May 1, 1951 F. J. SOWA 2,551,299

ELECTRICAL CONNECTOR AND METHOD OF MAKING THE SAME

Filed Oct. 6, 1943

Fig. 1.

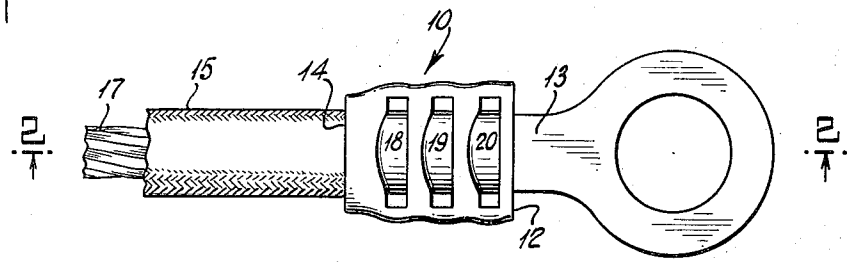


Fig. 2.

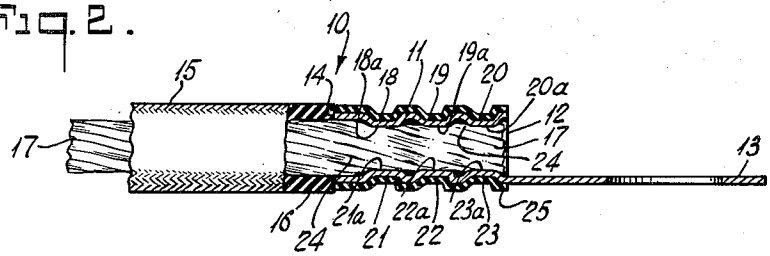


Fig. 3.

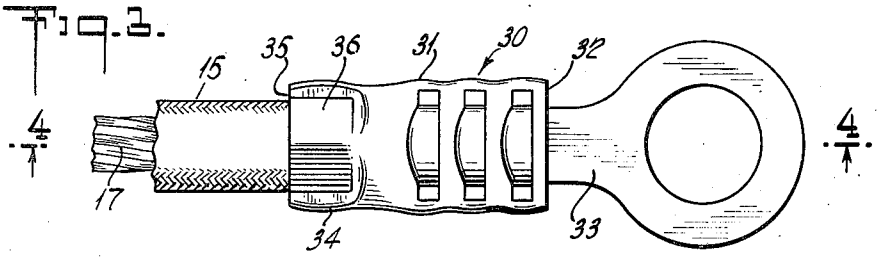


Fig. 4.

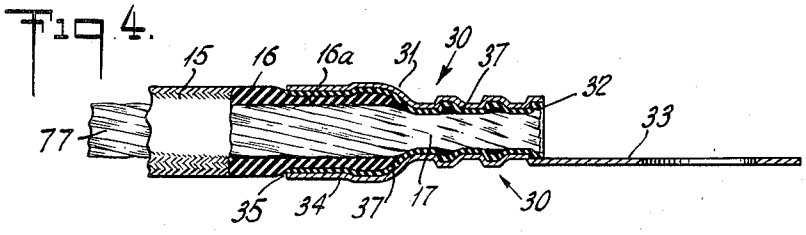
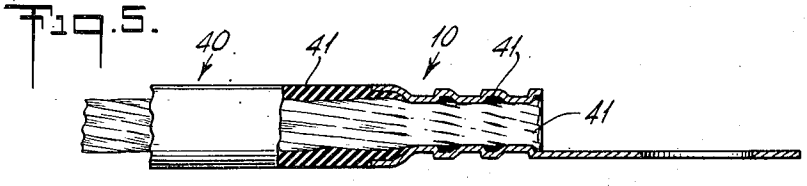


Fig. 5.



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ELECTRICAL CONNECTOR AND METHOD OF MAKING THE SAME

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7 Claims. (Cl. 173—269)

1

This invention relates to electrical connectors for conductors, and more particularly to a solderless type of connector, and a method of attaching it to a conductor end.

