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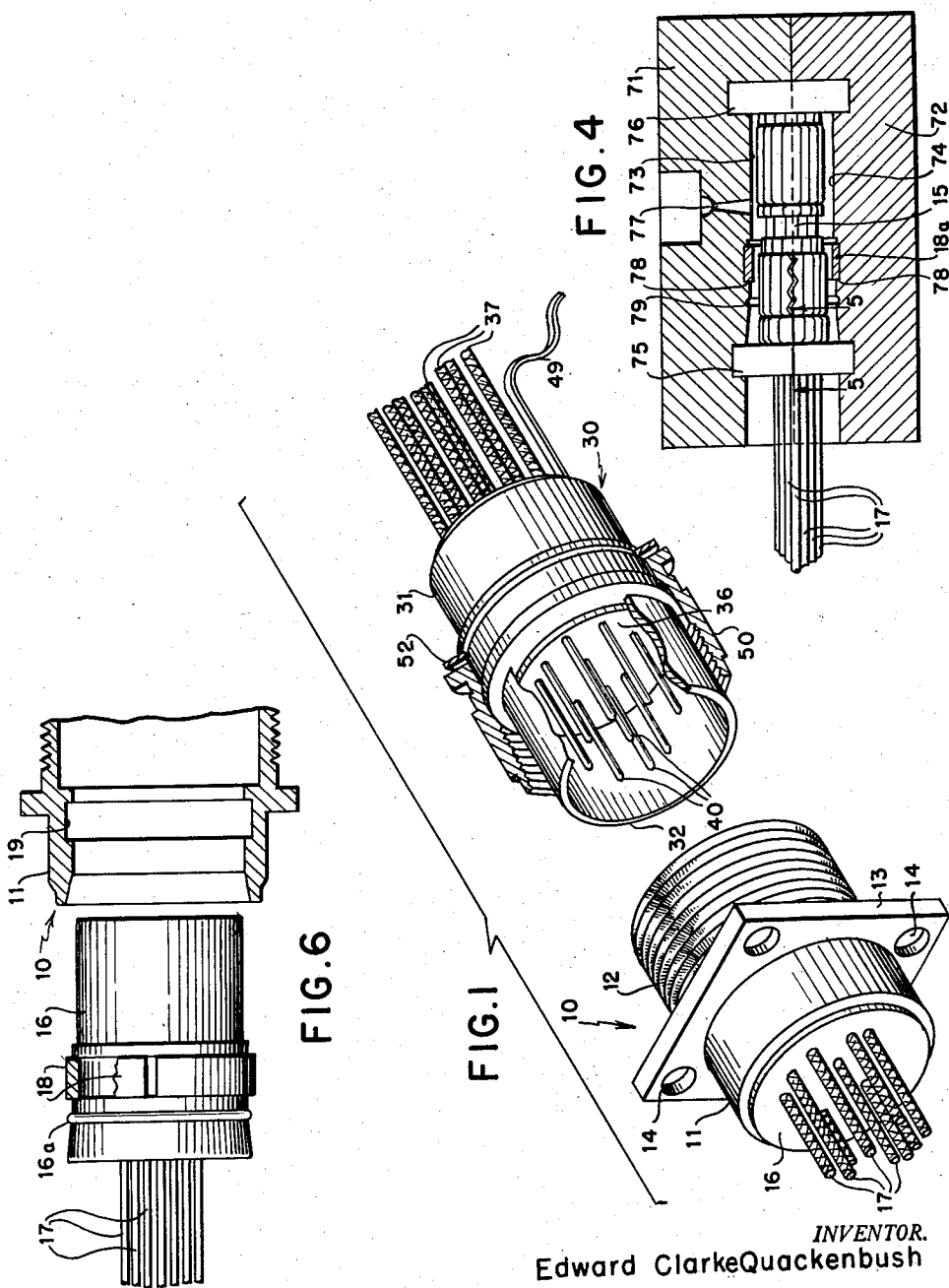
E. C. QUACKENBUSH

