Feb. 26, 1957 W. S. WATTS 2,783,447

ELECTRICAL CONNECTOR

Original Filed March 14, 1951 2 Sheets-Sheet 1

Fig. 1.

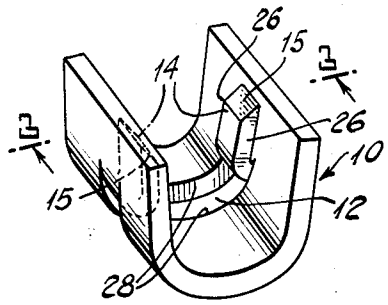


Fig. 2.

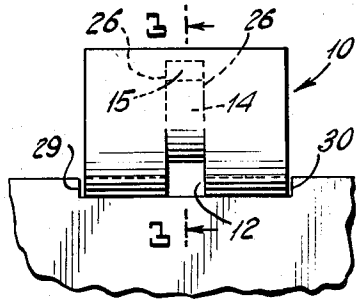


Fig. 3.

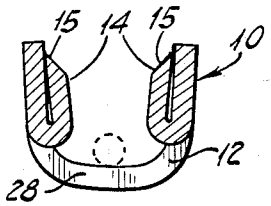


Fig. 4.

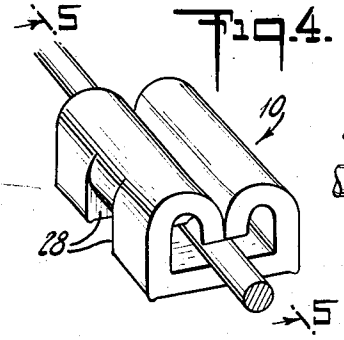


Fig. 5.

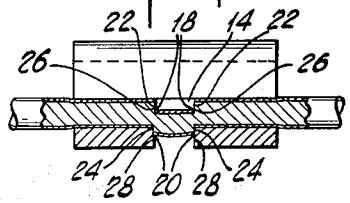


Fig. 6.

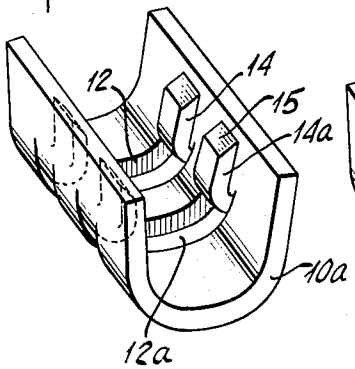


Fig. 7.

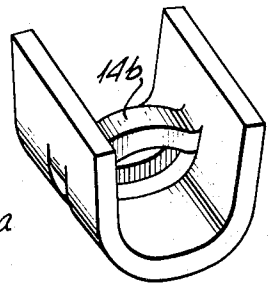


Fig. 8.

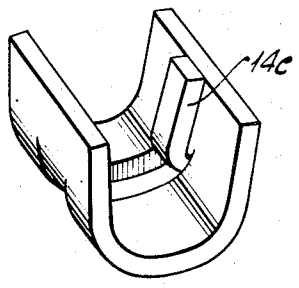
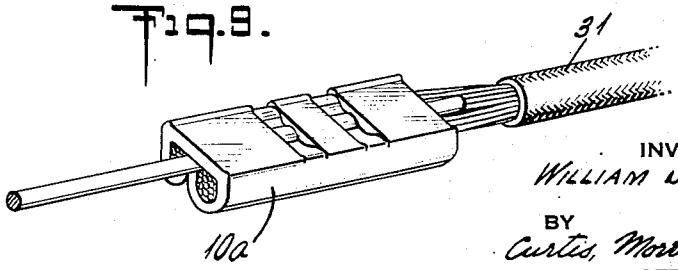


Fig. 9.



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ATTORNEYS:

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ELECTRICAL CONNECTOR

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Fig. 10.

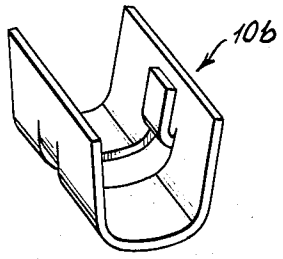


Fig. 11.

