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DuRocher et al.

[11] **3,753,214**

[45] **Aug. 14, 1973**

[54] **ELECTRICAL CONDUCTORS**

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[73] Assignee: **Essex International Inc.,** Detroit, Mich.

[22] Filed: **June 1, 1971**

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[52] **U.S. Cl.** ..... **339/102 R,** 339/149 R, 339/206 R, 339/275 T, 339/278 T, 29/630 R

[51] **Int. Cl.** **H01r 13/58**

[58] **Field of Search** ..... 29/630; 339/64, 182, 339/183, 252 P, 278 R, 278 M, 278 T, 48, 49 B, 50, 60, 63, 94, 218, 206, 207, 196, 102

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Assistant Examiner—Lawrence J. Staab
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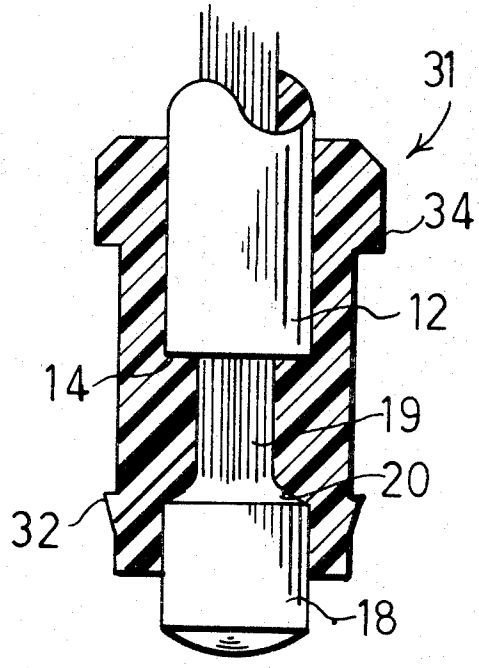
[57] **ABSTRACT**

An electrical conductor composed of either stranded or solid wire has at least at one end thereof a terminal the cross-sectional area of which is greater than that of the wire, the terminal constituting an integral part of the wire and being formed by axial and lateral deformation of the wire end. The terminal may be formed either by spinning or swaging, or both simultaneously, the wire end in a die having a forming chamber into which a swaging or spinning member may be thrust so as to deform the free end of the wire both axially and radially. The terminal and the adjacent portion of the wire are surrounded by an insulating sleeve adapted for insertion in an opening formed in a connector body in such manner that the terminal is exposed for electrical connection to another conductor which may be supported in another connector body. A compressible, elastomeric pad having conductive particles therein preferably is interposed between the confronting conductors of the connector parts so as to assure the establishment of a conductive path between adjacent conductors even though there may be some differences in the levels of the conductors in their respective connector parts.