2,881,479

ELECTRICAL CONNECTOR AND PROCESS OF MANUFACTURE

Filed Sept. 27, 1954

4 Sheets-Sheet 1



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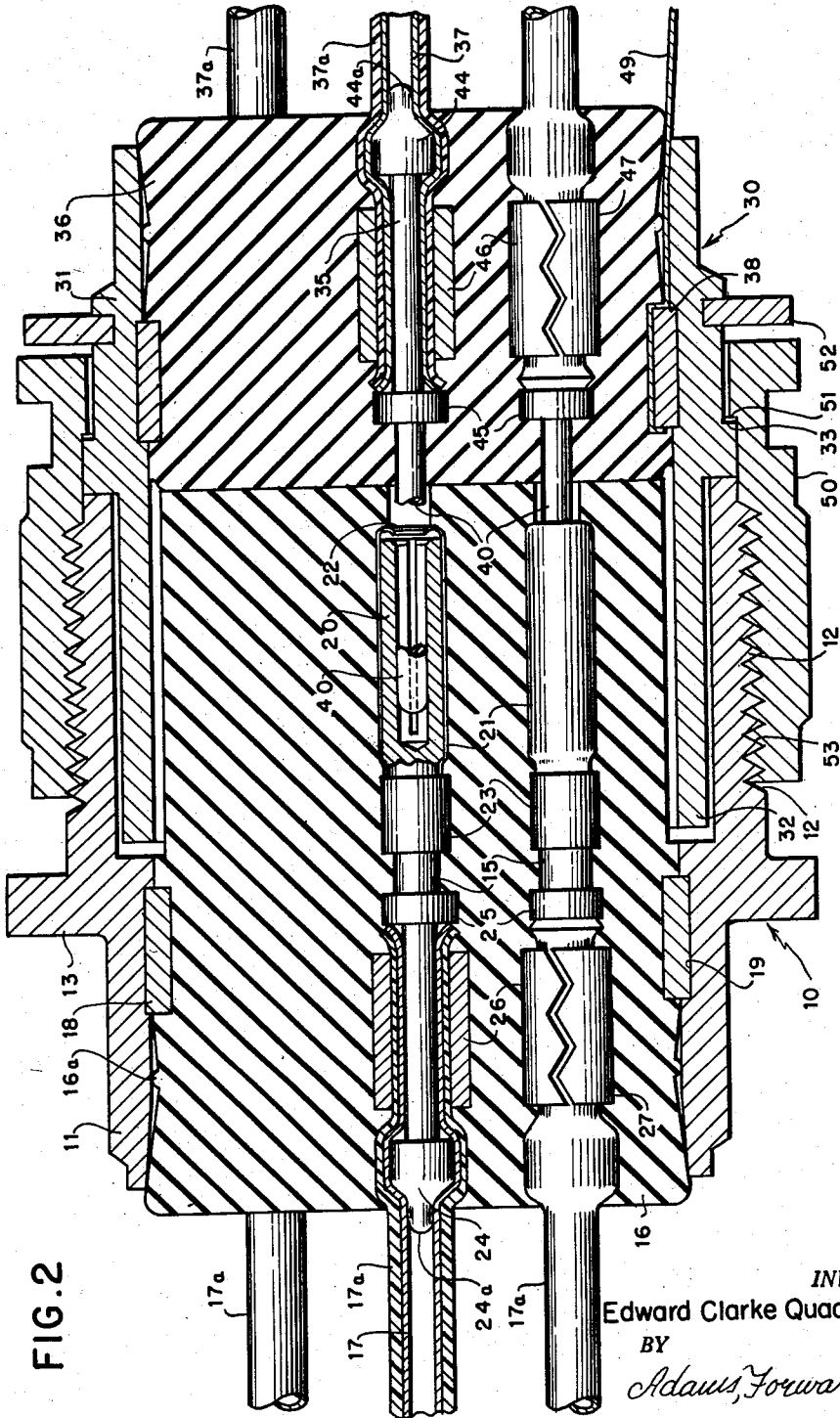
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4 Sheets-Sheet 2