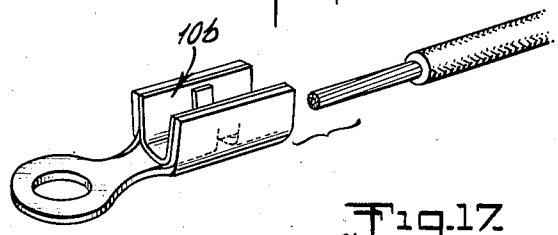


Fig. 17.

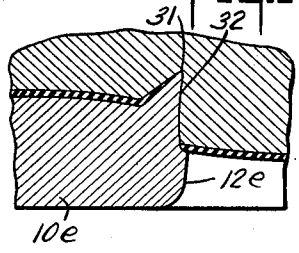
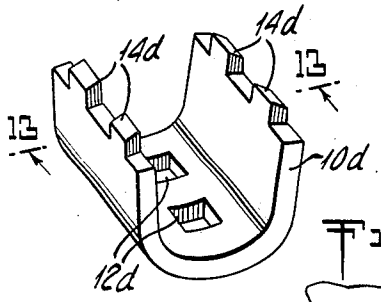


Fig. 12.



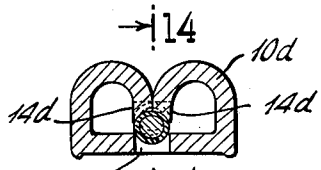


Fig. 18.

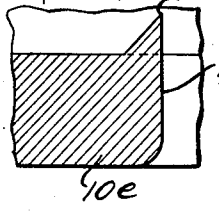


Fig. 13.

Fig. 15.

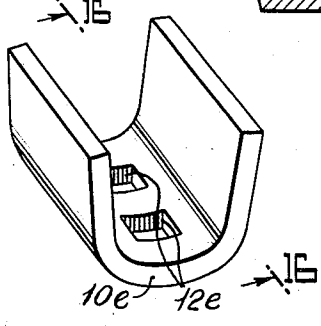


Fig. 14.

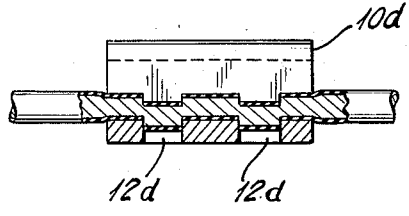
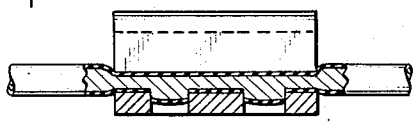


Fig. 16.



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2,783,447

ELECTRICAL CONNECTOR

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Continuation of abandoned application Serial No. 215,454, March 14, 1951. This application March 15, 1956, Serial No. 571,797

21 Claims. (Cl. 339—276)

This invention is a continuation of my copending application, Ser. No. 215,454, now abandoned, and relates to electrical connections and connectors and the method of making connections. More particularly this invention relates to connectors which are crimped onto insulated wires.

A primary object of this invention is to provide a connector that will pierce a tough insulation to make contact with the conductor. Another object is to provide a good low resistance connection with insulated wire. A further object is to provide a good electrical connection with insulated wires without having to first separately remove the insulating coat. Other and further objects will be in part obvious and in part pointed out in the following specification and drawings. The particular aspects of this invention will appear more readily by reference to the drawings in which:

Figure 1 is a perspective view of one embodiment of the invention showing the uncrimped connector;

Figure 2 is a side view of the connector of Figure 1;

Figure 3 is a section on line 3—3 of Figure 2;

Figure 4 is a perspective of the connector of Figure 1 after crimping;

Figure 5 is a section on line 5—5 of Figure 4 showing the partial shearing of a wire by the shear block and slot;

Figure 6 is a perspective view of an embodiment of the invention having double shear blocks;

