

March 17, 1964

G. J. SWANSON
ELECTRICAL CONNECTOR

3,125,395

Filed April 24, 1959

4 Sheets-Sheet 1

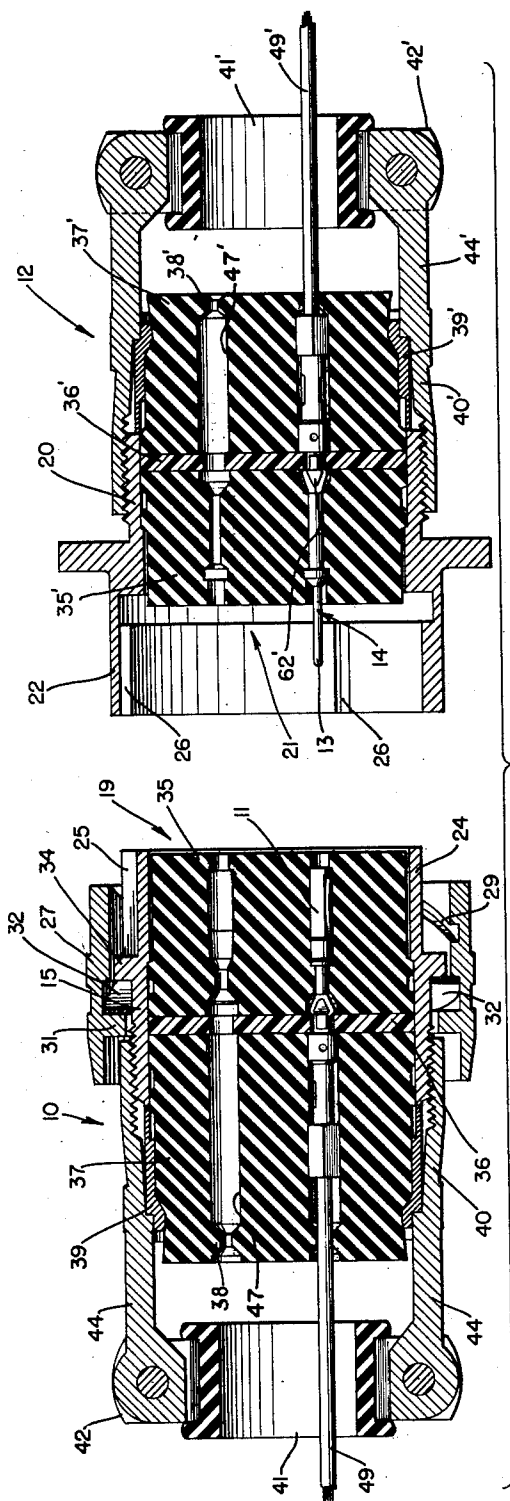


FIG. 1

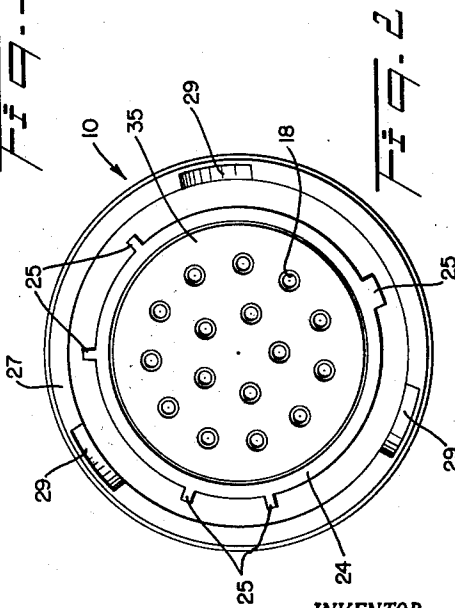


FIG. 2

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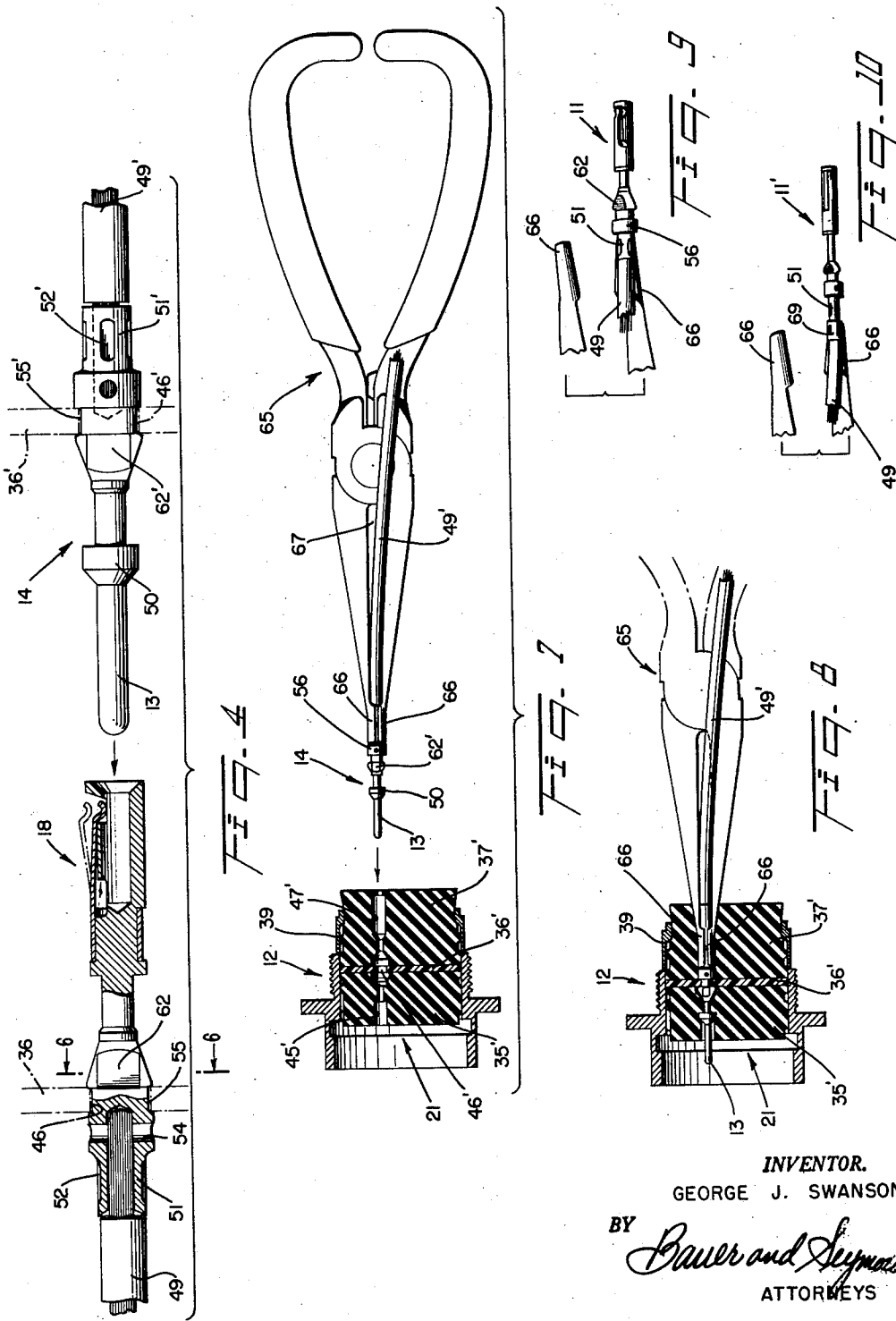
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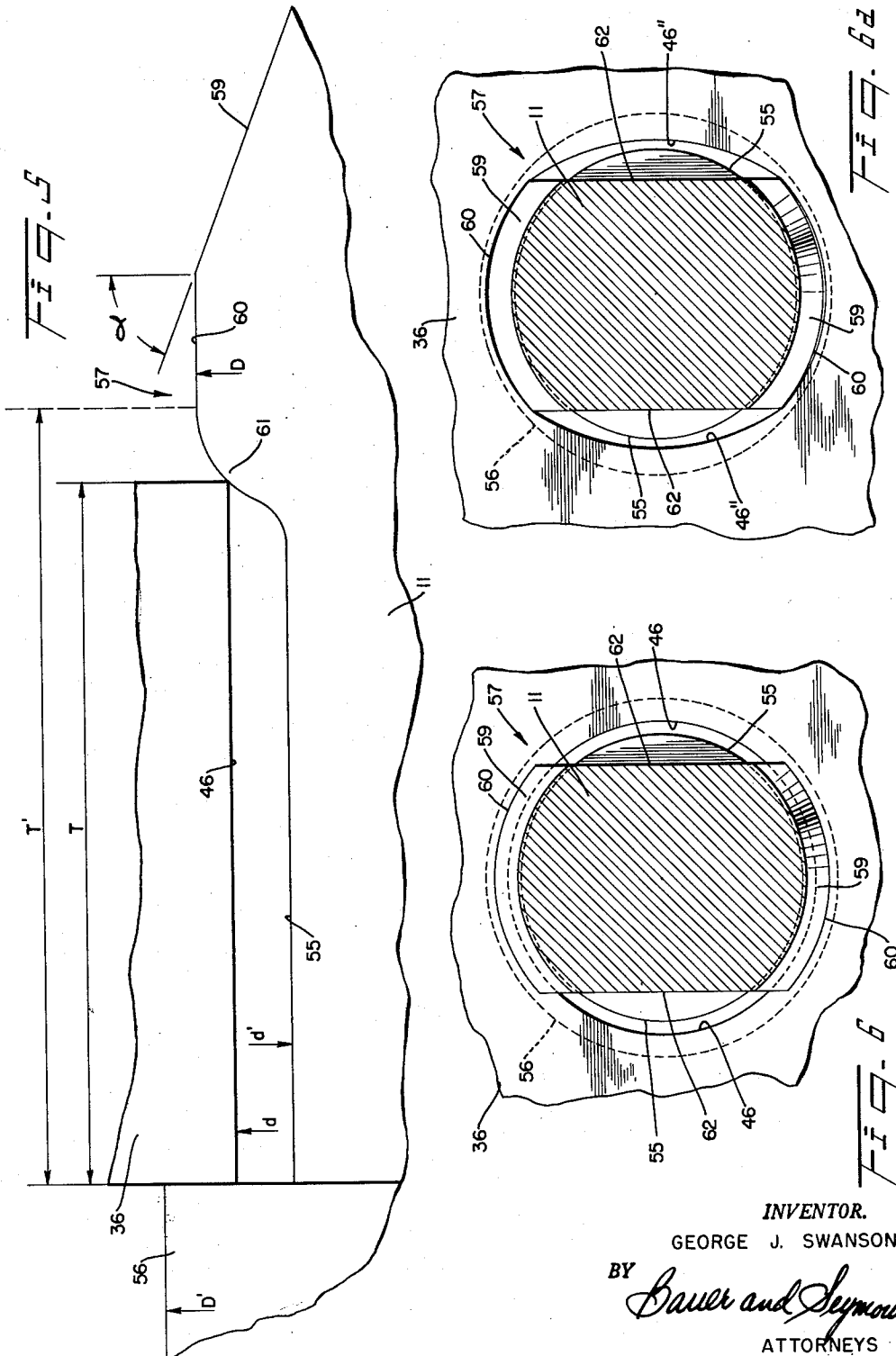
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4 Sheets-Sheet 3



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ELECTRICAL CONNECTOR

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Filed Apr. 24, 1959, Ser. No. 808,611
18 Claims. (Cl. 339-176)

This invention relates to electrical connectors, and particularly relates to a device for separably connecting electrical conductors such as wires, cables and the like.

The invention has among its objects the provision of a novel electrical connector of the pin and socket type.

A further object of the invention lies in the provision of a separable connector of the above indicated type, one or both of the connector parts having cooperating novel means for retaining the contacts in an insulating insert within the connector shell.

Still a further object of the invention lies in the provision, in a separable connector of the type indicated, of an improved contact-retaining means of such construction that a contact may be inserted into the connector part in fully operative position therein, after the contact has been connected to its conductor or wire, by a simple manipulation consisting essentially of thrusting the thus connected contact and wire axially into the connector part.

Yet another object of the invention lies in the provision of contact-retaining means of the type indicated whereby a contact may be removed, if necessary, from the connector part so as, for example, to correct a faulty connection to the connector part.

The above and further objects and novel features of the invention will more fully appear from the following detailed description when the same is read in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are for purposes of illustration only and not intended as a definition of the limits of the invention.