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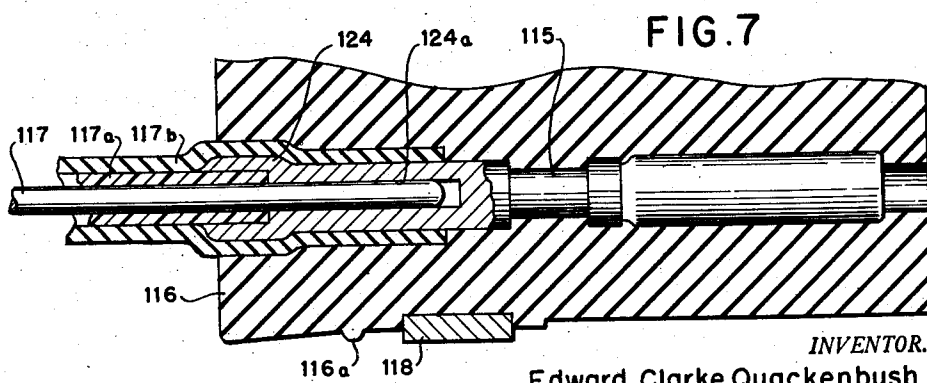
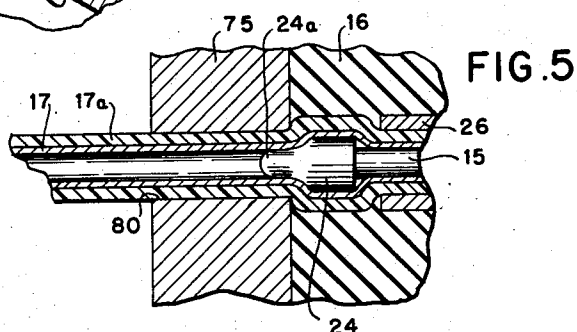
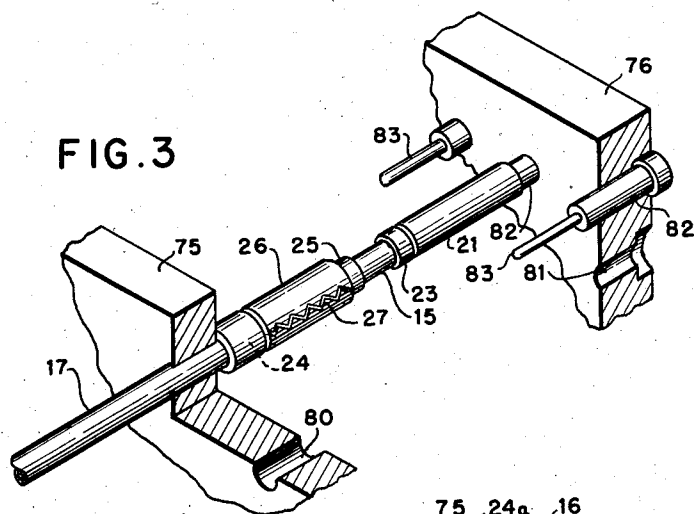
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4 Sheets-Sheet 3



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ELECTRICAL CONNECTOR AND PROCESS OF MANUFACTURE

Edward Clarke Quackenbush, Hamden, Conn., assignor to Whitney Blake Company, New Haven, Conn., a corporation of Connecticut

Application September 27, 1954, Serial No. 458,314

3 Claims. (Cl. 18—59)

My invention relates to electrical connectors particularly for use in radio and aircraft electrical circuits. The electrical connectors of my invention are of the general type of axially separable male and female connector assemblies in which each connector assembly includes one or more solid bar contact members fixed in a resilient insert housed within a metal shell and in which the connector assemblies are secured in axial engagement by peripheral engagement of the housings.

It is the general object of my invention to provide electrical connectors of reduced size and weight and having suitable construction for carrying radio and power circuits without sacrifice of equipment interchangeability and at the same time having improved moisture-proofing, vibration resistance and other connector improvements now considered necessary.

These and other objects of my invention are obtained essentially by molding the resilient insert about the bar contact members which have been previously assembled with the external electrical conductors. Integral molding of conductors and connector, however, presents at least three distinct problems:

It is necessary to support the solid bar contact members at each end during the molding cycle in order to avoid their displacement by the molding material during the time it is flowing into place around the contacts;

It is also necessary to secure the conductors in a manner preventing their being broken by the moving molding material; and

It is further necessary to secure a closed mold or "shut off" to confine the molding material within the mold by sealing the mold where the conductor emerges from the insert surface.