Figure 7 is a perspective view of another embodiment showing a connected shear block;

Figure 8 is a perspective view of still another embodiment;

Figure 9 is a perspective view of the connector of Figure 6 after crimping showing a two wire connection;

Figure 10 is a perspective view of a liner to be inserted in a solid connector embodying the instant invention;

Figure 11 is a perspective view of the liner inserted in a solid connector;

Figure 12 is a perspective view of another embodiment of the present invention;

Figure 13 is a sectional view on line 13—13 of Figure 12 after the crimping;

Figure 14 is a sectional view on a line 14—14 of Figure 13;

Figure 15 is a perspective view of a still further embodiment of the invention.

Figure 16 is a view similar to Figure 5 showing the connector of Figure 15.

Figure 17 is an enlarged fragmentary sectional view taken from any of Figures 5, 14 and 16 illustrating in detail the metal-to-metal contact between the crimped connector and wire at the sidewalls of the connector slot; and

Figure 18 is a sectional view similar to Figure 17 illustrating the inside edge of the connector slot before crimping.

In making connectors for crimping on insulated cables, it has often been found desirable to provide a series of

small spears or teeth to penetrate the insulation and make contact with the wire. This is particularly applicable where the wire is of the stranded type. In trying to apply these principles to tough-varnish-and lacquer-coated wires and particularly to solid wires insulated with polyvinyl acetals, e. g., "Formex" or "Formvar," it is found that the usual teeth do not penetrate the coating on the wire sufficiently to obtain a satisfactory electrical connection. The "Formvar" coating, especially, has proved practically impervious to the usual types of connectors.

I have now discovered that a satisfactory connection can be obtained by providing in the connector both a ferrule portion which firmly engages and reinforces the wire and a controlled shear structure which will shear the wire at least enough so that the shear edge cuts into the metal of the wire to provide good electrical contact and make the low resistance connection required.

Referring to Figures 1 and 2, a U-shaped ferrule-forming portion 10 is shown. This is cylindriform in that at least a substantial part of it approximates the form generated by movement of a line along a U and always normal to the plane of the U. This portion 10 has a transverse slot 12 punched from the bottom of the U as shown in Figure 3. The width of slot 12 is advantageously made 1½ to 2 times as wide as the thickness of the ferrule metal. As a practical matter it is desirable to make the slot as narrow as possible to reduce tooling expense, overall length of the terminal and the consequent cost and installation space requirements. Typically the slot approximates twice the width of the metal thickness. By punching the slot from the bottom, the burr (generally acuminate in configuration as shown at 31 in Figure 18), and therefore the sharpest edges, are obtained on the upward side of the ferrule slot and the downward side of the portion which is sheared out (hereafter referred to as the "shear Block"). This provides sharply rectangular edges along the lines of contact of the slot and shear block with the wire which ensures proper shearing and connection upon crimping as exemplified in Figure 17 by the area 32 of contact between the slot sidewalls and the metal of the wire exposed as a result of the insulation shearing action. This slot and shear block cooperate to form a "shear couple" which may be defined as opposed but offset surfaces adapted to exert opposing forces in closely adjacent planes on opposite sides of a wire, tending to shear it in two. This "shear couple" acts about a "shear plane" which may be defined as the plane which approximates the edge of the slot and the edge of the shear block and which is parallel to the forces of the shear couple.

The material punched out of slot 12 is advantageously severed at the middle and half of it bent up on the inside of each side of the ferrule portion to form shear blocks 14. By forming the shear blocks in this manner a beveled end 15 is obtained which permits easy insertion of the wire laterally into the top of the U.

One such shear couple acting at a single transverse plane will ordinarily make satisfactory contact where the current flow is not heavy; but it is advantageous to provide a number of couples at spaced shear planes to give multiple contact. In Figure 6 a perspective of such shear couples is shown.