8 Claims, 8 Drawing Figures



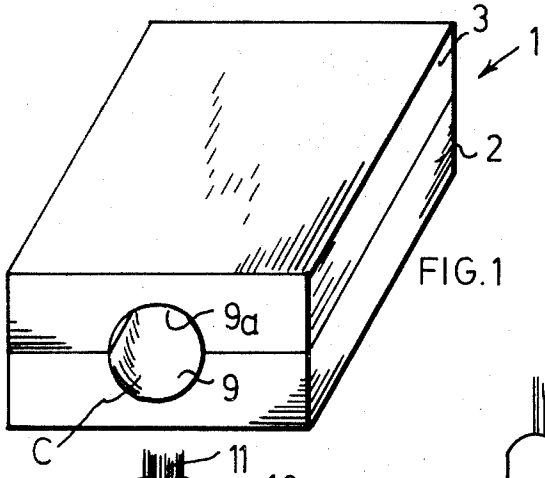


FIG. 1

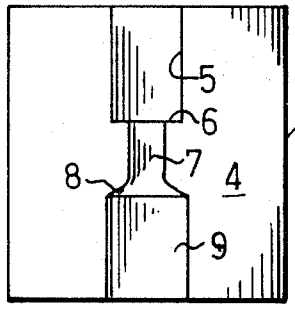


FIG. 2

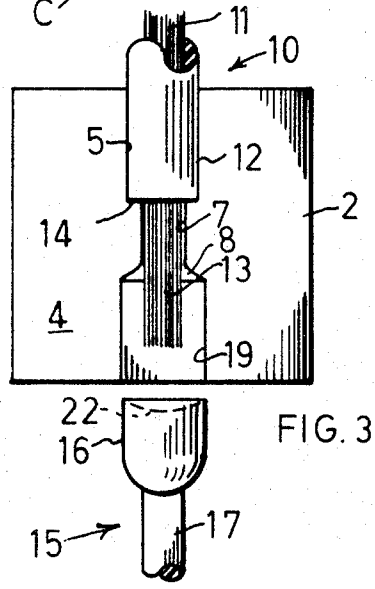


FIG. 3

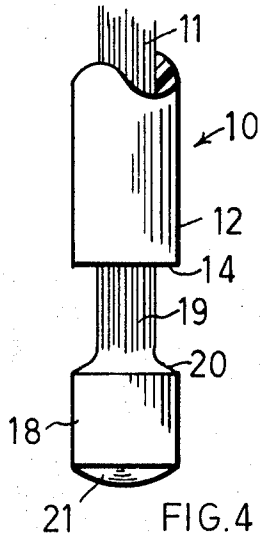


FIG. 4

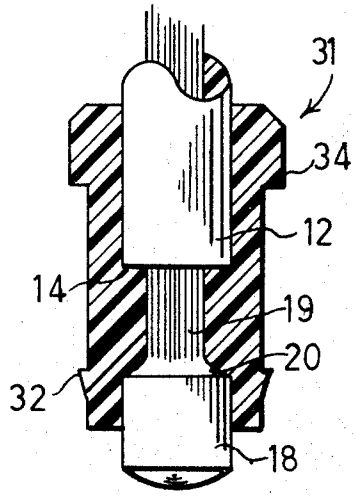


FIG. 7

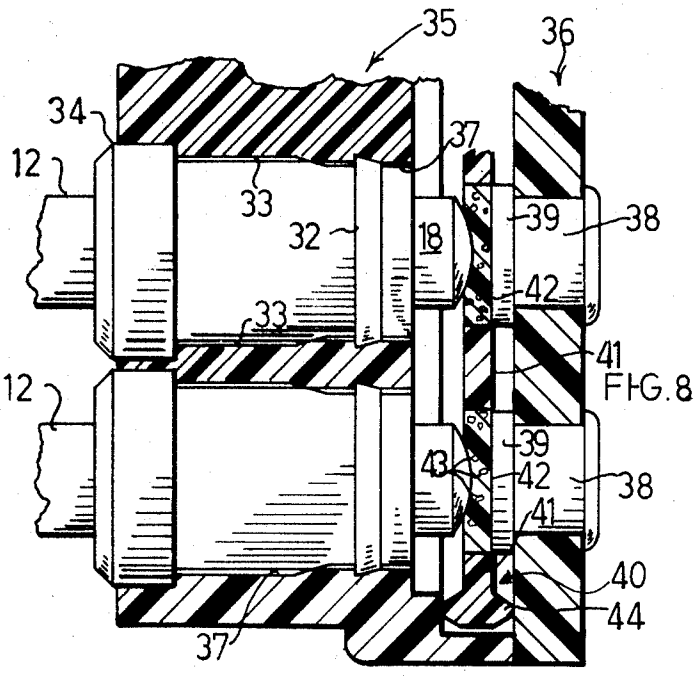


FIG. 8

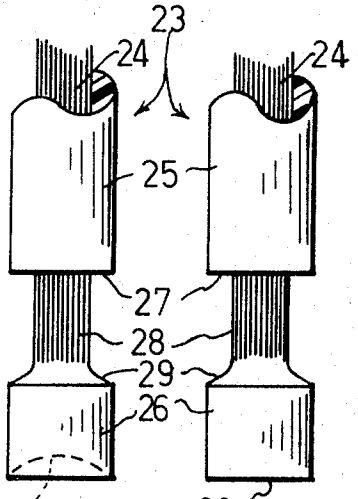


FIG. 5

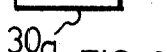


FIG. 6

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ELECTRICAL CONDUCTORS

The invention disclosed herein relates to electrical conductors and more particularly to conductive wires having integral terminals at their free ends formed in such manner as to facilitate the assembly of the terminals in connector bodies which may be joined to one another so as to establish a conductive path through the connectors. The invention also relates to improved connectors of the kind especially adapted for use with such integral terminals.

