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M. D. BERGAN
INSULATED WIRE JOINT

2,618,684

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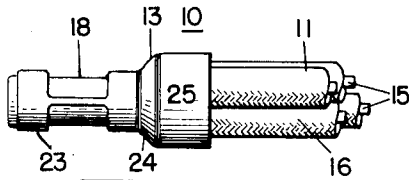


Fig. 1.

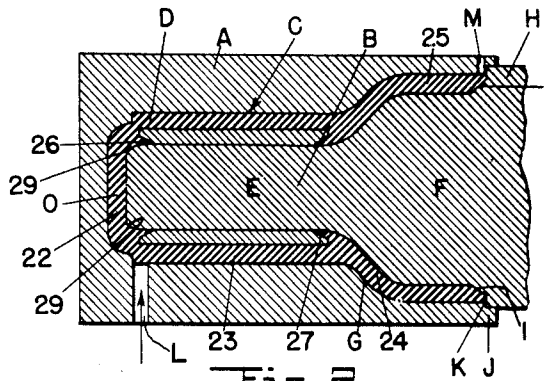


Fig. 2.

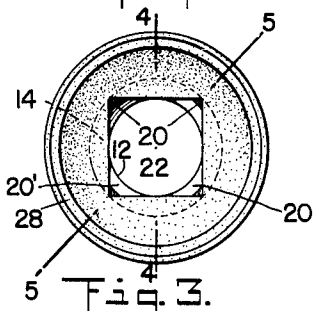


Fig. 3.

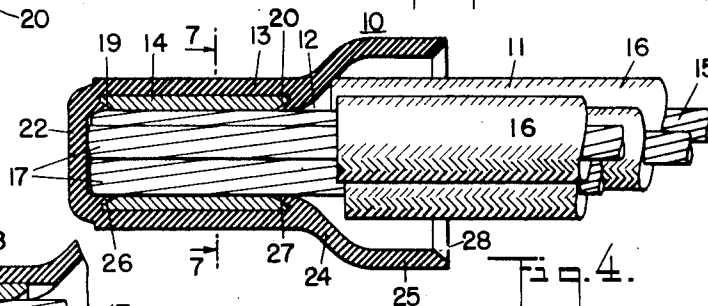


Fig. 4.

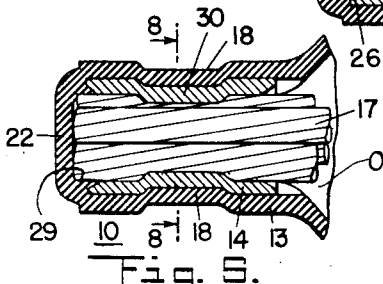


Fig. 5.

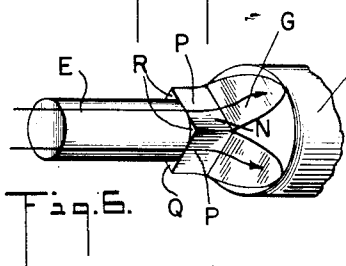


Fig. 6.

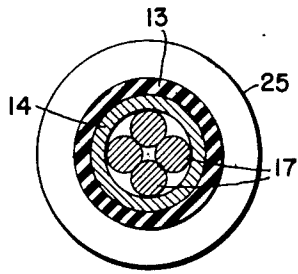


Fig. 7.

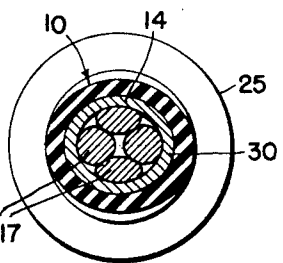


Fig. 8.

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INSULATED WIRE JOINT

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5 Claims. (Cl. 174-87)

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The invention relates in general to an electrical connector, sometimes hereinafter referred to as an insulated wire joint, and the invention specifically relates to an insulated pig-tail connector for permanently connecting a plurality of conductors electrically and mechanically in permanent relation. The invention also relates to an improved technique for forming the connector herein featured and to a detail of the male element of the mold for use in forming the connector.