The connector is then crimped onto a coated wire laid longitudinally within the ferrule portion. In crimping, the legs of the U (Figure 3) are curled inwardly and cold-forged downwardly as is now well known from the extensive use in the art of the inventions of James C. Macy, Serial No. 717,842, filed December 23, 1946. This crimping causes the inserted wire to be sheared (Figure 5)—but advantageously less than completely through—by the action of the shear blocks and the slot, the former forcing itself into the wire and the opposite side of the

wire into the slot thus to "key" the wire into the connector. To the extent that the wire bends down into the slot it creates a tensile stress in the insulation at the very point where it is subjected to shear stress by the edges of the shear block. At the same time the compression of the connector in the die imparts a sliding or slicing action to the shear block relative to the ferrule portion of the connector forcing the connected end partially back into the slot (Figure 9). This combined tension, shearing and slicing action breaks the insulation coating at points **18** and **20** and exposes the necessary uninsulated wire areas **22** and **24**. While this combined action is desirable, the shearing action is the primary and controlling one. In crimping, sufficient pressure is applied to cause the "key" section of the wire to flow longitudinally to give a solid low resistance electrical contact between the newly exposed wire surfaces and the shear block faces **26** and slot faces **28**. It is not necessary that the shear block and slot be directly opposite one another, but it is highly desirable that they be in the same axial zone, i. e., with their cooperating edges approximating a common shear plane normal to the axis of the ferrule.

In some types of connectors where the wire is harder than the connector, restraining abutments **29** and **30** (Figure 2) are provided on the crimper to prevent longitudinal spreading of the ferrule which might open the slot and impair the shear action by moving the couple **26—28** apart and away from the proper shear plane.

In joining a "Formvar" insulated wire with another; particularly an uncoated stranded wire, it has been found desirable to place the coated wire in the bottom of the connector with the other on top.

In joining "Formvar" and "Formex" wires, the terminal described has been found satisfactory in combinations up to four coated wires in a single terminal. As the number of wires to be joined increases, increasing care in the selection of terminal and wire sizes must be exercised to ensure partial shearing and proper connection of each wire.

While it is desirable that the shearing of the wire be only partial the dimension A is made long enough to ensure having the desired pull strength in cases of complete shearing of the wire. This serves moreover to hold the partially sheared wire rigid, so that it will not break by fatigue.

By forming the shear blocks out of the material from the slots, the connector is of substantially uniform cross-sectional area throughout its length. Thus the ferrule can strongly grip the wire on both sides of the shear block and clear to the ends of the ferrule.

In Figure 6, a pair of slots **12** and **12***a* is punched in the bottom of the ferrule portion and shear blocks **14** and **14***a* are folded up on the inside of the ferrule instead of the single slot and shear block of Figures 1–5. This improves the electrical connection by increasing the area of contact and ensures piercing of the insulation coating particularly when several wires are joined in one connector.

In Figure 7, the shear block **14***b* is a continuous piece formed from the slot joining the side of the ferrule-forming portion. This type can be used where it is desired to separate the "Formvar" insulated wire and other cables within the connector and ease in inserting the wires is not paramount.

In Figure 8 the shear block **14***c* is made in one piece and folded up along one side of the ferrule-forming portion in a manner similar to the folding up of the two portions in Figures 1 and 2.

In Figure 9 a stranded wire **31**, stripped at the end, is inserted on top of the Formvar wire in the connector whereby a good mechanical connection is formed upon crimping. A good electrical connection is formed in the same operation through the solid contact of wire **31** with the connector **10***a* which in turn makes a solid contact with the Formvar wire through the sheared areas.

Referring to Figure 10, a liner or ferrule portion **10***b*, adapted to be inserted in a solid connector, is formed similarly to the connector **10** of Figure 1. The liner is then inserted in a solid connector (Figure 11) and the assembly crimped onto the wire. Thus any of the usual solid connectors may be adapted for application to "Formvar" wires or the like. Also the liner may be chosen with a particular slot width and metal thickness for a given job thereby greatly increasing the flexibility of any solid connector.