In the terminating of a wire conductor it is conventional to strip the insulation from the ends of the wire and join the ends of the wire to terminals. The terminals may be formed from the same or different metal as that forming the wire and the manner in which the wire is joined to the terminals may involve any one of a number of processes, such as soldering, riveting, crimping, fusing, or the like. Regardless of the manner in which a separate terminal is joined to a wire, there inevitably will be a voltage drop across the juncture of the wire and the terminal. The voltage drop may be so small as to be expressed in millivolt units, but regardless of the value of the voltage drop, it results in electrical losses and generates heat. An advantage of the invention disclosed herein is that the voltage drop between a conductor and its terminal can be eliminated by shaping or deforming the free end of the conductor into the shape of a terminal, or, stated differently, by forming the terminal as an integral part of the conductor.

The conventional practice of joining a separate terminal to a conductor also has other disadvantages. Firstly, it is necessary to provide means for forming the terminal itself, and secondly, it is necessary to provide means for joining the terminal to the conductor. The terminal forming means and the terminal joining means frequently represent a substantial investment in machinery and material handling systems, as well as in factory floor space necessary to accommodate such apparatus.

Even though the utmost care may be taken in forming terminals and in joining them to conductors, it virtually is impossible to prevent at least some of the terminals from being malformed or improperly joined to their conductors, if for no other reason than the forming and joining machinery cannot always function perfectly because of wear, for example. If a terminal is joined improperly to its conductor, or is malformed, it may not be capable of being joined to a mating or companion conductor with proper electrical integrity. If it can be joined to a mating or companion conductor, a malformed or misjoined terminal may increase the voltage drop between the terminal and its conductor. In addition, a terminal which is imperfectly formed or joined to its conductor is difficult to assemble in a connector.

Even if all terminals are formed properly and are joined properly to their conductors, they frequently are of such size that, if a fairly large number of them are to be assembled in a single connector, the size of the connector must be inordinately large as compared to the size of the bundle of wires to which the terminals are joined. In accordance with this invention, however, a terminal formed as an integral part of a conductor may have a cross-sectional area which is larger than that of the conductor itself, thereby providing a desirably large contact surface, but the cross-sectional area of the terminal need be no larger than the combined cross-

sectional area of the conductor and its insulation, thereby making it possible to obtain the advantages of a relatively large contact area without the disadvantage of enlarging the connector in which the insulated wire is to be accommodated.

The formation of a terminal as an integral part of a conductor makes it possible to provide in an extremely simple manner any one of a number of differently shaped contact surfaces on the terminal. It also makes it possible to provide for the coating of the contact surface of a terminal with tin, silver, or some other material having electrical properties more desirable than those of the material from which the terminal itself is made.

The ability of an integral terminal to have a larger cross-sectional area than that of its conductor, but still be no greater than the combined cross-sectional area of the conductor and insulation, unless a larger cross-sectional area is desired, faciliates the design, construction and assembly of separable connectors and makes possible the assembly and mounting of the terminals in such connectors in such manner as to simplify the correction of mistakes as well as to promote better conductivity between confronting contacts.

Among the objects of this invention is to provide an integral terminal at either or both ends of an electrical conductor so as to avoid the problems inherent in the joining of conductors to separate terminals and at the same time obtain all of the advantages of conventional terminals.

Another object of the invention is to provide simple, inexpensive means for forming integral terminals at the ends of the conductors.

A further object of the invention is to provide an integral conductor and terminal construction which lends itself to rapid and economical assembly in multiple conductor connector devices.

Another object of the invention is to provide an improved connector construction for multiple conductors.

A further object of the invention is to provide an improved method of forming integral terminals at the ends of conductors.

Other objects and advantages of the invention will be pointed out specifically in the following description or will become apparent when it is considered in conjunction with the appended claims and the accompanying drawings, in which:

FIG. 1 is an isometric view of apparatus for forming an integral terminal at one end of a conductor;

FIG. 2 is a top plan view of the lower half of the apparatus shown in FIG. 1;

FIG. 3 is a view similar to FIG. 2, but illustrating a conductor in readiness to have an integral terminal formed at one end thereof;

FIG. 4 is an elevational view of the integral terminal formed with the apparatus of FIG. 3;

FIGS. 5 and 6 are views similar to FIG. 4, but illustrating different shapes of integral terminals;

FIG. 7 is a sectional view illustrating an integral terminal surrounded by an insulating sleeve; and

FIG. 8 is a sectional view of a plurality of terminals like that shown in FIG. 7 assembled in a connector body and in conductive relation with other terminals carried by another connector body.