Pig-tail connectors as now known are formed sometimes by inserting a plurality of wire conductors, when gathered together into a bundle, into a threaded metallic or porcelain binding sleeve and the sleeve inserted into a preformed cap of insulating material. To secure the conductors to the binding sleeve when made of metal it has been known to clamp the conductors between metal clamping jaws, sometimes with the clamping faces of the jaws threaded or roughened to enhance the connection between the conductors and the sleeve. The difficulty present in some such patented devices is that the connection between the conductors and binding sleeve is quite casual; not very positive even under the best of conditions, and the conductors are quite apt to slip out or to be pulled out of the sleeve irrespectively as to how tight the binding action may be, especially should a strong separating pull be imposed on the assembly of the sleeve and conductors. It has also been suggested to crimp a cap formed of ductile metal onto the bundle of conductors inserted into the cap and to screw or otherwise secure the cap within an insulating member. This crimping operation for securing a metallic binding sleeve of ductile metal onto the bundle of conductors is an improvement over the jaw clamping means above mentioned, but there is involved in this suggestion the additional step of subsequently securing the assembly of binding sleeve and conductors to the insulating member. This latter method obviously involves additional labor in a situation where it is not always easy to work, and at least involves additional expense in forming the jointure of complete assembly of pig-tail connector and its cables.

It has also been suggested that an electric terminal be formed with a conductor embrac-

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ing ferrule of cylindrical form over which is fitted one end of a preformed sleeve of insulating plastic material and the plastic sleeve formed of such thin cross section of material and otherwise fabricated so as to be easily distorted by a crimping operation thereon to cause the metallic ferrule covered thereby to bind a conductor intruded into the ferrule. While this practice has the advantage of utilizing a single crimping operation to distort both the metallic binding sleeve as well as its insulating plastic jacket, it likewise fails to prevent slipping between the ferrule and its insulating covering prior to being crimped into its final position and thus there is no assurance that in the final assembly the binding sleeve will be properly located on the conductors. It has also been suggested to press a metallic tubular sleeve into a preformed thimble of insulating material but this develops objectionable shoulders in the bore of the connector and shoulders in these connectors interfere with the desired ease of insertion of the conductors into place.

The primary object of the invention is to provide a simplified form of electric connector having the advantages of the similar types of ductile metallic sleeves or ferrules and insulating coverings now known, but in which the metallic sleeve and the insulating shell therefor can be secured together as an incident of molding the shell and in which the metal ferrule will thus be pre-fixed accurately in position in the insulation to form an improved type of pre-insulated wire joint and specifically a pre-insulated pig-tail connector.

Broadly, I attain this objective by forming the connector as a complete marketable unit formed solely of two parts, an insulating shell as a one-piece molded plastic unit and a metallic sleeve or ferrule lining the shell and anchored therein as an incident of molding the plastic shell, and which preformed metal lined connector may be carried in stock and crimped on to the conductors introduced therein with a single crimping operation performed at the time and place of use.

Still another object of the invention is to provide an electric connector integrally metal-lined as herein featured, and into which one or a bundle of the conductors may be easily inserted

without buckling or curling and which inserted conductors will be automatically located therein in prefixed relation to the metallic lining, binding sleeve or ferrule to be crimped thereon.

The invention has for another objective an improved method for molding the insulating shell with its lining sleeve or ferrule permanently anchored therein in accurately prefixed relation to the balance of the shell and in which the connector so pre-lined can be formed of the least possible amount of material and organized to facilitate its being crimped into place.

Various other objects and advantages of the invention will be in part obvious from an inspection of the accompanying drawings; in part will be fully set forth in the following description of one form of the pig-tail connector; and in part will be more fully set forth in the following particular description of a method of molding the connector and a method for crimping the connector onto conductors introduced into the same, and the invention also consists in certain new and novel modifications of the preferred methods and other features of construction and combination of parts hereinafter set forth and claimed.

