June 1, 1954

F. L. PIERCE

ELECTRICAL CONNECTOR

2,680,235

Filed Sept. 16, 1949

2 Sheets-Sheet 1

Fig. 1.

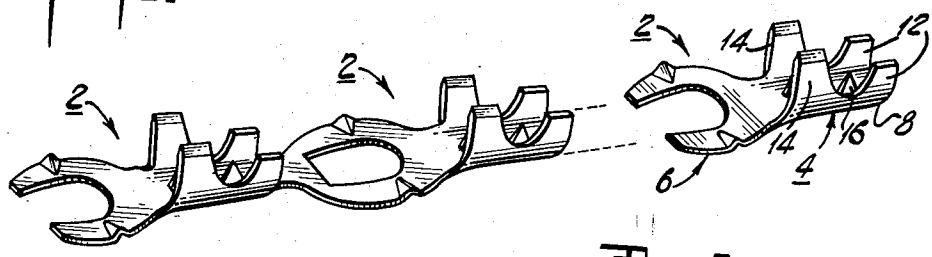


Fig. 2.

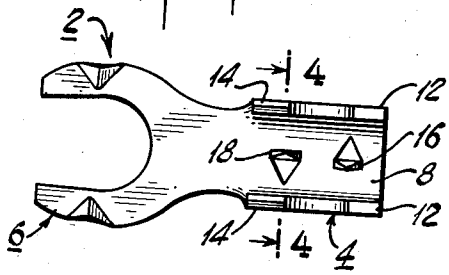


Fig. 4.

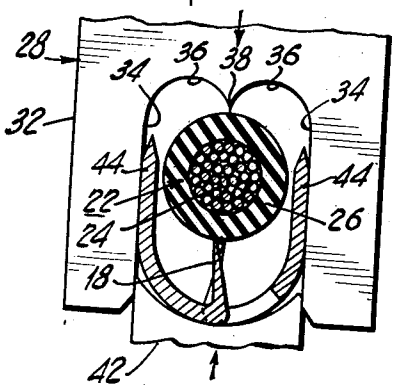


Fig. 3.

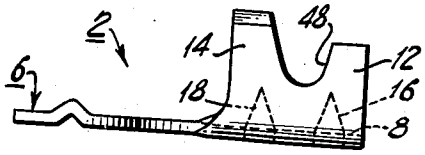


Fig. 5.

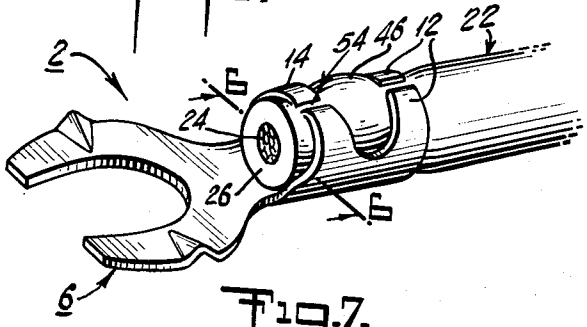


Fig. 6.

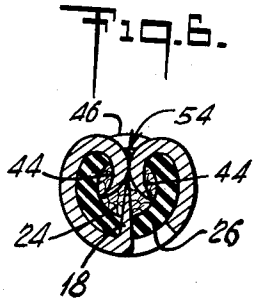
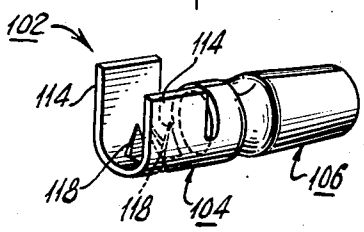


Fig. 7.



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Fig. 8.

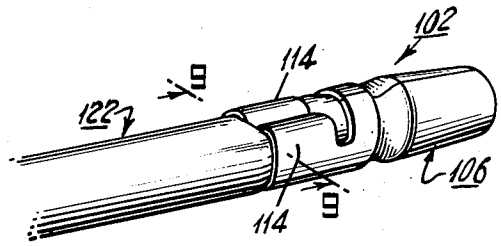


Fig. 9.