Apparatus for forming integral terminals at the ends of wire conductors in accordance with the invention

comprises a die assembly 1 composed of a pair of body members 2 and 3 adapted to be placed one atop another, as indicated in FIG. 1, the confronting surface of each of the members 2 and 3 being identical. As is shown in FIG. 2, the member 2 has a surface 4 adapted to confront the corresponding surface of the member 3. Extending from one end of the member 2 the surface 4 has therein a semi-circular groove 5 which terminates at its inner end in a semi-circular, abrupt wall or shoulder 6. Communicating with the groove 5 is one end of a groove 7 which is of less depth than that of the groove 5. The opposite end of the groove 7 is curvilinear or flared outwardly as at 8 and communicates with one end of a second semi-circular groove 9 having a depth corresponding to the depth of the groove 5. The flared end 8 of the groove 7 forms a smooth,arcuate juncture between the groove 7 and the groove 9. Although not shown in detail in the drawings, that surface of the body 3 which confronts the surface 4 of the body 2 has companion grooves exactly like the grooves 5, 7 and 9, respectively, so that, when the member 3 overlies the member 2, as shown in FIG. 1, the groove 5 and its companion groove form a cylindrical chamber, the groove 9 and its companion groove 9a form a similar cylindrical recess or forming chamber C, and the groove 7 and its companion groove form a cylindrical, reduced cross-sectional area throat establishing communication between the two cylindrical chambers.

The die 1 is adapted for use in forming a terminal at the free end of a conductor 10 which may comprise a stranded wire 11 composed of parallel copper or other conductive filaments, as shown in FIG. 3. The conductor includes insulation 12 which surrounds the wire and which may be stripped from the free end 13 of the wire in a conventional manner so that the free end of the wire projects beyond the end 14 of the insulation.

To condition the apparatus thus far described for use, the parts 2 and 3 are separated and the conductor 10 assembled with the member 2 in such manner that the insulation 12 lies in the groove 5 with its free end 14 abutting the shoulder 6. The free end 13 of the wire will lie at the base of and extend beyond the groove 7 into the groove 9, as indicated in FIG. 3. The radius of the groove 5 corresponds substantially to the radius of the insulation 12 and the radius of the groove 7 preferably corresponds to the radius of the wire 11. The depth of the groove 7, therefore, is less than the depth of the groove 5 by an amount corresponding to the thickness of the wall of the insulation 12. The radius of the grooves 9 and 9a may correspond to the radius of the insulation 12, but it may be greater if desired.

Following placement of the conductor 10 on the die part 2 as shown in FIG. 3, the member 3 then may be placed in overlying relation to the member 2 with the parts 12, 13 and 14 of the conductor 10 received in the grooves in the member 3 which correspond to the grooves 5, 7 and 9, respectively. The parts 2 and 3 then may be clamped in any conventional manner. The groove 5 and its companion groove may be roughened or be slightly under-sized with relation to the size of the insulation 12 so as to clamp the conductor in the die 1.

When the conductor is clamped in the die 1, a forming tool 15 provided with a head 16 having a configuration and cross-sectional area corresponding to the configuration and cross-sectional area of the forming chamber C may be introduced to the forming chamber. It will be understood that the size of the head 16 will be such as to enter the chamber with as little clearance as is possible.

The head 16 is carried by a shank 17 by means of which the head 16 may be introduced into the chamber C in which the free end 13 of the wire lies. As the head 16 enters the chamber, it engages the free end of the wire and exerts an axially compressive force on the latter sufficient to cause the wire to become heated and flow or be deformed both axially and radially outwardly so that its free end assumes a shape and cross-sectional area corresponding to the shape and cross-sectional area of the chamber C.

The head 16 may be moved axially only so as to form the terminal by a swaging process, or it may be moved axially and rotated either simultaneously with or after the application of the compressive force so as to form the terminal by a swaging and spinning process. The spinning of the head 16 in most instances will produce a smoother surface on the free end of the terminal. In either event the free end of the wire is deformed so as to provide an enlarged terminal 18 having a configuration like that of the forming chamber C and a cross-sectional area corresponding to that of the forming chamber. Inasmuch as the forming chamber provided by the grooves 9 and 9a has a greater cross-sectional area than that of the wire 11, the terminal 18 also will have a greater cross-sectional area than that of the wire 11. As shown in FIG. 4, however, the cross-sectional area of the terminal 18 is the same as the cross-sectional area of the combined wire and insulation. If a terminal having a cross-sectional area greater than that of the wire is desired, it is necessary only to enlarge the forming chamber C and the head 16.