With solderless connections, even under normal conditions of use, corrosion may creep into the area of contact between the connector and conductor and impair the conductivity as to result in voltage variations which though relatively slight are still much too great to permit efficient operation of many different types of instruments where even small changes in resistance may be significant.

It is accordingly among the objects of my invention to provide a simple, sturdy and durable electrical connector for solderless attachment to the end of an insulated conductor which, among other things, effectively seals contact areas of the conductor against the admission of air and moisture. It is a further object of my invention to provide a method of making an electrical connector of the above-mentioned type in a simple and efficient manner amenable to mass production manufacture. Another object of my invention lies in the provision of a method of applying under field conditions an electrical connector of the type under consideration. Other objects will be in part apparent and in part pointed out hereinafter.

According to my present invention, the crevices and openings within the ferrule portion of the electrical connector and between the wire strands of the conductor are filled with a plastic material. I have discovered that this plastic material may be, among others, one of the well known insulating plastics, especially the high polymers of hydrocarbons and other organic compounds, and that although such plastic may completely cover the wire and/or ferrule before assembly, that it does not interfere with good electrical contact in the crimped area but actually can improve both the initial contact established by the crimping and the stability of contact resistance during long use.

The invention accordingly consists in the features of construction, combinations of elements, arrangements of parts, and in the several steps and relation and order of each of the same to one or more of the others, all as will be illustratively described herein, and the scope of the application of which will be indicated in the following claims.

In the drawing, wherein I have shown several embodiments of my invention,

Figure 1 is a top plan view of an electrical conductor to the end of which is attached one form of my electrical connector;

2

Figure 2 is a section taken along line 2—2 of Figure 1;

Figure 3 is a top plan view of another form of my electrical connector secured to a conductor;

Figure 4 is a section taken along the line 4—4 of Figure 3; and,

Figure 5 is a section similar to those shown in Figures 2 and 4, of another form of my connector.

Similar reference characters refer to similar parts throughout the various views of the drawing.

Referring first to Figure 1, the connector is generally indicated at 10, and comprises a ferrule 11, from one open end 12 of which extends a terminal connector 13, the other end 14 of the connector also being open in order that the ferrule may receive the end of a conductor 15, preferably covered with insulation 16.

As is more clearly shown in Figure 2, the end of conductor 15 is preferably stripped of its insulation so that the metal wire or the strands 17 of the conductor may be inserted within the ferrule 11. After insertion of the stripped conductor end within the ferrule, the ferrule is crimped, as at 18—21, 19—22 and 20—23 on opposite sides, with sufficient force that the inner surfaces 18a, 19a and 20a, and 21a, 22a and 23a of the crimps are squeezed against the opposite sides of the strands of wire 17 with very substantial force so as to press the strands into close engagement. Indeed, the crimping pressure is preferably such that the strands of wire 17 are pressed substantially into a solid piece which appears substantially free from crevices if a cross section through the center of a crimp is cut and polished. Thus a good electrical contact between the ferrule and the conductor wire is assured.

A single crimp would be effective in many cases to accomplish the purposes of my invention. If, however, spaced crimps are first formed quite close together, and then while these are held compressed between the crimping dies the area therebetween is crimped, the plastic is first extruded from both sides into the central space and then being compressed in a confined space, the plastic is driven under pressure into the interstices and crevices between the crimped areas, thus assuring a perfect seal. A somewhat analogous effect is produced when two closely spaced crimps are formed simultaneously; the plastic first extruding from both sides into the narrow space between and at the final stage being com-

pressed under very high pressure which drives it into every space and crevice.

A short distance either side of this central cross-section, however, the wire will be less severely compressed, and gradually crevices appear and open out to relatively large openings between the strands beyond the crimp. Except for the present invention, these crevices would make entries wherein corrosion could begin and work its way in toward the crimp along the surfaces of the wire strands and of the ferrule. This corrosion I forestall by my present invention, completely excluding from a contact area all air and moisture; accordingly I have disposed the plastic material **24** between the wire strands **17** and the inside of ferrule **11**.