For a better understanding of my invention, reference is made to the appended drawings in which:

Figure 1 is an isometric exploded view of an electrical connector formed in accordance with my invention showing certain parts partially sectioned;

Figure 2 is a longitudinal sectional view of an electrical connector of my invention;

Figure 3 is a partially sectioned, isometric, partial view of the pre-molding assembly of solid bar contact members and electrical conductors prior to molding of the insert with portions of the mold illustrated;

Figure 4 is a cross-sectional view of the pre-molding assembly positioned in the mold just prior to injection of the resilient material which will form the insert;

Figure 5 is a partial cross-section taken at line 5—5 in Figure 4 after injection of the molding material;

Figure 6 is a plan view of the molded insert after removal of the mold illustrating the manner of its insertion into a metal housing shell shown in section;

Figure 7 is a cross-sectional view of a portion of the molded insert illustrating the use of a different type of electrical conductor; and

Figure 8 is a cross-sectional view of a molded insert illustrating the use of the same type of electrical conductor as shown in Figure 7 in which support and seal-

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off are obtained in a different manner and in which an alternate arrangement is utilized to provide mechanical connection between contact pin and conductor.

In the drawings, referring to Figures 1-6, the reference numeral 10 indicates a female connector assembly which is axially engageable with male connector assembly 30 and secured in such axial engagement by coupling ring 50.

Referring particularly to Figure 2, female connector assembly 10 is retained within approximately cylindrical metallic sleeve 11 (socket receptacle housing shell) provided with a threaded portion 12 on its outer surface at one end for engagement with coupling ring 50 as later described and provided with a transverse rectangular flange 13 located intermediate the ends of sleeve 11. Flange 13 is provided with holes 14 (see Figure 1) near each of its corners to permit female contact assembly 10 to be mounted to a flat surface passing through a hole therein.

Female contact members 15 are embedded in and bonded to resilient insert 16 which is generally cylindrical in shape with a slight outward taper toward its outer end through which conductors 17 extend. Insert 16 is retained within housing shell 11 in fluid-tight engagement therewith at the outer end of each but is spaced therefrom at the inner end of each providing an annular clearance between shell 11 and insert 16 beneath the threaded portion 12 of shell 11. Insert 16 is locked tightly in engagement with shell 11 by means of transversely slotted metal ring 18 which is bonded to insert 16 as later described and which fits within a groove 19 formed about the internal surface of shell 11 in a manner shown most clearly in Figures 2 and 6. Ring 18 is slotted so that as insert 16 is pushed into shell 11, ring 18 compresses radially until it reaches groove 19 into which it expands locking insert 16 in position. A bead 16a extends around the exterior of insert 16 and is formed integrally therewith on the tapered end surface between the end face of insert 16 through which conductors 17 extend and slotted ring 18. Thus when insert 16 is pushed into retaining shell 11 by inserting the mating end of insert 16 into the opposite end of shell 11, bead 16a is brought into tight compression against the inner surface of shell 11 as ring 18 locks in position in groove 19 and fluid-tight engagement of shell 11 and insert 16 is assured.

Solid bar female contact members 15 are elongated and generally cylindrical in shape. At one end they are provided with an axial bore and are slotted longitudinally to form two or more tines 20 adapted to receive and mate with a solid bar male contact member. A cylindrical sleeve 21, inwardly turned at end 22 to a diameter just passing the maximum size of male contact member which can be received by tines 20, is placed over the tine portion of contact member 15 abutting a central flange portion 23 integrally formed as a portion of contact member 15. Sleeve 21 is preferably crimped upon contact member 15 at its end which abuts flange 23.