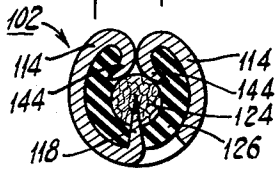


Fig. 10.

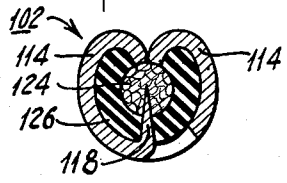


Fig. 11.

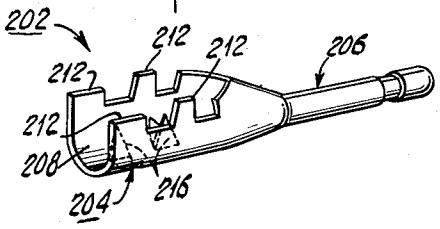


Fig. 12.

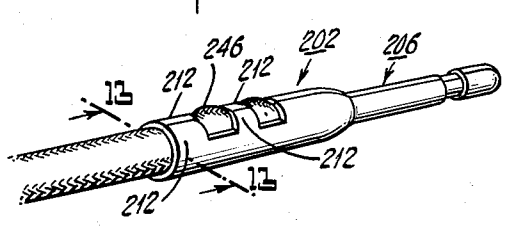
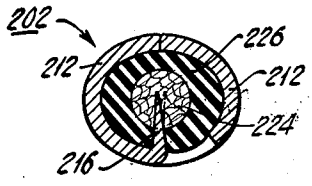


Fig. 13.



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Patented June 1, 1954

2,680,235

UNITED STATES PATENT OFFICE

2,680,235

ELECTRICAL CONNECTOR

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Application September 16, 1949, Serial No. 116,134

5 Claims. (Cl. 339—97)

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This invention relates to electrical connectors for use on insulated wire, and to the methods of making and applying such connectors. The invention relates particularly to insulation-piercing solderless type connectors.

Prior to this invention, it has been proposed to secure connectors to insulated wire by crimping the connector around the outside of the insulation and driving a sharpened conductive barb through the insulating sheath to the central conductor to complete the electrical circuit between the terminal and the conductor. For example, connectors have been proposed having sharp barbs or prongs extending upwardly from the bottom of a trough-like wire-engaging ferrule portion. The insulated conductor was intended to be pressed down upon these barbs so that the barbs would pierce the insulation sheath to make contact with the conductive core of the wire, the ferrule then being pressed around the outside of the insulation of the wire.

Such connectors can be attached to the insulated wire easier and more rapidly than the more usual type of connectors wherein the insulation must be stripped from the wire and the connector then crimped or soldered to the wire core. However, the solderless insulation-piercing connectors proposed prior to the present invention have not replaced other connectors for most applications because, in practice, the electrical connections produced by such connectors have not been satisfactory. This is in part because low contact resistance of the connector requires not only that the connector make contact with the conductive core of the wire, but that the two contacting members be maintained continuously under sufficient pressure that enough actual points of contact are established and maintained to carry the required current. Thus, with some suggested constructions the normal fatigue of the metal of the connector with aging causes enough decrease in contact pressure to interfere with the performance of the connector. Another difficulty has been that the area of the connector making contact with the conductive wire core has been small as compared with the cross-sectional area of the wire with the result that the connectors did not have sufficient current-carrying capacity for many applications.

Still another disadvantage of earlier connectors is that, subsequent to their being pressed onto an insulated conductor, the plastic or semi-fluid nature of the insulating sheath would allow the centrally located conducting core to move away from the contacting barbs thereby decreasing the effectiveness of the electrical connection. This "drifting" of the center conductor under the influence of the applied forces has been most troublesome with non-braided insulation sheaths such as rubber and the like. Moreover, the mechanical strength, particularly the tensile strength, in insulation piercing connectors, has generally been poor, especially when the conductor is insulated with such soft, semi-fluid, or rubber-like insulation.