This material may be selected from the wide variety of plastic materials available which have the property of adhering to the metal contact surfaces and extruding under pressure and which do not corrode metals. As examples of these, I can use with advantage either straight or plasticized raw rubber, polyisobutylene, synthetic rubbers, vinyl polymers, styrene polymers and acrylic type polymers; also cellulose derivatives such as cellulose nitrate, acetate butyrate and the like. These plastics ordinarily have excellent insulating qualities, but according to my present invention I take advantage of their plasticity to extrude them completely from the contact areas by the same pressure which forms the crimp.

The plastic used may be permanently plastic, or may be capable of conversion to a non-plastic material by heat or pressure or other special treatment; it should not, of course, become non-plastic spontaneously under conditions of storage or handling prior to application onto a wire.

Elastomers may be used in the same manner in that a thin film applied to the interior of the ferrule is formed to the surface of the wire strands in the crimped area and the strands push through the film into contact with the ferrule. In this case, however, the elastic properties of the film tend to crowd the film into the crevices between the wires and ferrule, and maintain a perfect seal after the manner of the familiar "rubber dam" used in dental work.

The conductor **15** is coated with the plastic or the inside of ferrule **11** is lined with the plastic, or both. The ferrule may then by placed over the end of the conductor and thereafter crimped. Upon crimping of the ferrule, the plastic flows from between the strands of the conductor and the ferrule at the bottoms of the crimps thus establishing electrical contact at these points. The plastic extruded from these points of contact is compacted in bordering zones, thereby effectively precluding the passage of air and moisture between the ferrule and the wire strands **17** into the points in the crimped contact zone. Furthermore, the pressure resulting from the crimping operations tends to force the plastic material into and among the strands of the stranded conductor so that in the event the strands are not completely squeezed together in a crimped zone, the plastic can be flowed into the interstices therebetween so as to seal completely contact areas within the ferrule.

Under certain circumstances, I have found it preferable also to insulate the outer periphery of ferrule **11**. Thus, I may apply to the outside of ferrule **11** a suitable insulation **25** which resists extrusion under pressure of the crimping die and, upon the ferrules being crimped, provides effective insulation thereon. However, the outer insulation may comprise the same sort of plastic as used within the ferrule so as completely to insulate the inside and the outside, as well as the ends thereof. Under such circumstances, I have found it advantageous to dip the ferrule in the insulating plastic prior to its being placed over the stripped end of the conductor.

Thus it may be seen that the insulating plastic **24** is effectively forced into and about the strands of conductor **15** and may even be forced between ferrule end **14**, and the adjacent edge of insulation **16** on conductor **15**. The insulating material lying between the open end **12** of the ferrule and the wire strands **17**, seals otherwise exposed areas of the conductor.

As shown in Figure 3, another form of my connector is generally indicated at **30** and comprises a ferrule **31** having an open end **32**, from which extends a terminal connection **33**. From the other end of ferrule **31** extends a collar **34** or the like, through the outer end **35** of which extends the end of insulated conductor **15**. As shown in Figure 4, a portion **16***a* of the conductor's insulation lies within ferrule collar **34**, the stripped end or wire strands **17** of the conductor lying within the ferrule **31**. The ferrule collar **34** is crimped as at **36** against portion **16***a* of the conductor insulation, ferrule **31** being crimped, as in the case of the ferrule shown in Figure 2, at two or more places so that the opposed sides of the crimps tightly squeeze, adhere to and have good electrical contact with the wire strands **17**. Disposed between the wire strands **17** and the ferrule is insulating material **37**, this material also lying between collar **34** and portion **16***a* of the conductor insulation, and also between the end **35** of the ferrule and the conductor insulation. The insulating material is extruded or forced into the localized areas indicated, in the same manner as that referred to above in connection with the connector shown in Figures 1 and 2, and may be applied either onto the inside of the ferrule, or onto the outside of the wire strands **17**, or both, so as to be in position and condition for extrusion into interstices around contact areas and about the wire strands when the ferrule is crimped thereon. While I have not shown an exterior coating of insulation on the ferrule of connector **30**, it is to be understood that ferrule **31** may be provided with an outer coating of insulating plastic in the same manner as that described in connection with connector **10** (Figure 2).