In the drawings:

Fig. 1 is a view in side elevation of a pig-tail connector constituting a preferred embodiment of the invention and showing the same in its final operative position in crimping engagement with the ends of a plurality of cables;

Fig. 2 is an enlarged axial sectional view showing a molding apparatus and illustrating the molding step in a method for forming the ferrule lined connector shown in Fig. 1;

Fig. 3 is an end view of the open end of the connector shown in Figs. 1 and 2 looking at the same from their right ends, before the cables are inserted therein as shown in Fig. 1, and with the completed connector of Fig. 2 removed from the molding apparatus;

Figs. 4 and 5 are each axial sectional views of the molded connector of the preceding figures with the cables inserted therein with the views taken at forty-five degrees rotation about their common axis taken respectively on the lines 4—4 and 5—5 of Fig. 3, but the connector not crimped on the conductor ends in Fig. 4, and with the connector distorted into crimped engagement with the conductor ends;

Fig. 6 is a view in perspective of the left end of the male element of the molding apparatus shown in section in Fig. 2;

Fig. 7 is a transverse sectional view through the uncrimped connector taken on the line 7—7 of Fig. 4; and

Fig. 8 is a similar view through the crimped connector taken on the line 8—8 of Fig. 5.

Referring to the finished assembly of connector and cables shown in Fig. 1, there is disclosed a pre-insulated, metal lined, pig-tail connector 10, molded to shape from a plastic insulating material and with a plurality of cables 11, herein shown to be four, inserted into the open end of the bore 12 of the connector as best shown in Fig. 4. The connector comprises two parts, an outer molded insulating shell 13 of the plastic material with a malleable metal sleeve or ferrule 14 lining an inner, reduced end portion of the bore 12 and equi-distantly spaced from opposite ends of the reduced end portion of the bore.

The cables illustrated are of conventional form and each includes a core forming conductor 15, solid or stranded, encased in a tube 16 of insulating material. Following conventional practices

in this respect the tube of insulation is stripped back from the ends of the cables 11 to provide bared ends 17 which are closely grouped together to form a bundle and the bundle inserted into the bore of the connector. The shell 13 is then crimped at the sleeve lined portion thereof to distort the metal ferrule 14 onto the bundle of bare end wires 17 by opposing crimps 18 to secure the cables to the connector with their bared conductor ends mechanically and electrically connected permanently to each other through the ferrule 14. The ferrule 14 is formed of some ductile highly conductive metal, for instance, a dead-soft copper.

Opposite ends of the ferrule 14 are bevelled to form inwardly inclined end faces forming an inner face 19 and an outer face 20 in each case forming an annular inwardly facing space adapted at each end of the sleeve to form a molding space for the interlocks hereinafter described.

It is a feature of this disclosure that the connector 10 as marketed is formed solely of two parts; the insulating shell 13 formed of plastic material and the lining tube ferrule or sleeve 14 formed of copper or like dead conductive metal. These two parts are in interlocked relation and otherwise free of any other fastening means. Neither of these two elements have any machining done on them prior to their being finally crimped onto the bared ends 17 of the conductors. In place of the dead, soft copper suggested as preferable for use in forming the metal ferrule 14, any other equivalent dead, soft metal may be used, for example, a copper-zinc alloy, say, about ninety per cent copper and ten per cent zinc, which has been found to be satisfactory in actual practice.

Referring to Fig. 2 for a more detailed disclosure of the connector and the manner of molding the same, there is disclosed a molding device comprising two coacting elements, an outer female element A and an inner male element B. The element A is provided with a molding cavity C wide open at one end and in which is centered the male element B as hereinafter described. A molding space D is formed between the elements and which space is initially vacant and herein shown to be filled with the plastic material of which the shell 13 is formed.

The male element is of one-piece pin-like form and includes mainly an inner solid cylinder E of small diameter, and an outer cylinder F of relatively larger diameter. It is a feature of the disclosure that the midlength portion of this element B has its diameters progressively increasing from the smaller cylinder E to the larger cylinder F to present a smooth surface G of bottle neck form, and which is of a double reverse curve, or S-shaped form in all axial cross sections. Along four equidistantly spaced-apart longitudinal lines the surface G gradually rounds without breaking from one to the other of the cylinders E and F of different cross sections.