In the drawings, wherein like characters refer to like parts throughout the several views,

FIG. 1 is a view taken partially in longitudinal axial section through two aligned confronting parts of a separable electrical connector made in accordance with one embodiment of the invention, the two connector parts being shown in position to be coupled together by axial movement toward each other followed by a manipulation of the locking means, some of the parts being shown in side elevation, the respective connector parts being shown with a set of two mating contacts, the contacts being omitted at other locations in the connector parts for clarity of illustration;

FIG. 2 is a view in end elevation of the connector part shown at the left in FIG. 1, the view being taken in the direction from right to left in FIG. 1;

FIG. 3 is a view in end elevation of the connector part shown at the right in FIG. 1, the view being taken in the direction from left to right in FIG. 1;

FIG. 4 is a schematic view partially in axial section and partially in side elevation of a pair of cooperating contacts in position to be immediately engaged with each other, the figure particularly illustrating the manner in which the contacts are accurately located axially of their mounting means and are prevented from axial displacement with respect thereto during the operations of connecting and disconnecting the contacts;

FIG. 5 is a view on an enlarged scale of a portion of FIG. 4, the view showing the relationship between the retaining plate of the insert and a contact retained thereby;

FIG. 6 is a view in transverse section on an enlarged scale through a mounted contact, the section being taken along line 6-6 of FIG. 4;

FIG. 6a is a view similar to FIG. 6, the view showing

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the manner in which the contact-retaining plate of the insert is distorted at the contact retaining passage there-through during the contact mounting operation;

FIG. 7 is a somewhat schematic fragmentary view illustrating the manner in which an assembled contact and wire are mounted within a composite contact locating and retaining insert assembly of the connector of the invention, the view showing the parts at the beginning of the contact-mounting operation;

FIG. 8 is a view similar to FIG. 7, but with the contact thrust into fully inserted position in the composite insert of the connector part by the assembling tool;

FIG. 9 is a fragmentary view in perspective showing the manner of engagement between the jaws of an assembling tool and a first embodiment of contact in accordance with the invention;

FIG. 10 is a view similar to FIG. 9, but showing the manner of engagement between the jaws of the assembling tool and a second embodiment of contact in accordance with the invention;

FIG. 11 is a view partially in longitudinal axial section and partially in side elevation of a tool which may be employed to disassemble, when necessary, the contacts from the connector parts of the connector of the invention;

FIG. 12 is an enlarged view partially longitudinal axial section and partially in side elevation of the operative portion of the tool of FIG. 11, the tool being adapted for the removal of a pin contact from the connector of the invention, the tool being shown in position to be applied to such pin contact;

FIG. 13 is a view in side elevation of the operative portion of the tool for removing a socket contact from the connector of the invention;

FIG. 14 is a somewhat schematic fragmentary view illustrating the removal of a pin socket from the connector of the invention, the view showing the start of such pin-removing operation; and

FIG. 15 is a view similar to FIG. 14, but showing the parts after the pin-removing tool has been applied to the pin and has been thrust rearwardly so as to disengage the pin from the retaining means therefor in the insert of the connector part.

The electrical connector of the present invention is particularly advantageous when it is employed with contacts which are connected to their respective conductors such as wires by being crimped thereto rather than soldered. In Herman Keller et al. U.S. Patent No. 3,028,776, there is disclosed and claimed a crimping tool for carrying out such wire-and-contact-connecting operation. Such crimped connection has, in general, proved to be more reliable than soldered connections, and is more economically made. Such connection eliminates the tinning of the wire; such tinning is disadvantageous in that it tends to make the tinned end of the stranded wire rigid and thus easily broken in the zone immediately adjacent to the joint. Further, no source of heat, such as a soldering iron, is necessary to make the joints, and since each joint is made before the contact is mounted in the connector part, the need for extremely painstaking work, required when wires are soldered to the closely spaced solder wells of assembled contacts in connectors made in accordance with the prior art is eliminated.

The electrical connector of the present invention is of such construction that, after a joint has been made between the end of a wire and a contact, the contact and wire may then be readily mounted into a previously assembled connector part including a shell having a contact-retaining insert therewithin. The contact and the insert of the connector of the invention have interfitting formations thereon so constructed and arranged that the contact may be thrust into its fully inserted operative po-

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sition by essentially straight line axial movement thereof, the contact being securely held in such position despite repeated operations of engagement with and disengagement from a mating contact. The construction of the insert and contact retaining formations is preferably such that, when necessary, the contact may be removed from the connector part by an operation which is the reverse of the assembly operation. As a result of such preferred construction, errors in circuit connections may be readily corrected without injury to the contact or to the locating and retaining insert of the connector part. It is to be understood, however, that, within the broader aspects of the invention, the contacts need not be thus removable after having been mounted in the insert.

Turning now to the drawings, there is shown in FIG. 1 a separable electrical connector of the multi-contact type, both halves of such connector being made in accordance with the present invention. The connector half or part at the left, designated 10 in the embodiment shown, is adapted to support and retain a plurality of socket contacts, one of which is shown at 11. The connector part shown at the right in FIG. 1 and generally designated 12, is adapted to support and retain a plurality of pin contacts, of which one is shown at 14. Connector parts 10 and 12 are shown somewhat separated but aligned so that the respective socket and pin contacts carried thereby will be placed in mating relationship when connector parts 10 and 12 are advanced into operative engagement. In the embodiment shown, the shells or housings of the connector parts, and the means for holding the connector parts in operative engagement, are generally similar to those disclosed in Hennessey and Swanson Patent No. 2,984,811.

Briefly, the connector part 10 has a tubular shell 15 having suitable annular recesses therein for mating with the forward portion of a composite insert 19 which is retained within shell 15. The inner wall of shell 15 also includes a conventional longitudinal extending key member which extends into a shallow groove in the exterior of the composite insert, whereby accurately to orient the insert angularly with respect to shell 15. Connector part 12 has a generally similar shell 20 which accurately retains a composite insert member 21 therein in a predetermined position both lengthwise and angularly with respect to shell 20.

In the embodiment of the connector shown, connector part 12 is of the wall mounted type having a forwardly extending hood portion 22 which is designed telescopically to receive the forward portion 24 of shell 15. Hood 22 and portion 24 of shell 15 are accurately oriented angularly with respect to each other by one or more interfitting splines 25 on portion 24 and interfitting grooves 26 on hood 22. Connector halves 10 and 12 are retained together in operative position by an outer nut member 27 rotatively mounted upon shell 15. Nut member 27 has three bayonet grooves 29 in its inner forward surface, such grooves receiving the pins 30, shown in FIG. 3, projecting radially from the outer surface of hood 22. When the pins 30 are received in the forward ends of grooves 29 and the nut 27 is turned in the proper direction (counterclockwise in FIG. 2), connector parts 10 and 12 are drawn strongly together by the action of nut 27, the axial thrust from the nut being transmitted to shell 15 from flange 31, on the nut 27, through a bent annular leaf spring 32 to a radially outwardly directed flange 34 on shell 15.