Thus it may be seen that connector **30** is not only securely attached to conductor **15** so as to be in good electrical contact with wire strands **17**, but also the end of the conductor can be effectively sealed against the admission into and flow therethrough of air and moisture.

In Figure 5, I have shown connector **10** applied to a conductor **40** which is provided with a plastic insulation of such a character that stripping of the conductor end is unnecessary prior to application or attachment thereto of connector **10**. Thus insulation plastic **41** has such properties of plasticity that when the connector **10** is crimped on the end thereof, as heretofore described, the plastic insulation coating reacts in the same manner as the plastic insulation **24**, for example, described in connection with the connector shown in Figure 2. Thus the plastic is forced into sealing rings **41** or the like, between adjacent crimps, and also into any interstices between adjacent wire strands **17**, effectively to preclude the flow of air and moisture therethrough. While

I have not shown the outside of ferrule 11 in Figure 5 insulated exteriorly, it will be understood that this ferrule may have an outer insulation as in the case of that shown in Figure 2.

Accordingly it will be seen that I have provided an electrical connector for solderless attachment to a conductor end, and a method of attaching the connector thereto, which attains the several objects set forth hereinabove in a thoroughly practical and efficient manner.

Many possible embodiments may be made of the mechanical features of the above invention, and the art herein described might be varied in various parts, all without departing from the scope of the invention.

I claim:

1. The method of attaching a metallic ferrule to an electrical conductor which includes the steps of, dipping said ferrule into a liquefied plastic insulating material so as to insulate it inside and out, solidifying the plastic, disposing said conductor within said ferrule, and exerting substantial pressure on said ferrule transversely thereof at spaced portions therealong to force said ferrule into good electrical contact with said conductor end and squeezing the plastic material within said ferrule along said conductor into localized areas between said pressed portions of the ferrule.

2. The method of attaching a metallic ferrule to an electrical conductor, which includes the steps of, applying a plastic insulating material on at least one of the contacting surfaces of said ferrule and said conductor, inserting said conductor in said ferrule, exerting substantial transverse pressure on said ferrule at longitudinally spaced portions thereof to force said ferrule portions into good electrical contact with said conductor thereby forcing said plastic insulating material into a compact mass between said spaced portions of the ferrule, and while maintaining said pressure at said spaced portions of said ferrule, exerting transverse pressure on said ferrule between said spaced portions to force said plastic material into all interstices within said ferrule between said first-mentioned spaced portions.

3. An electrical connector having an open-ended ferrule and a lining of solid insulating material on at least the inside of the ferrule, the insulating material having a resistance to cold pressure flow less than that of the metal of the ferrule.

4. In an electrical connection, an electrical conductor, and a sleeve-like connector ferrule telescoped over the conductor; the conductor being in good electrical contact at a plurality of points with the inside of the ferrule, and a corrosion-resistant plastic barrier on the inside of the ferrule surrounding and sealing the individual points of electrical contact therebetween against the atmosphere.

5. An electrical connector including a metallic ferrule having a wire-receiving portion therein; said ferrule being covered inside and out with a solid insulating material, insulating material on the outside of the ferrule being harder than that on the interior of the ferrule and having a resistance to cold pressure flow not significantly less than that of the metal of the ferrule.

6. The method of providing an electrical connector on the end of an electrical conductor which includes the steps of: providing an electrical connector ferrule having metal contact portions therein, providing an electrical conductor having metal contact portions thereon, applying to the contact portions of one of the electrical members a coating of a malleable plastic insulating material, putting the ferrule over contact portions of the conductor, and pressing ferrule contact portions against conductor contact portions in a plurality of axially spaced areas with such force as to cause plastic film flow and the establishment of opposing contact portions in good conducting relationship.

7. The method of making an electrical connection which includes the steps of: providing a metallic connector ferrule having a wire-receiving portion therein, insulating the inside of the ferrule with plastic insulating material which is solid, but softer than the metal of the ferrule when crimped at room temperature, inserting electrical conductor strands into the thus insulated wire-receiving portion of the ferrule, and crimping the ferrule onto the strands with sufficient pressure to penetrate said insulation at a substantially line or point contact to cause a cold metal flow in the ferrule and conductor strands.

FRANK J. SOWA.

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