Referring to Figure 12 a cylindriform ferrule-forming portion **10***d* has on the edges thereof projections **14***d* and in the bottom transverse slots **12***d*. In crimping the projections **14***d* act similarly to the shear blocks **14** and **14***a* of Figure 6 to force the wire to be crimped into the slots so as to shear the tough insulation and give the good electrical contact required (Figures 13 and 14).

In Figure 15 transverse slots or holes **12***e* only are punched in the bottom of the cylindriform ferrule-forming portion **10***e*. This embodiment of my invention is used with the more readily shearable types of insulations. In this embodiment I used a confining type crimp that will force the wire into the slot and cause it to flow axially within the slot to ensure good electrical contact. In a crimp of this type, generally as shown in Figure 16, the burrs **31** formed in the punching operation are especially beneficial in assuring that severance of the wire insulation and subsequent exposure of the metal of the wire for metal-to-metal contact with the slot sidewalls occurs. With this embodiment it is necessary to use such high crimping pressures that while good electrical contact is obtained, the mechanical strength is low so that this embodiment can be used only where great strength is not necessary.

While there are given above certain specific examples of this invention and its application in practical use and also certain modifications and alternatives, it should be understood that these are not intended to be exhaustive or to be limiting of the invention. On the contrary, these illustrations and the explanations herein are given in order to acquaint others skilled in the art with this invention and the principles thereof and a suitable manner of its application in practical use, so that others skilled in the art may be enabled to modify the invention and to adapt it and apply it in numerous forms, each as may be best suited to the requirement of a particular use.

I claim:

1. A terminal of the type adapted for pressure application on a wire to form an electrical connection therewith, comprising a cylindriform ferrule-forming portion with a slot therein and a mating block thereon spaced from said slot but with edges thereof adjoining the same transverse planes as edges of said slot but respectively on opposite sides of said planes, said block being effective upon crimping said ferrule portion to force and shear partially the wire against the edges of said slot.

2. A connector of the type defined by claim 1 wherein said block is formed out of said slot and joins the sides of said ferrule-forming portion.

3. A connector of the type defined by claim 1 wherein said block comprises the material from said slot folded up on the inside of said ferrule-forming portion.

4. A connector of the type adapted for pressure application on a wire to form an electrical connection therewith, comprising a ferrule-forming portion, a pair of transverse slots in the bottom of said ferrule portion and a corresponding pair of shear blocks on the inner wall of said ferrule portion with their edges respectively lying close to the same transverse shear plane as the edges of the slots.

5. A connector of the type defined by claim 4 wherein said shear blocks comprise portions folded up from said slots substantially against the sides of said ferrule-forming portion.

6. A connector of the type adapted for crimping on a wire to form an electrical connection therewith, comprising a cylindriform ferrule portion, at least one trans-

verse slot in the bottom of said ferrule, a corresponding number of sheet metal blocks in said ferrule portion adapted to mate upon crimping said ferrule with said slots to partially shear said wire, the edges and side walls of at least said slot providing an electrical contact with said wire.

7. In the art of of making electrical connections of the type having a ferrule forming portion adapted to be pressure formed about a wire the steps of punching at least one transverse slot in the bottom of the ferrule-forming portion, folding up the material from said slots substantially against the sides of said ferrule portion, inserting a wire within the ferrule and across the slot, and pressure forming said ferrule portion to force the wire against the edges of the slot so as to partially shear said wire.

8. The method of making an electrical connection including punching out a pair of transverse slots in the bottom of a ferrule-forming portion of an electrical connector, folding up the material from said slots substantially against the sides of said ferrule-forming portion, inserting the end of at least one wire insulated with a thin tough coating of varnish or the like in said ferrule-forming portion crimping said ferrule-forming portion onto said wire with a pressure sufficient to partially shear said wire adjacent said slots whereby a good electrical contact is obtained.

9. An electrical connector adapted for pressure application on a wire or the like, including a ferrule-forming portion, a liner adapted to be inserted in said ferrule-forming portion, comprising in turn a ferrule portion having at least one slot on one side thereof, and a corresponding shear block on at least one side adjacent to said first side.