The outer edge portion of the enlarged cylindrical end F of the pin-like male element B is provided with an outstanding end flange H forming a closure for the open end of the molding cavity C. The inner portion of the outstanding flange H, as it meets the perimeter of the outer end of cylinder F is provided with a bevelled shoulder I inclined at about 45 degrees. The extreme outer end of the mold cavity is enlarged in diameter to form an annular rim J which defines the open end of the female element A. The rim J is defined at its inner end by a step shoulder

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K on which the flange H rests when fitted within the rim J. The female element A is provided at the end at or just beyond the place where the annular face 19 of the ferrule 14 is to come with a material intake vent L leading from the outside of the mold into the molding space D at the closed end of the cavity. At the opposite end of the mold space the element A is provided with a plurality of air escape vents M following usual mold practices in this respect.

It is the intent here to locate the sleeve or ferrule 14 in an accurately preset position in the mold so that when the finally molded connector is removed from the mold the ferrule 14 will be set in its intended position in the finished article and substantially centered midlength of the barrel 23. The prelocating of the ferrule 14 necessarily means that the mold must be provided with an accurately located limiting stop against which the ferrule can abut. As above noted it is also a requirement that the funnel forming surface G be as smooth as possible. In order to obtain these two objectives a peculiar form of limiting stop for the ferrule is provided on the male element B at the point where the smaller diametrical cylinder E starts to increase in diameter to form the curved surface at G. For a detailed showing of this ferrule stop reference is made to Fig. 6. The end of the small cylinder E as it enlarges to form a bottle neck is formed into a flat rectangular parallelepiped N whose sides are of equal length and equal to the diameter of the cylinder E. Cylinder E is centered in the flat side Q facing the cylinder E and coacts therewith to form four circumferentially and equidistantly spaced apart triangle faced stops R. The center of each side P is tangent to the surface of the cylinder E so that there are four relatively wide flow lines of uninterrupted surfaces two of which are indicated by the long arrows in Fig. 6 across which the plastic material flows without interruption from the stop N.

In preparing the mold for use its elements A and B are separated, if not already so, the metal ferrule 14 is inserted with a sliding fit on the small end E of the male member and advanced thereon until its bevel face 20 abuts squarely against the four exposed corner stops R. This has the effect of fixedly locating the ferrule on the male element in that position which the lining ferrule is to occupy in the finished connector. The male element with the ferrule so threaded thereon is located telescopically centered in the molding cavity C, with the flange H fitted snugly within the rim J and abutting the shoulder K. This interfitting of the mold elements at the outer end of the mold cavity operates to properly locate the inner end of the male member relative to the bottom and outlining side of the mold cavity and in this way defines the cross section of material of the shell 13.

Thermoplastic material O such as vinylidene chloride or a condensation polyamide, is introduced into the mold cavity C through the inlet vent L following conventional practices in introducing such self-hardening plastics into molds. The plastic material, of course, takes the form imposed thereon by the mold elements and by the pre-formed ferrule and as it fills the mold cavity gives the desired configuration to the shell 13. By reason of the fact that the shell is molded into its final form the plastic material forming the shell is free of internal strains and this unstrained condition tends to minimize any tend-

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ency of the shell to crack open when subjected to the subsequent crimping operation.

The connector 10 considered as a whole is closed at one end by an end wall 22 formed of the plastic O and includes a metal lined barrel 23 of relatively small diameter, a bottle neck shaped mid-portion 24, and an outer skirt or collar 25 of relatively large diameter with its bore dimensioned in the instant case to receive the ends of the four cables 11 with their insulation tubes 16. The bore of the mid-portion 24 gradually and smoothly reduces in cross section, funnel-like, and at its point of minimum cross section forms a smooth annular throat for receiving the more or less constricted bared ends 17 and for guiding the ends so constricted smoothly into the metal-lined portion of the bore 12.