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It is an object of the present invention to provide a solderless insulation-piercing connector that makes a good electrical connection and that is simple and economical in use and which, in a large measure, overcomes the disadvantages of earlier solderless type connectors. In one embodiment of the invention a wire-engaging ferrule portion is provided with an inwardly extending sharpened barb positioned between two oppositely-disposed ear portions which are adapted to be circled and driven inwardly on or into the conductive core of the wire so as to clamp the conducting core of the insulated wire firmly in compression between the ear portions and the barb thus holding the wire in excellent contacting relationship with the connector irrespective of concurrent or subsequent flow, or distortion in the shape of the insulating material.

In addition to providing for the transverse gripping of the conducting core, as mentioned above, the invention also provides for anchoring the conductor against axial movement with respect to the connector by providing an additional pair of oppositely disposed ears, displaced axially a substantial distance from the first pair, which also grip the insulating material and extrude it under pressure into the space between the two sets of ears, thereby increasing the mechanical strength, particularly in tension, of the assembly and maintaining continued clamping force on the conductive core, thus insuring mechanical and electrical stability under normal conditions of use for a long period of time.

Thus, in one aspect, this invention is directed to a simple connector structure and method of its application to insulated wire which provides a connection of excellent electrical stability and high tensile strength. In another aspect, this invention is directed to an electrical connector of the insulation-piercing type which is electrically and mechanically secure and which has substantially higher-current carrying capacity than is known in such connectors in the prior art. Another aspect relates to an electrical connector and method of application which will make and maintain secure electrical connection of high current capacity with an electrical conductor even

through a relatively large thickness of a pliable insulation sheath. These and other aspects, objects, and advantages of the invention will in part be pointed out in, and will in part become apparent from the following description when considered in conjunction with the accompanying drawings, in which:

Figure 1 is a perspective view of a strip of electrical connectors embodying the invention, for use in automatic connector-assembling machinery;

Figure 2 is an enlarged plan view of the connector shown in Figure 1;

Figure 3 is an elevational view of the connector shown in Figures 1 and 2;

Figure 4 is a sectional view of the connector shown in Figure 1, taken along line 4—4 of Figure 3, and an insulated conductor in a die structure for assembling the connector and conductor;

Figure 5 is a perspective view of the connector of Figure 1 after being assembled with an insulated conductor;

Figure 6 is a cross-sectional view taken along line 6—6 of Figure 5;

Figure 7 is a perspective view of a connector showing another embodiment of the invention.

Figure 8 is an isometric view of the connector shown in Figure 7 after being assembled with an insulated conductor;

Figure 9 is a cross-sectional view taken along line 9—9 of Figure 8;

Figure 10 is a sectional view similar to Figure 9 showing another embodiment of the invention;

Figure 11 is an isometric view of a plug type connector representing still another embodiment of the invention;

Figure 12 is an isometric view of the connector shown in Figure 11 assembled with an insulated conductor; and,

Figure 13 is a cross-sectional view taken along line 13—13 of Figure 12.

Components serving similar functions in different embodiments of the invention have been designated by adding one hundred to the indicating numerals of such similar components in each succeeding embodiment.

Figure 1 shows a group of electrical connectors which have been fabricated in a continuous strip to facilitate handling and their use in automatic machinery, which cuts apart the individual connectors, generally indicated at 2, and assembles them with the insulated conductors. Each connector 2 includes a wire-engaging ferrule-forming portion, generally indicated at 4, shown here as a trough-like channel, and a secondary connecting portion, generally indicated at 6, shown representationally as a forked or "spade-tongue" connector, such as is used for making a connection to a screw-type binding post or the like, which is formed integrally with the ferrule-forming portion 4 to which it is joined by a neck portion 7.

