages in the first and second insulating means.

28. In a connector assembly as set forth in claim 27,
the detent means being provided with a configuration relative to the passages in the first insulating means which permit the detent means to be retained in the passages at a fixed position in the passages but to be removed from the passages after disposition in the passages.

29. In a connector assembly as set forth in claim 28,
the unrestricted configuration of each detent means being oval with a cross-sectional dimension exceeding the cross-sectional dimension of the passage in which it is mounted, and
the detent means being positioned at random in the passages in the first insulating means with respect to the orientation of the cross-sectional dimensions.

30. In an electrical connector having a receptacle section and a plug section and a housing around each of said sections, a plurality of contacts having circumferential recesses disposed within each of said sections being capable of assuming a contiguous relationship wherein the contacts in one of said sections unite with the contacts of the other of said sections wherein at least one of said sections comprises:
first and second insulating means disposed in contiguous relationship to each other for separating and insulating said contacts wherein portions of said first and second insulating means respectively define first and second passages which extend longitudinally within said housing, said contacts being disposed within said first and second passages; and
locking means inwardly biased in their free states with respect to said contacts and at least partially disposed within said first and second passages, said locking means engaging the circumferential recesses in said contacts in the assembled relationship of the first and second insulating means and the contacts resisting the withdrawal of said contacts from said passages whereby said holding force can be overcome by rearward force on said contacts to enable the removal of said contacts, said locking means and said circumferential recesses in said contacts being shaped to

cooperate for cam action to flex the locking means outwardly to release the contacts in response to axial withdrawal force on the contacts.

31. The electrical connector as defined in claim 30 wherein said section further comprises:

locking fingers at the forward end of said locking means, said locking fingers being biased inwardly and disposed in contiguous relationship with said recesses in said contacts;

said passages in said second insulating means being dimensioned to accept said locking fingers when said locking fingers are disposed within said recesses and to reject said locking fingers when said locking fingers are not disposed within said recesses wherein the rejection of said locking fingers prevents said second insulating means from assuming said contiguous position with said first insulating means and thereby provides an indication that the locking fingers are not properly seated in said recess.

32. The connector as defined in claim 30 wherein:

said contacts are cammed relative to said locking fingers to expand said locking fingers radially outwardly from said recesses in response to the rearward movement of said contacts so that said locking fingers engage said second insulating means prior to the complete withdrawal of the contacts from said recesses whereby further rearward movement of said contacts are prohibited.

33. The connector as defined in claim 32 wherein said camming by said contacts is provided by:

a rearwardly facing taper extending outwardly from said recess, said locking fingers expanding radially outwardly by the camming action from said taper in response to the rearward movement of said contacts.

* * * * *