It is particularly noted that as the plastic material is forced through the vent L and into and along the mold cavity it moves from left to right of the showing in Fig. 2, and thus bears against the exposed left end 19 of the metal sleeve or ferrule 14 and acts frictionally along the outer side of the same to force the advance end 20 firmly on to the four stops R if the ferrule is not already in such place. As the plastic material in effect flows to all parts of the mold cavity it eventually underlaps both of the bevel faces 19 and 20 thus forming integral annular interlocks 26 and 27 at opposite ends of the metal ferrule and between the same and the male element E to anchor the sleeve 14 to the barrel portion 23 of the plastic shell 13. Where the outer bevel face 20 of the sleeve 14 contacted the four stops R (Fig. 6) to form joints between the sleeve and the parallelepiped N in the course of molding the shell, there was, of course, no plastic and thus when the connector is removed from the mold there is exposed four points of metal each of triangular form as shown at 20' in Fig. 3. It is noted that the interlocks 26 and 27 feather inwardly towards each other to a sharp edge and that their diameters at their junction with ferrule 14 is the same as the internal diameter of the sleeve thus providing a smooth continuous cylindrical surface between the ends of the metal ferrule 14 and the plastic shell 13. At the outer end of the skirt 25 the bevelled shoulder I forms a funnel-like opening or chamfer 28 to the open end of the bore 12 to facilitate the introduction of the cables 11 into the bore. The entire wall surface defining the bore 12 from end to end is smooth and thus free of any shoulders or other projections from its funnel-like conductor intake opening 28 to its end closed by the end wall 22. The cylindrical wall defining the small diametered inner portions of bore 12 in the portion thereof forming the barrel 23 merges in a re-entrant curved corner 29 into the end wall 22. In this way the bared cable ends are funnelled into place without any obstruction or resistance to their insertion such as would be presented if the bore wall did not have the smooth surfaced funnel shape herein featured.

The connector herein illustrated is intended to be quite small, very small. In the device illustrated the plastic shell 13 has a total all-over length of $\frac{3}{4}$ of an inch; the skirt 25 is $\frac{1}{8}$ of an inch long with an OD of 0.437 and an ID of 0.375; the barrel 23 is $\frac{1}{8}$ of an inch long with an OD of 0.281 and an ID of 0.183 and with a wall thickness of 0.062 of an inch. The metal ferrule 14 is $\frac{3}{8}$ of an inch long; had an OD of 0.203 of an inch; and ID of 0.183 of an inch and thus a wall thickness of 0.024 of an inch.

As suggested in Fig. 4, the bared conductor ends 17 are usually half-twisted into a bundle and the same inserted into the bore 12 through the open end 28 of the connector preferably with a rotating twist in the direction of the initial manually arranged lay of bared ends as the advance end of the bundle is turned somewhat as a cork inserted into a constricted bottle neck. The conductors are inserted until they can be no further advanced by reason of their engagement with the end wall 22. The operator then knows the wires 17 are in their prefixed location to locate the ferrule 14 in proper position when the barrel 23 is finally crimped thereon.

With the bare conductor ends 17 in place as shown in Fig. 4, the barrel 23 and its lining sleeve or ferrule 14 are distorted by squeezing together the opposite sides thereof to form the crimps 18 in opposite sides of the shell and therethrough to form the crimps 30 in the ferrule 14 as shown in Fig. 5. It is seen from Fig. 5 that the squeezing pressure forming the crimps 18 reduces the original cross-sectional dimensions of both the stock plastic shell 13 as well as the metal lining ferrule at its mid-length portion from its initial form circular in cross section into a form elliptical in cross section with the effect that the wires forming the ends 17 are more closely compacted, and the crimps 30 bite into opposite sides of the wire bundle to key them to the connector. The device illustrated meets the requirements of the electrical code which call for a strength of thirty pounds pull on preformed insulators of this type and of 2100 volts minimum without voltage breakdown of the insulating shell.

While the invention has been described specially in its application to a closed end pig-tail connector, it is obviously within the scope of the disclosure to provide the shell 13 of open end tubular form, that is, without the end wall 22, and thus form if desired an open end sleeve into opposite ends of which conductors may be inserted end to end to form a splice and secured to the connector by crimping as herein disclosed.