The ferrule-forming portion 4 (see also Figures 2 and 3) includes a base portion 8 having two pairs of upwardly extending, oppositely-disposed, lateral ears 12 and 14 which are spaced from each other axially, that is, longitudinally along the axis of the connector. The base 8 is provided with two upwardly extending, spaced, barbs or prongs 16 and 18 which are positioned near the longitudinal center line of the connector and, respectively, between each pair of opposed ears 12 and 14. By placing at least a portion of each of the barbs 16 and 18 between an adjacent pair of the ears in the same transverse plane, that is, in a plane extending at right angles to the longitudinal axis of the connector and through a pair of opposed ears, a clamping or gripping action on the conductor core is obtained, as will be described later. The connector advantageously is formed of corrosion proofed steel, but other materials such as copper or brass can be used if desired.

Figures 5 and 6 show a connector 2 assembled with a conventional insulated conductor, generally indicated at 22, having a centrally located metallic conductive core 24, formed in this example of twisted wire strands, surrounded by a sheath 26 of insulating material. The forward ears 14 have been curled sharply inwardly and driven end-wise down through the insulating sheath 26 and between the strands of the conductive core 24, thus making intimate contact with these strands over a substantial area. Such piercing of the strands is not always used; a scraping contact which clamps the entire conductor between the ear portions 14 is sometimes preferred, and will be illustrated subsequently.

In order to assemble the connector 2 with the insulated conductor 22, the conductor 22 is placed in the trough of the ferrule-forming portion 4 of the connector, which is positioned in a die structure, generally indicated at 28 in Figure 4. The upper die 32 includes spaced parallel wall portions 34, which extend, respectively, into sharply curved portions 36, which at their juncture form a sharp ridge 38, which if desired can be somewhat blunted to reduce wear on the die. The lower die 42 drives the connector 2 and the upper die 32 together curling the ears 14, as they follow along the inwardly curved die surfaces 36, and driving them downwardly end-wise into the insulated conductor 22. Dies such as this can be used in automatic machines which sever the connector 2 from its strip during the cycle in which the connector is crimped onto the conductor 22. This method of curling laterally-opposed ear portions, is disclosed more fully in the copending application of James C. Macy, Serial No. 717,842, filed December 23, 1946.

The ear portions 12, in this embodiment, are curled around the periphery of the insulation sheath 26, by a portion of the die structure 28 or other suitable means (not shown) and compressed and cold-worked thereagainst so that the ears 12, exerting pressure through the insulation 26, clamp the conductor core 24 firmly down upon the barb 16 thereunder. These ears 12 and the ears 14 exert a compressive force on the deformable insulation sheath 26 resulting in an outwardly extending bulge 46 of insulation between the ears 12 and the ears 14.

The above-described arrangement results in several advantageous features which may not be entirely apparent from the structural description. For example, the barb 18 is disposed in a transverse plane (perpendicular to the longitudinal axis of the connector) through the ears 14, so that the conductor core is driven down upon the barb 18 and held compressively thereagainst by the faces of the tips 44 of the ears 14. The contact pressure between the ears 14 and barb 18 and the conductor core 24 is made and maintained at a high value without depending upon transmission of these forces through the insulating material, and the conductor core is firmly locked in position so that it cannot drift or work away from the areas of contact, thus assuring good conductivity even at low voltages. This arrangement is of particular importance

when relatively thick or pliable insulating material is used.