The embodiment of separable connector shown is adapted simultaneously either to make or break the electrical circuits in a plurality of wires. Thus the inserts 19 and 21 of the respective connector parts each carries the same number of mating contacts. Such inserts are required accurately to locate the respective contacts both as regards their radial distance from the axis of the connector part and their spacing angularly about such axis, to locate the contacts accurately axially of the shell of

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the connector part, to maintain the contacts electrically insulated from each other, and to seal the outer or rear ends of the contacts and the wires connected thereto from the atmosphere. In the connector of the present invention such insert has the further function of allowing the assembled contacts and wires connected thereto to be inserted into the previously assembled composite insert and connector shell by an operation involving substantially only axial movement of the contact relative to the insert and shell. In preferred embodiments of the connector, the configuration of the parts is such that the contacts may also be removed, if necessary, by relative axial movement between the contact and the connector shell and insert.

The composite inserts 19 and 21 are generally similar, differing only as to the axial length of the forward portions thereof and the contour of the portions of the passages through the insert which are located in such forward portions. Taking insert 19 as typical, such insert has a forward, contact-locating portion 35, an intermediate contact-retaining plate 36, and a rear contact end conductor-sealing grommet 37. Forward portion 35 of the insert is made of a relatively stiff rubber or rubber-like material, whereby accurately to locate the contacts, as explained. Plate 36 is made of a relatively stiff but yieldable electrical insulating material. In one embodiment of the invention, plate 36 is made of a molded resin such as nylon. The grommet 37 is made of a rubber or rubber-like material of an intermediate durometer value, whereby the grommet may be readily deformed by a compressing means so as to seal it about the contacts and their wires.

As will be explained hereinafter, the parts of the composite insert are preferably bonded to each other and to the connector shell prior to the mounting therein of the contacts and their connected wires. The connector of the invention is designed to be sold in partially disassembled form: thus, as to the connector shown, the composite inserts 19 and 21 will have been assembled within and bonded to their respective shells 15 and 20. The pin and socket contacts will not as yet have been mounted in the inserts, and the rear housing parts, including the grommet compressing sleeves and the conductor clamping means shown, will not have been mounted upon the shell parts 15 and 20. The final assembling of the parts, including the connection of the contacts to conduit wires and the mounting of the thus assembled contacts and wires in the connector parts, is carried out by the consumer.

Thus in the wiring of an aircraft, for example, the worker will cut the various wires to length and mount the contacts on the ends thereof in situ, following which he will insert the contacts and connected wires into the respective connector parts, after having telescoped over the conduits or wires the appropriate elements which will ultimately be assembled with the shells to lie rearwardly thereof. After the contacts have been mounted in their respective axial passages in the insert 19, connector part 10 will be completed by advancing nut 27 into place, by disposing grommet compressing sleeve 39 over the rear end of the grommet 37, and by screwing home the rear portion 40 of the housing of connector part 10, whereby to compress the grommet radially inwardly upon the contacts and the wires extending therethrough. Finally, the rubber clamp grommet 41 is slid into place about the grouped conductor wires, and is held clamped against the wires by the split clamping means 42 attached to arms 44 projecting rearwardly from housing part 40.

The assembling of connector part 12 is carried out in a similar manner. Since the parts at the rear of the shell of connector part 12 are substantially identical with those at the rear of connector part 10, they are designated by the same reference characters but with an added prime.

The manner of location and retention of contacts 11 and 14, respectively, in connector parts 10 and 12 will

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be more fully understood by a consideration of the shapes of the unoccupied passages in the respective inserts, shown substantially in their relaxed configurations in FIG. 1, with the shapes of the contacts 11 and 14 which such passages are to accommodate. The portion 45 of such passage which lies in forward insert portion 35 has such configuration as generally snugly to embrace the forward socket portion 18 of contact 11 and to provide an opening through which the pin 13 may be inserted into the socket. The passage 45 thus has a radially inwardly projecting annular portion which engages the shank of contact 11 rearwardly of the socket. The plate 36 has a circular cylindrical hole 46 therein in alignment with each passage 45, the relaxed diameter of such hole 46 slightly exceeding the maximum diameter of any portion of the socket 18, so that the socket may be freely inserted into the insert through hole 46 in the plate. Immediately forwardly of plate 36, passage 45 in forward insert 34 has a relaxed shape which is frusto-conical, and which converges in a forward direction, the rear, larger end of such frusto-conical portion somewhat exceeding the diameter of hole 46.

The portion of the passage through the insert in the rear grommet portion 37 is designated 47. Passage 47 has a relaxed diameter throughout its length such as to pass the contact 11 fairly freely therethrough. Adjacent its outer end, grommet 37 has an inwardly projecting annular sealing flange portion 38 which is adapted to be squeezed tightly about the wire 49 connected to contact 11 when the parts are fully assembled as shown in FIG. 1. As above explained, grommet 37 is made of relatively soft rubber-like material which may be readily temporarily distorted when contact 11 is being assembled or disassembled therethrough.

The same considerations exist in the design of the configuration of the passage through insert 21 in connector part 12. Thus the portion of the passage in forward insert part 35', here designated 45', has such shape as snugly to embrace pin contact 14, including the forward enlarged portion 50 thereon, and to allow the pin 13 to protrude forwardly of insert portion 35'. The hole 46' in contact retaining plate 36' is of such relaxed diameter as freely to pass enlargement 50 on pin contact 14 therethrough. The portion of the passage in grommet 37' is generally the same as that in grommet 37, being of such diameter as fairly freely to pass the pin contact therethrough, and having an inwardly projecting annular portion 38' adjacent its rear end which is sealingly pressed against the wire 49, connected to contact 14, when the parts are assembled as shown in FIG. 1.

The manner of connection of the wires to the respective contacts, and of the holding of the contacts in their respective inserts are generally the same. These features will be understood more fully upon consideration of FIGS. 4, 5, and 6. As there shown, the rear ends of the contacts are provided with ferrules, designated 51 for contacts 11 and 51' for contact 14, into which the ends of the respective wires 49 and 49' are inserted. The fully inserted condition of the wires relative to the ferrules may readily be detected by the assembler by looking into the transverse passages 54 through the contacts at the forward end of the ferrules. The wires are electrically connected to the contacts and firmly secured thereto by the crimping of the ferrules so as to form opposing indentations 52, 52' in the side walls thereof. Such crimping of the contacts upon the wires may conveniently be performed by the use of a crimping tool such as that described and claimed in the above referred to Keller et al. Patent No. 3,028,776.