The opposite end of contact member 15 is provided with an expanded tip 24 and tip extension 24a. Conductor 17, which is a hollow conductor of braided wire construction having an insulated jacket 17a, is stretched over bulbous tip 24 up to a second central flange portion 25 on contact member 15. A sleeve 26 is crimped over conductor 17 at a position intermediate tip 24 and flange 25. Sleeve 26 serves to retain conductor 17 in tight electrical contact with contact member 15 and is formed by wrapping a piece of sheet metal about conductor jacket 17a with ends almost abutting. Preferably the ends of sleeve 26 are provided with interlocking teeth 27.

Male connector assembly 30 similarly includes a cylindrical retaining sleeve 31 (plug receptacle housing shell), male contact pins 35, insert 36 and conductors 37. Shell

31 tightly engages insert 36 throughout the length of insert 36 which is tapered toward its outer end like insert 16 to facilitate the introduction of a transversely slotted locking ring 38 for securing insert 36 in position within shell 31. Insert 36 is similarly provided with an integrally formed bead 36a which compresses tightly against the inner surface of shell 31 to assure fluid-tight engagement between insert 36 and shell 31 when ring 38 is locked in position. Shell 31, however, differs from shell 11 in several respects. It is provided with a cylindrical elongated inner extension 32 which slides within the annular clearance between insert 16 and shell 11 when assemblies 10 and 30 are engaged. Coupling ring 50 slides over shell 31 until stopped by a small outwardly extending flange 33 which abuts an inner shoulder 51 at the outer end of coupling ring 50. Split ring type retainer clip 52 snaps in position in a groove about the outer surface of shell 31 behind the outer end of coupling ring 50, permitting coupling ring 50 to slide axially over the surface of shell 31 only a short distance. The inner end of coupling ring 50 is threaded along its inner surface at 53 to permit ring 50 to be screwed upon threaded portion 12 of shell 11 and thus lock assemblies 10 and 30 in their axial engagement.

Male contact members 35, like female contact members 15, are elongated and generally cylindrical in shape. Contacts 35, like contacts 15, have an expanded tip 44 and tip extension 44a over which hollow conductors 37 extend up to a center flange 45. Conductors 37 are secured in position by sleeves 46 having teeth 47 which interlock. Contacts 35 extend at their inner pin ends 40 beyond the inner surface of insert 36 and are positioned so that upon axial engagement of assemblies 10 and 30, ends 40 are received by and mate with tine portions 20 of female contact members 15.

When it is desired to ground shells 11 and 31 and coupling ring 50, this can conveniently be accomplished by securing a braided ground strap 49 to ring 18 or 38 (as shown in Figure 2) and passing it out between the receptacle shell and insert to external connection with a grounded conductor.

From the preceding description it will be seen that my electrical connector contains a minimum of heavy metallic parts. It is, moreover, vastly superior to the electrical connectors heretofore available in that the resilient inserts are cast or molded integrally about the pre-assembled solid bar contact members and electrical conductors in a manner firmly embedding the contact members within the insert so that they cannot be pushed out upon axial engagement of mating assemblies. At the same time, my connector is free from the disadvantages of prior connectors in that it is impossible to engage a male assembly having pins of a diameter which would spread the tine socket portions of the female contact members. By use of sleeve 21, I am thus able to control the maximum pin size which may be used and prevent accidental engagement with male contact members which would overly strain the female contact members, possibly rendering them inoperable for future use. At the same time, sleeve 21 functions to prevent straining tines 20 when the mating pins 40 are angularly or transversely displaced from their proper position. It will be further observed that the use of the slotted ring type locking method for engaging the inserts within their retaining shells is a considerable improvement over the retaining methods of the prior art, which usually involve the use of snap rings and the like. By tapering the insert and shell, and by providing an integrally formed bead about the insert, I can ensure a tight water-proof connection between the insert and the shell.

A most important aspect of my invention is the method by which I mold the plug and socket assemblies as integral units with the conductors.

Referring more specifically to Figures 3 and 4, I have illustrated in Figure 3 a view of the assembled conductors 17 and female contact bars 15 as they are set up prior to the molding operation. It will be understood that the

pre-assembly of the male contact members and conductors 37 is identical with a small exception which will be pointed out hereafter.