In addition, the barbs 16 and 18 can be fabricated economically by cutting two oppositely directed V-shape notches in the base 8 of ferrule-forming portion 4 and bending the severed portions of the base upwardly to form the barbs. The resulting openings in the base 8 must be sufficiently small that the ferrule is not weakened excessively, but the barbs must be long enough to insure adequate contact with the core 24 of the insulated conductor 22. Moreover, the strength and orientation of the barbs must be such as to prevent the barbs from bending downwardly instead of piercing the insulation when the connector is assembled. Accordingly, after the initial formation of the barbs, by stamping or other means, the barbs are swaged, or otherwise shaped, to form a pointed and sharpened projection, which process results in lengthening of the barbs and at the same time making it easier for the barbs to penetrate the insulated conductor 22. The final length of the barbs advantageously is at least equal to one-half the transverse width of the channel of the ferrule-forming portion 4, so that the barbs are at least equal to the radius of any circular conductor placed in the ferrule-forming portion 4. In order to prevent the barbs from bending toward the openings which resulted from their formation, the barbs are bent slightly beyond the vertical position, so that the point of each barb is directly above the solid portion of the ferrule channel at the junction of the base 8 and the barb.

In order to provide maximum contact area between the ears 14 and the conductor core 24, the ears 14 are generally quadrilateral in shape and the upper ends of these ears are rectilinear in the direction of the longitudinal axis of the core 24, so that substantially greater contact area is achieved than if the ears were formed in a generally triangular configuration, and larger surface areas are effective in clamping the conductor core 24 between the ears 14 and the barb 18.

In order that the ears 14 can readily penetrate the insulation, and extend between the strands of the core 24 where that is desired, the upper end of these ears are reduced in thickness, as by swaging. In adapting ear portions such as those shown at 14 for use in curling dies of the type shown in Figure 4, such knife-edge-like configuration has been found helpful in preventing buckling of the ears during crimping and in obtaining early conformation of the ear portion 14 with the die surface during the crimping operation, which assures that the ear portions 14 assume the proper curvature for making contact with the conductor core 24 in the desired precise manner, as well as in enhancing the ability of such ear portions to pierce the insulation sheath 26 of the conductor 22.

Such swaging of the ear tips is advantageous also for the ears 12 as it enables the ears to be simply wrapped around and compressed down upon the insulation sheath with the curled "set" of the ears extending to their tips, thus giving the compacted ears a smoothly curved surface where they meet.

It is to be noted also that the forward edges 48 of the ear portions 12, which are compressed around the insulation sheath and co-operate with the ear portions 14 to extrude, by virtue of their compression upon the sheath 26, the previously-mentioned bulge 46 of insulation, are substantially rectilinear and at least partially abut the adjacent edges of bulge 46 of insulation. The firm grip thus obtained on the insulation by the ears 12 and 14 also increases and helps to maintain the compression of the insulation in the area of contact and increases the support of the conductor core. Further advantages derive from the fact that the bulge 46 of insulation maintains a continued pressure between the insulation sheath 26 and the ear portions 12 and 14; this has been found to retard the entrance of corrosive fluids into the area of contact between conductor core 24, the ear tips 44, and the barbs 16 and 18.

It is to be understood that the rearward ear portions 12 also can be driven into contact with the conductor core 24, as are the ears 14, to provide even greater area of contact. Such an arrangement is advantageous where maximum current-carrying capacity is desired.

In the above embodiment, the ear portions 14 are so constructed, and the upper die 32 is so designed, that the ear tips 44 are curled away from each other in the connection, thus clamping the conductor core 24 between the faces of tips 44 and the barb 18. The ears are shown tapered in thickness from each side to form the knife-edges on their upper surfaces, which aid in enabling the ear tips 44 to curl readily in the die 23, as previously discussed. Note also the lateral separation, as at 54, of the ears 14 at their points of entrance into the insulation sheath 26, leaving a portion of the insulation sheath 26 compressed in the space 54 between the ears 14, thus giving the contact area added protection against the entrance of corrosive fluids.

In some instances, such separation of the ears 14, or even the curling apart of their tips 44 can be advantageously replaced by maintaining the abutting face-to-face relationship of the ear tips 44, which occurs early in their curling and crimping cycle, in the completed connection. Thus the ears 14 remain in actual contact with their tips canted outwardly so as to produce a lateral clamping effect analogous to that shown in Figure 6, though of lesser degree, which tends to restrain the conductor core 24 from moving laterally.