The manner of retention of contacts 11 and 14 against axial movement relative to their respective inserts are the same in the embodiment of connector shown; a detailed description of the means for retaining a contact in insert 19 of connector part 10 will suffice.

Immediately forwardly of ferrule 51, contact 11 has

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two axially spaced plate-engaging formations thereon which cooperate with the retaining plate 36 stably to retain the contact in a predetermined axial position relative to the connector part in which it is mounted. In the embodiment shown, the contact-retaining means also selectively allows the withdrawal of the contact when it becomes necessary, for example, to correct a faulty circuit. The rear contact-retaining formation on the contact, designated 56, is the form of an abrupt, right-angled annular shoulder having a diameter appreciably exceeding the diameter of hole 46 in plate 36. Shoulder 56, when in engagement with the rear surface of plate 36, definitely locates contact 11 axially and prevents its further forward travel after it has been fully mounted within the insert. The second, forward formation on the contact, generally designated 57, is made up of two oppositely facing ramp-like portions which function momentarily to deform the plate 36 in the vicinity of hole 46 there-through both during the insertion of the contact into operative position within the insert and its withdrawal therefrom.

The forward portion of the forward formation is in the form of diametrically opposed frusto-conical surfaces 59 which converge in a forward direction to a root portion on the body of contact 11, such root portion being of somewhat smaller diameter than the diameter d of hole 46. Surfaces 59 are separated by the opposite flat surfaces 62. The rear, larger diametered ends of frusto-conical portions 59 join with a short circular cylindrical zone 60, which has a diameter D appreciably exceeding the relaxed diameter of hole 46 in plate 36. Forwardly of shoulder 56 the body of contact 11 is provided with an axially short circular cylindrical seat 55 having a diameter d' which is somewhat less than the diameter d of hole 46. The zone of the body of contact 11 between the rear end of surface 60 and the forward end of seat 55 is formed mainly of a rearwardly convex toroidal surface 61 which merges smoothly with surface 60 at its forward end and is connected at its rear end to seat 55 through a short radiused fillet.

In the embodiment of connector shown, the plate 36 preferably has a thickness which lies within the range $T-T'$ (FIG. 5) that is, when the contact is installed in the plate the forward edge of the plate 36 at hole 46 preferably lies upon toroidal surface 61. With such construction, surface 61 constantly resiliently deforms resilient plate 36 so that the plate constantly urges the contact 11 forwardly, so that shoulder 56 is thrust against the rear of the plate, thereby accurately locating the contact in an axial direction. Plate 36 has sufficient resilience that during installation of the contact in the plate and its withdrawal therefrom, the hole 46 is momentarily deformed, generally as shown at 46'' in FIG. 6a. The presence of the opposite flattened zones 62 at the location of means 57 allows the hole 46 to be generally deformed into an oval; after means 57 has passed plate 36, the hole 46 therein generally resumes its circular shape, except for the portion of its sidewall overlying surface 61.

In accordance with the invention, should it not be desired that the contacts shall be removable, or at least readily removable, from the insert, the plate 36 can be made of a thickness such that it snugly fits within seat 55 and does not overlie curved surface 61 much, if at all. Such construction accurately locates the contact in an axial direction, but makes it increasingly difficult to retract the contact from plate 36, because of the increased steepness of the angle at which the forward edge of plate 36 initially engages curved ramp surface 61.

FIGS. 7 and 8 illustrate the operation of mounting a pin contact 14, which has been crimped to a wire 49', in connector part 12. In carrying out such operation, there is conveniently employed an assembling tool 65 which closely resembles a pair of needle-nosed pliers. The forward ends of the jaws of tool 65 are in the form of thin axially extending shells 66 which, when closed, present

substantially a circular cylindrical passage longitudinally between them. Portions 66 of the jaws are so constructed that, when closed upon the rear ferrule end of the contact 14, they firmly grip the contact and maintain it from deflection. The outer diameter of jaw portions 66, when such portions are closed upon the ferrule 51' of the contact, does not appreciably exceed the diameter of shoulder portion 56 of the contact. Rearwardly of gripping portion 66 the forward legs of the tool are relieved from each other to form an elongated space 67 which somewhat exceeds the diameter of wire 49'.

With the contact 14 gripped by tool 65 in the manner shown in FIG. 7, and with wire 49' extending rearwardly from gripping portions 66 of the tool and thence laterally from space 67, the tool and its gripped wire and contact are advanced axially of connector part 12 with the contact in alignment with the proper passage 47' in the insert thereof. After contact 13 has been initially inserted into passage 47', continued advance of the contact eventually brings the parts into the position shown in FIG. 8, wherein the forward contact-retaining formation 57 on contact 14 has snapped through the hole 46' in retaining plate 35'. When such fully inserted position of the contact has been reached, the tool 65 may be retracted merely by pulling it rearwardly of the connector part 12, following which the grommet 37' contracts into snug engagement with the rear end of contact 14 and with the wire 49' crimped thereto.

In FIG. 9 the forward gripping portions 66 of the tool 65 are shown in the process of being engaged with the ferrule of a socket contact 11. Ordinarily the pin and socket contacts of one size of connector are so made that the same assembling tool 65 may be employed to assemble both the pin and the socket contacts thereof. Thus the ferrule 51 of socket contact 11 will have substantially the same diameter as ferrule 51' of pin contact 14.

In some instances, particularly when the wire 49 is of small diameter, there may be employed pin and socket contacts which have a second, rear, ferrule which may be crimped about the end of the insulation on the wire. FIG. 10 shows an alternative socket contact 11' of such construction. Contact 11', in addition to the wire-engaging ferrule 51', has a second, rear, ferrule 69 which is clenched about the end of the insulation on wire 49. In installing contacts such as contact 11', the gripping portions 66 of an assembling tool are preferably clampingly engaged with the rear ferrule 69 in the manner indicated in FIG. 10.

As indicated above, in its preferred embodiment the electrical connector of the present invention incorporates contact retaining means of such character that the contacts may be removed from their operative position within the insert of the connector part without injury to either the contacts or the insert. In FIGS. 11-15, inclusive, there are illustrated contact-removing tools which may conveniently be used in the manner of removal of typical contacts made and retained in accordance with the invention.