10. In a connector adapted for pressure application on a solid insulated wire, a liner adapted for insertion in a ferrule portion of said connector comprising a cylindriform ferrule portion having at least one slot in the bottom thereof, and corresponding shear blocks formed from the material from said slot and folded up substantially against the sides of said liner ferrule portion, whereby on crimping said wire is partially sheared and forced into said slot to provide electrical and mechanical contact with said connector.

11. An electrical connection comprising a wire, a tough thin insulation coating on said wire, a substantially rigid ferrule portion, shear means defining a shear couple disposed about a plane substantially perpendicular to said wire positioned within the length of said ferrule portion, said ferrule portion engaging a length of the wire on either side of said shearing means to hold it against flexure, and said shearing means laterally displacing by shearing relative to each other, the portions of said wire directly adjacent said plane to cut through the insulation coating and form good electrical contact between said wire and said ferrule but not to sever completely said wire.

12. An electrical connector for pressure application on a solid wire having a thin tough paint-like insulation to make electrical and mechanical connection therewith comprising, a sheet metal ferrule forming portion having a generally U-shaped cross-section, a narrow transverse slot cut in the bottom of said ferrule, a generally rectangular block of sheet metal positioned on each wall of said ferrule portion at the ends of said slot, said blocks being of substantially the same thickness and width as said slot thereby on crimping a wire inserted therein has a segment of a length substantially equal to the width of said slot partially severed and laterally displaced from the wire to expose insulated portions of said wire for urging metal to metal contact with said connector.

13. A connector as described in claim 12 wherein said blocks comprise the metal from said slot folded up at each end thereof against the inside of said ferrule portion

and wherein the upper edges thereof are tapered outwardly to facilitate the insertion of a wire therein.

14. An electrical connector for crimping on a solid insulated wire to make electrical contact therewith comprising a sheet metal ferrule-forming member adapted to be crimped about a portion of the length of the wire, shearing means in said ferrule member for partially shearing the wire to expose and contact the metal thereof including a slot having a sharp edge extending transversely across said ferrule member and a bar of sheet metal effective upon crimping the ferrule to force the wire against said edge, the cross sectional area of metal of said ferrule member along the length thereof to be crimped being substantially constant.

15. An electrical connector for crimping on a solid insulated wire to make electrical contact therewith comprising a sheet metal ferrule-forming member having a generally U-shaped cross section, at least one bar-shaped portion of said member being partially struck therefrom and displaced therein to provide a narrow transverse slot with a sharp edge extending across the bottom of said ferrule member, said bar being disposed within said ferrule member to maintain the cross sectional area of the metal of said ferrule member substantially constant whereby a wire placed across said slot is subjected upon crimping said ferrule to a shearing stress at said edge.

16. In an electrical connection with a conductor having a coating of insulating material thereon, a sheet metal ferrule-forming member in ferrule-like configuration tightly embracing said conductor substantially throughout the length of the ferrule, metal in an intermediate portion of the ferrule being removed to define transverse opposed sidewalls within the sheet metal thickness and terminating at the inside surface of the ferrule in sharp transverse edges, the conductor being firmly pressed against said edges with the coating thereof being pierced along the transverse lines defined by said edges, a portion of the conductor extending downwardly between the sidewalls to widen the break in said coating and to expose an area of metal of the conductor for face-to-face contact with said sidewalls, the sharp edges restraining the coating on the conductor on either side of said conductor portion from entering between the sidewalls.

17. An electrical connector for connection with a conductor having a coating of insulating material thereon comprising a sheet metal ferrule-forming member having a base and sidewalls and adapted to be crimped in ferrule-like configuration tightly about the conductor substantially throughout the ferrule length, said base being interrupted intermediate its length by a gap defined by open and opposed walls within the thickness of the ferrule sheet metal and extending substantially transversely to the longitudinal axis of the ferrule, the inner edges of the transverse walls extending inwardly of the inside surface of said ferrule and terminating in sharp transverse projecting edges for piercing the coating on the conductor, said transverse walls being spaced to receive therebetween and to contact in face-to-face metal engagement an extruded part of the conductor portion spanning said edges upon crimping the ferrule, said sharp edges being adapted to restrain the conductor coating on either side of the spanning portion from entering between said transverse walls during crimping.