By means of a connector as thus preformed, any number of cables within the capacity of the connector may be secured in interspliced electrically connecting relation. The ferrule 14 in its tightening engagement with the conductor ends 17 welds them in intimate inter-bearing relation so that in effect the bundle of wires at 17 become a closely related strand banded together and electrically interconnected by the ferrule 14.

As the ferrule 14 is located in place accurately as a factory proposition, the mechanic in the field need pay no attention to the locating of ferrule 14 on the conductors; he simply inserts the conductors as far as they will go and forms the crimps 18 with assurance that the wires hidden from view within the shell will be properly connected as intended by the manufacturer of the connector.

I claim:

1. An article of manufacture constituting a preformed pig-tail connector for electrically and mechanically connecting a plurality of bared ends of cable conductors when crimped onto the bared ends of the conductors inserted therein, said connector formed of a hollow shell of insulating plastic material having a bore of small diameter at one end and of relatively large diameter at the other end, the portion of the wall outlining the bore in the part thereof between the ends of large and small diameters rounding bottle-neck-like from one of said portions into

the other and providing funnel-like surfaces for collecting and guiding the conductor ends into the bore of small diameter, and a long, thin, sleeve-like cylindrical ferrule formed of dead soft copper embedded in the wall outlining the bore of small diameter, the bore of the metal ferrule forming a continuation without change of diameter or axis of the bore of the portion of the shell in which it is embedded, the material forming the plastic shell extending integrally in lapping relation across at least a part of the cross section of the metal at both ends of the sleeve and adhering thereto to anchor the sleeve plastically and permanently in place in the shell against relative axial movement.

2. The connector defined in claim 1 and in which the metal ferrule has at least one of its opposite ends beveled inwardly to form an internally beveled endless ring and with the plastic material at least partially lapping and adhering to the surfaces forming the ends of the sleeve and thus forming interlocks at opposite ends of the ferrule to secure the ferrule permanently locked in the shell.

3. A connector formed of an outer shell of insulating plastic material having a bore open at least at one end and a sleeve-like ferrule of soft copper forming a lining for at least a portion of the length of the bore, opposite ends of the copper ferrule being inwardly beveled, said ferrule being embedded in the plastic material and secured in place thereby against relative movement, the bore of the sleeve being flush with the bore wall in which it is embedded, one beveled end of the metal ferrule being lapped circularly by the insulating plastic material to provide an interlock of annular form between the ferrule and shell at this end of the ferrule, the other beveled end of the metal ferrule being lapped by the insulating material at a plurality of circumferentially spaced-apart points, leaving said other beveled end exposed in the parts thereof between the lapped, spaced-apart points.

4. An insulated electric connector comprising two concentric cylindrical tubes in telescopic relation and forming a cylindrical joint therebetween, the outer tube being formed of a molded plastic insulating material, the outer cylindrical face and at least parts of the two ends of the inner tube being embedded in the wall of the bore of the outer tube and plastically secured thereto by virtue of being so embedded, said inner tube being formed of a soft malleable metal having high conductivity, and the faces of the tubes which form the cylindrical joint therebetween being in molded contacting relation but otherwise free of any load across the joint.

5. An electric connector including a hollow molded shell of insulating plastic material having a bore of small diameter at one end and of relatively large diameter at the other end, the portion of the wall outlining the bore in the mid-length part thereof between the ends of large and small diameters rounding in bottle-neck form from one of said end portions into the other, and a sleeve-like cylindrical ferrule of ductile metal embedded in and plastically sealed in the wall outlining the bore of small diameter and forming a lining for the major portion of its length, the material forming the plastic shell forming an incomplete ring lapping the ferrule at the end thereof nearest the bore of large diameter, a plurality of circumferentially spaced-apart portions of the ferrule end so lapped being exposed to view

through the breaks in the incomplete ring and the bore wall forming flat S-curves in the longitudinal axial planes which lie between the exposed portions of the ferrule end thereby to form at least two smooth curved surfaces continuously rounding from the bore of large diameter into the bore of the ferrule and free of shoulder breaks for engaging the conductors when inserted into the bore at its end of large diameter and for guiding the conductors along said S-shaped curves into the adjacent end of the ferrule bore.

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