The contact-removing device shown, generally designated 74, is in the form of a hollow handle 75 having means on its forward end for the removable mounting of the appropriate contact-removing tool 76. The other contact removing tools are conveniently stored within the handle. In FIGS. 11 and 12 the tool 76 there shown is for the removal of a pin contact from a connector part, and thus has a forward portion 77 in the form of a thin axially directed tube which accurately receives the contact pin 13 within it; the outer diameter of tube 77 does not appreciably exceed the diameter of the enlargement 50 on the contact pin.

The tool 79, which may alternatively be mounted upon the forward end of handle 75, as shown in FIG. 13, is in the form of an elongated pin with a forward axially extending end 80 having a diameter substantially that of the contact pin. End 80, which is designed to be received

in socket 18 of a socket contact 11, has a length which somewhat exceeds the length of the passage in socket 18, so that the socket-removing thrust is exerted upon the inner end of the passage in the socket. Tool 79 has a rear enlarged shank 81 which aids in guiding tool 79 within the insert in the connector part, once portion 80 of the tool has been inserted within socket 18.

In FIGS. 14 and 15 there is somewhat schematically illustrated the operation of removing a pin contact 14 from a connector part 12. The proper tool 76 is applied to handle 74, and the tubular portion 77 of tool 76 is now advanced toward pin 13 in alignment therewith. After tubular portion 77 has been telescoped over the projecting end of pin 13, continued movement of portion 77 to the left causes it to penetrate within the passage in the insert 21 and to engage the enlargement 50 on the contact pin, and thereafter causes the contact 14 to move to the left (FIG. 14) and the forward contact-retaining formation 57' thereon to snap rearwardly through the hole 46' in plate 36'. The diameter of tool portion 77 is somewhat less than that of hole 46', so that the tool may then freely be thrust toward the left, as shown in FIG. 15, substantially completely to remove the contact from the insert 21.

The assembling of the shell of the connector part and the composite contact locating and retaining insert may conveniently be carried out as follows. The connector shell, which is ordinarily made of metal, is degreased as by being subjected to a suitable solvent. The rear face of the forward portion of the insert (for example, 35 in connector part 10) and the forward face of the grommet 37 are roughened as by being sanded on a suitable abrading surface. Both sides of the contact-retaining plate 36 are roughened as by either being sanded or blasted with abrasive. All such roughened surfaces should be flat to facilitate proper binding. The rear face of the forward insert part, in addition to being flat, must be accurately located so as to lie accurately in a predetermined position axially of the connector shell when parts are fully assembled.

After being thoroughly cleaned, the parts are bonded together. A convenient and satisfactory method for securing such bonding is as follows. A uniform coating of a suitable adhesive is applied to the mating diameters of the forward insert portion (35), the metal shell, the rear face of the forward portion of the insert, the forward face of the grommet (37), and both sides of the contact retaining plate (36). All of such parts are now baked for a short time at a relatively low temperature, so as preliminarily to set the adhesive. The forward portion of the insert is now snapped into place in the shell, following which the shell with the forward portion of the insert 35 therein is baked to adhere such parts together. After such assembly is returned to room temperature, a fresh coating of adhesive is applied to both sides of plate 36, the adhesive coatings on the rear face of the forward insert part 35 and the forward face of grommet 37 are reactivated, as by being treated with a suitable solvent.

The shell with insert part 35 assembled therein is now mounted upon a suitable alignment fixture having a base plate and a plurality of alignment pins projecting vertically therefrom, there being one such pin for accurately fitting within each of the passages in insert portion 35, plate 36, and grommet 37. Plate 36 is now mounted upon the upwardly projecting pins of the fixture, and the grommet 37 is then superimposed upon plate 36 and held thereagainst under light pressure, as by a suitable clamping means cooperating with the alignment fixture. The fixture, with the connector parts mounted thereon as described, is now charged into a suitable oven where the parts are baked at such temperature and for such length of time as to complete the bonding of insert portion 35 to the shell, and to bond the plate 36 to insert portion 35

and to grommet 37 completely over the interfaces between such parts.

For the purposes of illustration there are given below the salient dimensions of the parts retaining a contact of a typical electrical connector made in accordance with the invention. The contact, which is of the size known commercially as "Size 16," has a maximum diameter in its forward portion (of element 50 if it is a pin contact; of socket 18 if it is a socket contact) of .125 in. Zone 60 has a diameter of .135 in.; surface 59 makes an angle α of 69° with a plane transverse to the axis of the contact. Seat 55 has a diameter of .120 in., hole 46 in plate 36 has a diameter of .131 in., and shoulder 56 has a diameter of .141 in. The intersection of surfaces 59 and 60 lies .078 in. from shoulder 56 along the axis of the contact. The elements of surface 61, which lie in axial planes through the contact, are portions of circles tangent to surface 60, and extend down substantially to the level of seat 55 except for the interposed fillet therebetween, such fillet having a maximum radius of .004 in.

The plate 36, which in the described embodiment is made of molded nylon sold under the trade-name "Zytel 101 nylon," has a thickness which may range from (FIG. 5) $T=.060$ in. to $T'=.068$ in. As shown in such figure, when the plate 36 has its minimum permissible thickness its forward edge approximately overlies the midpoint of surface 61. When plate 36 has its maximum permissible thickness, its forward edge approximately overlies the transverse line of tangency between surfaces 61 and 60.

Many of the advantages of the electrical connector of the present invention will have become apparent in the foregoing description. There are, of course, other advantages; among them are the fact that the novel contact-retaining means and the preferred novel means connecting the contacts to their lead wires add little if anything to the space requirements of the contacts of electrical connectors of the prior art. Consequently halves of electrical connectors in accordance with the present invention may readily be made of such dimensions as to mate satisfactorily with complementary connector halves made in accordance with the prior art.

Although only one embodiment of the invention has been illustrated in the accompanying drawings and described in the foregoing specification, it is to be especially understood that various changes, such as in the relative dimensions of the parts, materials used, and the like, as well as the suggested manner of use of the apparatus of the invention, may be made therein without departing from the spirit and scope of the invention as will now be apparent to those skilled in the art.

What is claimed is:

1. An electrical connector comprising in combination a substantially rigid contact supporting plate having a passage therethrough and an elongated metal contact extending through said passage, said contact having a first enlarged portion forming a shoulder engaging one face of said plate around said passage to hold said contact against movement in one direction relative to said plate and having a second enlarged portion axially spaced from said first portion forming a tapering shoulder facing said first-named shoulder and engaged intermediate the radial extremities thereof by said plate at the junction of the other face of the plate with the wall of said passage to restrain said contact against movement in the other direction relative to said plate, that portion of said contact between said shoulders being of smaller transverse section than said passage and said contact being rigid and so constructed in the region of said second enlarged portion that the peripheral shape and dimensions of said second enlarged portion are unaffected by compressive radial forces applied thereto.