In the above embodiment wherein three metal portions are driven adjacently into the conductor 22, the final stages of compression of the wire-connector assembly is opposed by the reaction of the compressed wire, and, particularly with small wires or those having insulation sheaths which are relatively thin, tough, or lacking in pliability, the compression of the insulation sheath should be relieved by holes in the connector walls, either in the base or ear portions, into which the insulation can extrude and allow proper setting of the ear portions. With sufficiently thick and pliable insulation sheaths, extrusion into the hole in the base portion 8 left by the upturned barbs 16 and 18, plus the longitudinal axial extrusion, is usually sufficient to permit such proper setting.

Figures 7, 8 and 9 show another embodiment of the invention wherein a connector, generally indicated at 102, includes a secondary connector in the form of a tip 106 and a ferrule-forming portion, generally indicated at 104, having two upwardly-extending, opposed, generally quadrilaterally-shaped ears 114. These ears extend axially along the connector blank for a sufficient distance to encompass two upwardly-extending barbs 118, similar to the barb 18 of Figure 1.

Figure 9 shows a vertical section through the

connector 102 after assembly with an insulated conductor 122, having an inner conductive core 124, either solid or stranded, and an outer sheath 126 of insulating material. The ears 114 curve upwardly around the outside of the insulation 126 and thence downwardly into the insulation. The ends of the ears 114 are advantageously sharpened or swaged to form a knife-like edge and the tips 144 of the ears are oppositely curved, as by a die structure, such as is shown at 28 in Figure 4, with their surfaces in pressure contact with the outer surface of the conductor core 124. The pointed barbs 118 extend upwardly from the bottom of the ferrule-forming portion 104 and make contact with the core 124.

Thus, the connector 102, at the position of each of the barbs 118, makes intimate contact with the conductor core 124 at three points spaced approximately equidistant around its periphery, anchoring the core 124 firmly in position and providing other advantages pointed out above.

With larger size conductors, or where the insulation is thin or relatively rigid, it is not necessary to curl the ears 114 to obtain this three point clamping effect. Figure 10 shows an embodiment wherein the ears 114 are curved upwardly, around the insulation 26, as above, but in which they extend downwardly through the insulation sheath 126 so that their rectilinear ends abut the upper surface of the conductor core 124. Because of the relatively long axial length of the ears 114 and because contact between the ears 114 and the core 124 is maintained substantially throughout the axial length of the ears, a relatively low resistance connection is provided.

When conductors having thin or rigid insulation sheath are to be used in circuits that do not demand connections with high current capacity, the connector can be made smaller and simplified, by using two sets of laterally-opposed ears in a manner similar to that described in connection with Figures 1 to 6, but in which the ears do not pierce the insulation, but are wrapped around the insulation sheath and cold-worked to remove their elastic memory. If the ears are adjacent the upturned barb, the great compression thus acquired in the area of contact compacts the insulation thereunder and reduces the likelihood that the conductor core will work away from the barb.

Figures 11, 12 and 13 show such an embodiment of the invention wherein a connector, generally indicated at 202, includes a ferrule-forming portion 204 and a secondary connector in the form of a plug 206. The ferrule-forming portion 204 includes a channel-like base portion 208 having two pairs of opposed, axially spaced, generally quadrilaterally-shaped, ears 212 extending upwardly therefrom.

The connector is provided also with two barbs 216 each positioned between one of the two pairs of ears 212, the arrangement and construction being generally similar to the embodiment described in connection with Figure 1.

Figure 12 shows the connector 202 after assembly with an insulated conductor 222. In this embodiment, the ears 212 extend around the insulation sheath 226, but do not pierce it. The compressive force achieved by the spaced quadrilateral ears 212, which produces a bulge 246 of insulation between the ears, being relied upon to maintain the contact between the conductor core 224 and the connector 202. This arrangement results in a simple and easily-assembled connector which is satisfactory for many purposes, but which can not be expected to have so much current carrying capacity as the connector shown in Figure 1.