The mold itself (see Figure 4) may be of any conventional type suitable for molding rubber, or thermoplastic or thermosetting synthetic dielectric materials which are resilient in the cured solid state. As shown in the drawing, the mold conventionally includes a pair of platens 71 and 72 having internal die surfaces 73 and 74, respectively, for shaping the lateral surface of insert 16 in the illustrated case, or of insert 36 when forming male connector assemblies.

The end surfaces of the inserts to be molded are formed by a pair of rectangular plates 75 and 76 which are positioned within the mold transversely to the line of division of the mold separated from each other.

The mold is also provided with an aperture of conventional type forming a sprue channel 77 through which the molding material is introduced. It is not necessary that only one channel be used but in the conventional manner the sprue channel may be divided into any number of runner channels to insure even distribution of molding material. Introduction of molding material, degating of the sprue, and runners if any, and ejection of the molded insert from the mold are carried out in a conventional manner.

Suitably, the mold is further provided with a groove 78 which extends about the circumference of the insert to be molded and receives a metal insert ring 18a which, after the molding operation, is cut transversely in one or more places to form transversely slotted ring 18. The mold is further provided with a groove 79 which extends about the circumference of the insert to be molded and forms bead 16a on the exterior tapered end surface of insert 16.

In preparing the molding assembly for the molding operation, rectangular plates 75 and 76 are placed on a bench, in a vise or in suitable jigs retaining them the proper distance apart. Each plate 75 and 76 is provided with a series of transverse passages 80 and 81, respectively (see Figure 3) which correspond in number and position to the number and position of contact members to be formed in the insert. A conductor 17 is drawn through each hole 80. A female contact pin 15 is then pushed into hollow conductor 17 so that bulbous tip 24 slides down inside hollow conductor 17 to a position where the end of conductor 17 abuts flange 25. Sleeve 26 is then crimped over conductor 17 and pin 15 is capped at its other end with sleeve 21 to protect the tines.

A pin 82 is then pushed in through hole 81 to seal hole 81 and at the same time seal the opening 22 of sleeve 21. In Figure 3 it will be seen that the opening 22 of sleeve 21 is spaced a short distance from the face of plate 76. Thus, in the finished insert after molding, tip 22 of sleeve 21 is spaced back a short distance from the inner face of the insert (see particularly Figure 2). At the same time bulbous tip 24 is jammed tightly down against hole 80 with tip 24a extending within hole 80 pinching jacket 17a in the opening of hole 80 and against plate 75 around hole 80 providing an effective tight seal during the molding operation.

It will be noted that pin 82 is provided with an elongated extension 83 which has the same external dimensions as the internal dimensions of the tine-socket portion 20 of pin 15 and thus prevents any molding material from creeping within the socket portion of female pin 15. Sleeve 21 similarly prevents molding material from entering between tines 20.

After assembling conductors 17 and pins 15 with pins 82 in plates 75 and 76, the assembly is positioned within the mold half 72 with insert 18a. Mold half 71 is then clamped down sealing off the interior portion of the mold, suitably under extreme pressure. As will be noted in Figure 4, the side of the mold containing rectangular plate insert 75 is apertured to pass conductors 17.

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Upon assembling the mold as indicated above, the molding material is introduced through sprue channel 77 under high pressure to fill the entire cavity between plates 75 and 76 and to bond ring 18a. Suitably the internal faces of plate members 75 and 76 and die faces 73 and 74 are coated with a parting agent to prevent adhesion of the molded insert to such faces and thus facilitate ejection. Generally it is unnecessary to use any adhesive material to secure a bond between ring 18a and the molding material forming the insert. These are of course conventional operations and can be varied within the accepted practices of the molding industry.

After introduction of molding material the mold is retained closed under pressure to cure the injected material. Heat is applied to cure rubber and thermosetting materials where these are used, whereas for thermoplastic materials the mold is suitably provided with cooling tubes through which a liquid coolant flows. In any event, the molding material is cured under curing conditions consistent with molding material employed and thereafter mold members 71 and 72 are parted and insert 16 removed from the mold and then separated from members 75 and 76, removing pins 82. Ring 18a as noted above is then cut transversely so that upon sliding into shell 11 it will compress radially in the tapered portion in the end of shell 11 until it reaches groove 19 which permits ring 18 to expand to its normal position and lock insert 16 within shell 11.