2. An electrical connector comprising in combination a contact supporting plate having a passage therethrough, said plate being substantially rigid but sufficiently resilient-

ly pliable in a radial direction to permit slight deformation of said passage in response to substantial radial pressure against diametrically opposed wall portions thereof, and a rigid elongated metal contact extending through said passage, said contact having a first enlarged portion forming a transverse shoulder engaging one face of said plate around said passage to hold said contact against movement in one direction relative to said plate and having a second enlarged portion forming a tapering shoulder facing said transverse shoulder, said tapering shoulder being resiliently gripped intermediate the radial extremities thereof by said plate adjacent the end of said passage to restrain said contact against movement in the other direction relative to said plate, that portion of said contact between said shoulders being spaced radially inward from the walls of said passage, and said second enlarged portion having a permanent, unyielding peripheral shape adapted to deform said passage and thereby set up and maintain tension in the plate around said passage, whereby the plate exerts a radially directed gripping force on said tapering shoulder.

3. An electrical connector as defined in claim 2 wherein said second enlarged portion on the contact forms a second tapering shoulder facing away from said transverse shoulder whereby said second portion may be passed through said passage upon deformation of the latter in response to substantial force effecting longitudinal movement of said contact in said one direction.

4. An electrical connector comprising in combination a substantially rigid but slightly resiliently deformable contact supporting plate having a passage therethrough and an elongated metal contact extending through said passage, said contact having a transverse shoulder engaging one face of said plate at one end of the passage to hold said contact against movement in one direction relative to said plate and having an enlarged portion axially spaced from said transverse shoulder said enlarged portion being rigid and permanently, unyieldingly, peripherally shaped to enlarge the relaxed transverse dimensions of the passage in at least one sector while permitting contraction of the transverse dimensions of the passage in an adjacent sector, whereby the plate is tensioned around said passage to exert a radially directed gripping force against said enlarged portion of the contact, said plate adjacent the other end of said passage surrounding and resiliently gripping a part of said enlarged portion having a transverse dimension greater than the corresponding relaxed dimension of said passage, that part of said contact between said shoulder and said enlarged portion being radially inwardly spaced from the walls of the said passage.

5. An electrical connector comprising a tubular housing, an electrically insulating insert member secured within said housing, said insert member comprising a forward, contact-locating portion made of resilient rubber-like material, a contact-retaining plate made of substantially rigid but slightly resiliently deformable material positioned rearwardly of the forward portion, the forward portion and the plate being intimately bonded to each other over substantially the entire extent of their interfaces, and means rearwardly of the plate thrusting the plate in a forward direction against the forward portion of the insert member, said insert member having a passage longitudinally therethrough, and an elongated contact having a substantial part of its length located within said passage, said contact having axially spaced formations thereon cooperating with the forward and rear edges of that portion of the passage located in the plate through which the contact extends to retain the contact from appreciable longitudinal movement relative to the insert member during normal operations involving connecting and disconnecting the connector, the forward formation on the contact being such as to allow such forward formation to be snapped through the portion of the passage in the plate in the forward direction and said

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forward formation being resiliently gripped by said plate only at the forward end of the portion of the passage in said plate to yieldably retain the contact against rearward movement relative to the insert member.

6. An electrical connector comprising a tubular shell, a composite electrically insulating insert member secured within said shell, said insert member comprising a forward, contact-locating portion made of resilient rubber-like material, an intermediate contact-retaining plate made of substantially rigid but resiliently deformable material, and a rear contact-sealing grommet made of resilient rubber-like material, said insert member having a passage longitudinally therethrough, and an elongated contact having a substantial part of its length located within said passage, said contact having axially spaced radially enlarged formations thereon cooperating with the forward and rear edges of that portion of the passage which is located in the plate and through which the contact extends to retain the contact from appreciable longitudinal movement relative to the insert member during normal operations involving connecting and disconnecting the connector, the forward formation on the contact being such as to allow such forward formation momentarily to resiliently deform the plate in the vicinity of the portion of the passage through the plate and thus to be snapped through the plate by thrusting the contact in the forward direction relative to the plate and said forward formation, at a zone spaced less than the thickness of said plate from the rearward formation, having a transverse dimension greater than the corresponding relaxed dimension of said portion of the passage in the plate, whereby said forward formation is resiliently gripped by said plate in the zone of the forward end of said portion of the passage.

7. An electrical connector comprising a tubular shell, a composite electrically insulating insert member secured within said shell, said insert member comprising a relatively stiff forward, contact-locating portion made of resilient rubber-like material, an intermediate contact-retaining plate made of substantially rigid but slightly resilient molded resin, and a rear relatively soft, contact-sealing grommet made of resilient rubber-like material, the forward portion, the plate, and the grommet being intimately bonded together over substantially the entire extents of their interfaces, said insert member having a plurality of passages longitudinally therethrough, and elongated contacts located within said passages, each of said contacts having axially spaced radially enlarged formations thereon cooperating with the forward and rear edges of a hole in the plate through which the contact extends to retain the contact from appreciable longitudinal movement relative to the insert during normal connecting and disconnecting operations, the forward formation on the contact having a ramp-like configuration to allow such forward formation momentarily to deform the plate in the vicinity of the hole and thus to be snapped through the hole in the plate by thrusting the contact in the forward direction relative to the plate and said forward formation having a portion within the forward end of said hole which has a transverse dimension greater than the corresponding relaxed dimension of the hole whereby said forward formation is permanently gripped by said plate to yieldably retain the contact against rearward movement relative to the insert member, said contacts having substantial parts of their lengths located within the composite insert member, the grommet being resiliently deformable to allow the insertion of the contacts therethrough.

8. An electrical connector comprising in combination a contact supporting plate having a passage therethrough, said plate being substantially rigid but sufficiently resiliently pliable in a radial direction to permit slight deformation of said passage in response to substantial radial pressure against circumferentially spaced wall portions thereof, and an elongated metal contact extending through said passage, said contact having a first enlarged portion

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forming a transverse shoulder engaging one face of said plate around said passage to hold said contact against movement in one direction relative to said plate and having a second enlarged portion forming a tapering shoulder comprising circumferentially spaced sectors of a convex toroidal surface facing said transverse shoulder and resiliently gripped intermediate the radial extremities thereof by said plate adjacent the end of said passage to restrain said contact against movement in the other direction relative to said plate, that portion of said contact between said shoulders being spaced radially inward from the walls of said passage.