It is to be understood that the word connector is used herein in its generic sense, including end terminals, terminals for connecting insulated wires to binding posts, jacks, or the like, as well as connectors for joining two or more lengths of wires.

From the foregoing it will be observed that the connectors embodying my invention are well adapted for the attainment of the ends and objects herein set forth and to be manufactured economically, since the separate features are well suited to common production methods and are subject to a variety of modifications as may be desirable in adapting the invention to different applications. It is to be understood that many other embodiments of my invention may be made and, accordingly, all matter hereinbefore set forth or shown in the drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. An electrical connection comprising an electrical conductor having a central core of electrically conductive material and a surrounding cylindrical sheath of pliable insulating material, and a connector for making electrical contact with said core including a ferrule portion substantially surrounding said sheath in compressive gripping relationship and having three inwardly projecting portions, a first one of which has a sharp point that penetrates the said core and the other two of which abut said core at two points generally opposite said first portion thereby anchoring said central core firmly in position in said connection and making permanent electrical contact therewith.

2. An electrical connection comprising an electrical conductor having a central wire core and a surrounding sheath of pliable insulating material, and a connector having a base portion, a barb extending upwardly from said base and into said core, and two laterally-opposed ear portions extending from opposite sides of the base adjacent said barb and around and in compressive engagement with said sheath, said ears being curled inwardly into said insulating sheath in opposed face-to-face relationship with the face of each of said ear portions making pressure contact near its tip with said central core, said ears entering said insulation at spaced points on the surface of said sheath and a portion of the sheath being held in compressive engagement between the adjacent surfaces of said ears.

3. An electrical connection including an electrical conductor having a centrally-positioned wire core and a surrounding sheath of pliable insulation, and a connector having a ferrule portion including a base portion extending along and in intimate pressure engagement with the outer surface of said insulation, a barb extending inwardly from said base and penetrating said central core, and a pair of laterally-opposed ear portions extending from the said base around said sheath and inwardly into it outside said central core, said ears being in opposed face-to-face relationship at the point of entrance into said sheath and each being in pressure engagement with the outer surface of said central core, said ears engaging said core at spaced points generally opposite said barb, said conductor being anchored in position between said barb and the surfaces of said ears.

4. A connection comprising an electrical conductor having a centrally-positioned wire core and a surrounding sheath of pliable insulation, and a conductor having a ferrule portion including a base portion extending along and in intimate pressure engagement with the outer surface of said insulation, a sharpened barb extending inwardly from said base and penetrating said core, and a pair of laterally-opposed quadrilaterally-shaped ears having rectilinear ends extending substantially parallel with the longitudinal axis of said conductor, said ears extending from opposite sides of said base around the outer surface of said sheath and thereinto, the ears being in face-to-face relationship at the point of entrance into said sheath and said rectilinear end surfaces of said ears abutting said central core substantially opposite said barb.

5. An electrical connection including an electrical conductor having a centrally-positioned wire core and a surrounding sheath of pliable insulation, and a connector having a ferrule portion including a base portion extending along and in intimate pressure engagement with the outer surface of said insulation, a pair of laterally-opposed quadrilaterally-shaped ear portions having rectilinear ends extending substantially parallel with the longitudinal axis of said central wire core, said ears extending from opposite sides of said base around the outer surface of said sheath with their ends in substantially abutting relationship, the end portions of said ears exerting substantial compressive force

radially inwardly on said insulation, and a sharpened barb extending inwardly of said base between said ears, the end portion of said barb engaging said central core, substantial compressive pressure being maintained between said core and said barb by radial force exerted by the oppositely-disposed end portions of said ears, said base portion having an opening therein adjacent said barb permitting extrusion thereinto of the insulation sheath to assure good mechanical and electrical contact between said barb and the central core.

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