In molding the male contact pins 35 within insert 36, as indicated above, the identical procedure is utilized except that no sleeve 21 is employed and pin ends 40 of each male contact bar 35 are inserted into the holes 82' (not shown) of the corresponding plate 76' (not shown) in place of pins 82.

It will be understood that although I have shown a particular order of assembly of pins 15 and conductors 17 with plates 75 and 76, such order is of no particular consequence and can be changed to suit the particular operations in any given manufacturing installation. For example, pins 82 can be positioned within plate 76 and then plates 76 and 75 may be mounted within mold half 72. Thereafter pins 15 may be placed in position and conductors 17 drawn through holes 80 and secured to pins 15. In this arrangement after conductors 17 are drawn over ends 24 of contact bars 15, sleeve 26 is rolled over each conductor 17 between end 24 and flange 25 and then is crimped in place.

What is important is the positioning of the preassembled conductors 17 and pins 15 within the mold supported by pins 82 and by tip extension 24a, and with bulbous tip 24 squeezing conductor jacket 17a tightly about the inner end of hole 80 in a pinched or puckered manner, thus providing adequate end support for the contact members during the molding operation and providing a tight seal about openings 80 to prevent the molding material from being extruded through such openings during the subsequent molding operation. Also, by supporting conductors 17 over contact bars 15, the conductors are secured against breakage during the movement of the molding material into the mold.

Figure 5 is a cross-section taken in Figure 4 illustrating the pinching of conductor 17 about hole 80 which seals in the molding compound forming insert 16 and also illustrating how tip extension 24a supports member 15 in hole 80.

Figure 7 is a cross-section of a female insert 116 showing a modification in the practice of my invention for securing contact members 115 to a solid or stranded conductor 117 having an insulated covering 117a. In this variation the conductor is a solid or stranded rather than a braided hollow conductor. Otherwise the construction and sealing features are the same. In order to accomplish sealing this contact member 115 has a bulbous tip 124 which acts as a tip extension. Rather, member 115 is provided with a bore 124a into which conductor 117

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passes and is advantageously crimped or soldered in such position. Bore 124a extends with a narrow diameter sufficient to accommodate the bare conductor 117 for a considerable portion of the length of member 115 and as an enlarged bore for only a short distance to accommodate insulated covering 117a. In such usage in order to provide an adequate seal in the mold, I slip a short rubber covering sleeve 117b over the assembled connection of conductor 117 and contact member 115 so that when the assembled contact member and conductor are positioned within the mold as described above covering 117b is pinched into hole 80 of plate 75 by bulbous tip 124 to seal opening 80. At the same time tip 124 provides the necessary end support for contact member 115 during the molding operation.

It is of course apparent that this manner of supporting member 115 is fundamentally the same as the sealing and supporting obtained with the hollow conductor shown most clearly in Figure 5. It is further apparent that the sealing and supporting system of Figure 5 is not limited to "braided hollow" conductors, for where a contact tip 24 can be inserted down the center of a stranded conductor, the same result can be achieved.

One manner by which this can be accomplished is to form a tip extension on the contact member with a steep pitch screw corresponding to the winding of the strands of conductor. A simple rotation of the contact member into the end of a stranded conductor thus permits the screw tip extension to be inserted up the center of the strands and at the same time extends the insulation over the end of the contact member so that when the assembled conductor and contact member are positioned for molding the resilient insert, the end of the contact member which is connected with the conductor extends underneath the insulation into the die face defining the end of the insert providing support for the contact member during the molding operation. Such a method of contact between conductor and solid bar contact member can be used effectively with hollow braided conductors, stranded conductors and particularly with tinsel conductors. In the case of tinsel conductor, it is desirable to have the contact member pierce the insulation of the tinsel conductor in order to achieve adequate electrical connection with the electrical conductor. In such case, the use of an extra sleeve of insulation over the assembled conductor and contact member as shown in Figure 7 is desirable.

Referring to Figure 8, yet another manner of providing conductor assembly with the contact member in accordance with my invention is shown.