9. An electrical connector comprising a tubular shell, a composite electrical insulating insert member secured within said shell, said insert member comprising a forward, contact-locating portion made of resilient rubber-like material, an intermediate contact-retaining plate made of substantially rigid material capable of slight resilient deformation and a rear contact-sealing grommet made of resilient rubber-like material, said forward portion and the grommet intimately contacting opposite faces of the plate over substantially the entire extents of their interfaces and said insert member having at least one passage longitudinally therethrough, and an elongated contact located within said passage, said contact having axially spaced radially enlarged formations thereon cooperating with the forward and rear edges of a hole in the plate through which the contact extends to retain the contact from appreciable longitudinal movement relative to the insert during normal connecting and disconnecting operations, the forward formation on the contact being longitudinally tapered and of oblong transverse section having a major axis of slightly greater length and a minor axis of less length than the corresponding relaxed dimensions of said hole such as to allow such forward formation momentarily to deform the plate in the vicinity of the hole and thus to be snapped through the hole in the plate by thrusting the contact in the forward direction relative to the plate.

10. An electrical connector as defined in claim 9 wherein said forward formation has a rearwardly tapering portion at least partially surrounded by said plate and engaged by said plate at the junction of the forward face of the plate with the wall of said hole.

11. An electrical connector comprising a tubular shell, a composite electrically insulating insert member secured within said shell, said insert member comprising a relatively stiff forward, contact-locating portion made of resilient rubber-like material, an intermediate contact-retaining plate made of substantially rigid material capable of slight resilient deformation and a rear relatively soft, contact-sealing grommet made of resilient rubber-like material, said forward portion, the plate, and the grommet being bonded together along their interfaces, said insert member having at least one passage longitudinally therethrough, and an elongated contact located within said passage, said contact having axially spaced radially enlarged formations thereon cooperating with the forward and rear edges of a hole in the plate through which the contact extends to retain the contact from appreciable longitudinal movement relative to the insert during normal connecting and disconnecting operations, the forward formation on the contact having circumferentially spaced ramp-like configurations circumferentially joined by reduced portions to allow such forward formation momentarily to resiliently deform the plate in the vicinity of the hole and thus to be snapped through the hole in the plate by thrusting the contact in the forward direction relative to the plate, said contact having a substantial part of its length located within the composite insert member, the grommet being resiliently deformable to allow the insertion of the contact therethrough.

12. An electrical connector comprising a tubular shell, a composite electrically insulating insert member bonded to said shell, said insert member comprising a relatively

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stiff forward, contact-locating portion made of resilient rubber-like material, an intermediate contact-retaining plate made of substantially rigid but slightly resiliently deformable material and a rear, relatively soft contact-sealing grommet made of resilient rubber-like material, said insert member having at least one passage longitudinally therethrough, and an elongated contact having a substantially part of the length thereof located within said passage, said contact having axially spaced radially enlarged formations thereon cooperating with the forward and rear edges of a hole in the plate through which the contact extends to retain the contact from appreciable longitudinal movement relative to the insert during normal connecting and disconnecting operations, the forward formation on the contact having a forward ramp-like configuration to allow such forward formation momentarily to deform the plate in the vicinity of the hole and thus to be snapped through the hole in the plate by thrusting the contact in the forward direction relative to the plate and having a rear ramp-like configuration extending into said hole and engaged intermediate its radial extremities by the plate at the forward end of said hole.

13. An electrical connector comprising in combination a substantially rigid contact supporting plate having a passage therethrough and an elongated metal contact extending through said passage, said contact having a first enlarged portion forming a shoulder engaging one face of said plate around said passage to hold said contact against movement in one direction relative to said plate and having a second enlarged portion axially spaced from said first portion forming a tapering shoulder facing said first-named shoulder and engaged intermediate the radial extremities thereof by said plate at the junction of the other face of the plate with the wall of said passage to restrain said contact against movement in the other direction relative to said plate, that portion of said contact between said shoulders being of smaller transverse section than said passage and said second enlarged portion having some transverse dimensions thereof smaller than the corresponding transverse dimensions of said passage, whereby said second enlarged portion may be passed through said passage upon deformation of the latter in response to substantial force effecting longitudinal movement of said contact in said passage.

14. An electrical connector comprising a tubular shell, a composite electrically insulating insert member bonded to said shell, said insert member comprising a relatively stiff forward, contact-locating portion made of resilient rubber-like material, an intermediate contact-retaining plate made of relatively stiff but elastically deformable molded resin and a rear, relatively soft, contact-sealing grommet made of resilient rubber-like material, said insert member having a passage longitudinally therethrough, and an elongated contact having a substantial part of its length located within the said passage in the composite insert member, said contact having axially

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spaced radially enlarged formations integral therewith and cooperating with the forward and rear edges of a hole in the plate through which the contact extends to retain the contact from appreciable longitudinal movement relative to the insert during normal connecting and disconnecting operations, the rear formation comprising an abrupt annular shoulder extending substantially around the body of the contact and the forward formation having two similar diametrically oppositely extending enlargements on the contact body, each of such enlargements having ramp-like configurations facing in opposite axial directions from the zone of greatest radial dimension of said enlargements to allow such forward formation momentarily to deform the plate in the vicinity of the hole, whereby the contact may be snapped into and out of operative engagement with the contact-retaining plate.

15. An electrical connector as defined in claim 14, wherein the forwardly facing ramp-like configurations are parts of the frustum of a forwardly converging cone, the hole in the plate is round, the forwardly and rearwardly facing ramp-like configurations of each said enlargement are axially aligned, and said enlargements are circumferentially separated by zones of reduced diameter on the body of the contact.

16. An electrical connector as defined in claim 14, wherein a predominant part of the zone of the contact body between said enlarged formations thereon is round and has a diameter at least somewhat less than the relaxed diameter of the hole in the contact-retaining plate.

17. A connector as defined in claim 14, wherein the rearwardly facing ramp-like configurations are in the form of rearwardly convex portions of a torus.

18. A connector as defined in claim 14, wherein the distance between the forward and rear formations on the contact body is so related to the thickness of the plate that when the shoulder on the contact engages the rear edge of the hole in the plate, the forward portion of the sidewall of such hole partially overlies said rearwardly facing ramp-like configuration of the forward formation.

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