18. In an electrical connection with an insulated conductor, a channel-shaped sheet metal ferrule-forming member having a base and sidewalls with the conductor disposed lengthwise therein, the sidewalls of the channel terminating in continuous side edges substantially parallel with the longitudinal axis of the channel, said sidewalls being curled inwardly and downwardly and against the conductor forcefully pressing the conductor against the channel base substantially throughout the length of the ferrule, a slot intermediate the length of said base and defining open and opposed walls within the thickness of the sheet metal ferrule, said walls extending trans-

versely and parallel to the longitudinal axis of the ferrule, the inner edges of the transverse walls extending inwardly of the inside surface of the ferrule and terminating in sharp transverse projecting edges, the insulation of the conductor being pierced by said sharp edges along the transverse lines defined thereby, a part of the conductor portion spanning said transverse edges projecting downwardly between the transverse walls to widen the break in said insulation and to expose an area of metal of the conductor for face-to-face contact with said transverse walls, the sharp edges restraining the insulation of the conductor on either side of the spanning portion from entering said slot.

19. In the art of making electrical connections of the type having a sheet metal ferrule-forming member adapted to be pressure formed about an electrical conductor having a coating of insulating material thereon, the steps of displacing metal from an intermediate portion of the ferrule to define transverse opposed sidewalls terminating in sharp edges at the inside surface of the ferrule, disposing the conductor lengthwise in the ferrule across the edges, pressing the conductor against the edges to cause the edges to pierce the conductor coating by crimping and compressing the ferrule about the conductor, extruding by further compression of the ferrule a portion of the conductor downwardly between the side walls to expose metal of the conductor for face-to-face contact with the sidewalls, the sharp edges restraining the conductor coating on either side of said portion from entering between the sidewalls, whereby the conductor is firmly embraced throughout substantially the length of the ferrule and in metal-to-metal contact therewith at the sidewalls.

20. In the art of making electrical connections of the type having a sheet metal ferrule-forming member adapted to be pressure formed about an insulated electrical conductor, the steps of displacing metal from an

intermediate portion of the ferrule to define transverse opposed sidewalls terminating in ribs tapering to sharp edges and projecting inwardly from the inside surface of the ferrule, disposing an insulated conductor lengthwise in the ferrule across the edges, pressing the conductor against the edges to cause the edges to sever the coating by crimping and compressing the ferrule about the conductor, extruding by further compression of the ferrule a portion of the conductor downwardly between the sidewalls to expose metal of the conductor for face-to-face contact with the sidewalls, the sharp edges restraining the insulation of the conductor on either side of said conductor portion from entering between the sidewalls, whereby the conductor is firmly embraced throughout substantially the length of the ferrule and in metal-to-metal contact therewith at the sidewalls.

21. In the art of making electrical connections of the type having a sheet metal ferrule-forming member adapted to be pressure formed about an electrical conductor having a coating of insulating material thereon, the steps of punching at least one slot from the bottom of an intermediate portion of the ferrule to define transverse opposed sidewalls terminating in sharp acuminate edges projecting inwardly from the inside surface of the ferrule, disposing the conductor lengthwise in the ferrule across the edges, pressing the conductor against the edges to cause the edges to pierce the conductor coating by crimping and compressing the ferrule about the conductor, extruding by further compression of the ferrule the conductor portion spanning the edges downwardly between the sidewalls to expose metal of the conductor for face-to-face contact with the sidewalls, the sharp edges restraining the conductor coating on either side of the spanning portion from entering between the sidewalls, whereby the conductor is firmly embraced throughout substantially the length of the ferrule and in metal-to-metal contact therewith at the sidewalls.

No references cited.