Figure 8 in particular shows a female insert 136 about which is bonded a split ring 138 and about which insert is integrally formed a moisture-sealing bead 136a. The general construction and shape of insert 136 is that of insert 16. Contact members 135, however, differ in the manner of their engagement with solid or stranded conductors 137.

The female contact members 135 are embedded in and bonded to resilient insert 136 and are elongated and generally cylindrical in shape. At their mating ends they are provided with an axial bore and are slotted longitudinally to form tines 140 adapted to receive and mate with a solid bare male contact member (not shown). A cylindrical sleeve 141, peened over at end 142 to form an opening having a diameter just passing the maximum size of male contact member which can be received by tines 140 is placed over the tine portion of female contact member 135 abutting a central flange portion 143 of contact member 135. Sleeve 141 is crimped on contact member 135 at its end which abuts flange 143.

The opposite end of female contact member 135 is provided with an axial bore forming a barrel extension 144. Conductor 137 having an insulated jacket 137a is connected with female contact member 135 first by removing the insulated jacket 137a for a short distance baring a section of the wire. Preferably the diameter of bore 144

is just large enough to receive the wire forming conductor 137 so that the wire can be inserted into bore 144 extending almost half way into contact member 135 while the insulated jacket 137a extends a shorter distance over the surface of barrel end 144 of female contact member 135. Barrel 144 is then crimped as indicated at 145 to secure mechanically the electrical contact between conductor 137 and female contact member 135.

It is thus apparent that molding of insert 136 about assembled conductors 137 and contact members 135 is essentially the same as previously described. The length of female contact member 135 is such that its tip 144a extends beyond the end of resilient insert 136, and that jacket 137a puckers around tip 144a, inside an opening in a mold plate similar to rectangular plate 75 to provide the necessary end support for contact member 135 and to prevent extrusion of molding compound out of the mold along the surface of resilient jacket 137a. At the same time, jacket 137a extends over the surface of female contact member 135 a substantial distance into the interior of insert 136. Thus during the molding operation, ample area is provided for forming a firm bond between jacket 137a and insert 136 to exclude moisture at the point of entry of conductor 137 into insert 136.

I also contemplate construction of connectors which can use alternate schemes for locking the mating inserts. In some circumstances the necessity of retaining shells can be dispensed with. The connectors constructed in accordance with my invention provide contact members bonded firmly to the insert and consequently the contact members are not readily pushed or pulled out of the insert during normal usage. The requirement of rigid radial enclosure provided by a retaining shell is therefore eliminated and a pair of inserts having engaging male and female contact members can be used to form a complete connector assembly.

This application is a continuation-in-part of my application Serial No. 413,387, filed March 1, 1954, now abandoned.

I claim:

1. A method of molding a resilient body for an electrical connector which comprises extending an end of a conductor through a bore into a mold having an internal configuration complementary to the exterior shape of the resilient body to be molded, extending an insulated covering on said conductor through said bore to said end of said conductor within said mold, connecting a solid bar

contact member having a mating end and a non-mating end at the non-mating end thereof in electrical contact with the said end of said conductor within said mold, extending said insulated covering over said non-mating end of said contact member, inserting the non-mating end of said contact member into said bore within said insulated covering in said mold, the transverse dimensions of said non-mating end of said contact member being such that only limited entrance of said non-mating end of said contact member into said bore is permitted whereby the inserting of said non-mating end of said contact member into said bore within said insulated covering functions both to pinch said insulated covering tightly in the opening of said bore into said mold and thereby seal said opening and to support the non-mating end of said contact member, supporting said contact member at the mating end thereof in said mold, filling said mold interior with molding material which is resilient in the cured solid state, curing said molding material in said mold to form a resilient body bonded to said contact member and said insulated covering, and removing the molded body from said mold.

2. A method of molding a resilient body for an electrical connector according to claim 1 in which said contact member is a female contact member and is supported at the mating end by inserting a pin through said mold into said mating end.

3. A method of molding a resilient body for an electrical connector according to claim 1 in which said contact member is a male contact member and is supported at the mating end by inserting the male pin of said male contact member into said mold.

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