As is illustrated in FIG. 4 that portion of the wire 11 which occupies the throat provided by the groove 7 and its companion groove forms a neck 19 between the terminal 18 and the end 14 of the insulation 12. Due to the flared end 8 of the groove 7, and the correspondingly flared end of the companion groove in the member 3, an arcuate or curvilinear shoulder 20 is provided at the juncture between the terminal 18 and the neck 19. The shoulder 20 compensates for work hardening of the wire during the forming operation and makes the juncture between the terminal and the neck less susceptible to being broken.

The free end 21 of the terminal 18 illustrated in FIG. 4 is convex. To produce the convex end, the free end of the forming head 16 is concave as indicated at 22.

It is not necessary that the conductor 10 be formed of stranded wire or that the free end of the terminal formed thereon have a convex free end. As is indicated in FIGS. 5 and 6, a conductor 23 comprises a single wire filament 24 surrounded by insulation 25, the free end of the wire being deformed in the same manner as the free end 13 of the stranded wire 11 so as to provide an enlarged terminal 26 spaced from the free end 27 of the insulation by a neck 28 and an arcuate shoulder 29. The free end 30 of the terminal 26, shown in FIG. 5 is concave, whereas the free end 30a of the terminal 26 shown in FIG. 6 is flat. The concave end 30 may be formed by a member exactly like the member 16 except for a convex end in lieu of the concave end 22, and the flat end 30*a* may be formed by a member like the member 16 except for a flat end in lieu of the concave end. The conductor 23 shown in FIG. 6 corresponds exactly to the conductor shown in FIG. 5, except for the difference in the shape of its free end.

If it is desired, a metallic powder such as silver or any other metal having better conductive properties than those of which the conductor wire is formed may be added to the forming chamber prior to formation of the terminal so as to coat the latter with the other material. During the swaging or spinning process the powdered metal will be distributed over the end of the terminal. The finished terminal also may be dipped in molten tin or the like if desired.

Following the formation of an integral terminal at the free end of a conductor, the conductor may be removed from the die **1** whereupon it may be used in any conventional manner. For some purposes it is desirable to mold by conventional means an insulating sleeve at the terminated end of the conductor. Such a sleeve is indicated at **31** and preferably comprises a glass-filled resin of insulating material that completely surrounds the neck **19** and the adjacent portions of the insulation **12** and the terminal **18**, the free end of the terminal **18** being exposed. Since the material forming the sleeve **31** fills the space between the end **14** of the insulation **12** and the shoulder **20**, the sleeve **31** is interlocked with the insulation **12** and the terminal **18** so as to prevent relative axial movement of the sleeve and the conductor **10**.

The sleeve **31** preferably has a circumferential, compressible ring **32** adjacent one end of the sleeve and a number of axially extending, compressible ribs **33** which are located between the ring **32** and an enlarged base **34** at the opposite end of the sleeve **31**.

Conductors of the kind disclosed herein are especially adapted for assembly in multiple conductor connectors of the kind illustrated in FIG. **8** as comprising a pair of body members **35** and **36** each of which is formed of insulating material. The body **35** has a plurality of sockets **37** for the accommodation of a corresponding plurality of conductors **10**, each of the sockets **37** having a diameter so related to the diameter of the sleeve **31** that the parts **32** and **33** will bear forceably against the surface of the socket **37** so as frictionally to retain the terminated end of the conductor in the socket. Any sleeve may be removed from its socket, however, if necessary.

The body **36** carries a number of conductors **38** corresponding to the number of the conductors carried by the body **35**, each of the conductors **38** having a terminal **39** which confronts the terminals **18** when the bodies **35** and **36** are arranged in confronting relation. The terminals **18** may bear directly against the terminals **39**, if desired, but it is preferred to interpose therebetween an elastomeric member **40** of the kind disclosed in copending application, Ser. No. 34,320, filed May 4, 1970 and now U.S. Pat. No. 3,648,002. The member **40** comprises a pad **41** of resilient, compressible, nonconductive material such as silicone rubber provided with inserts **42** composed of such non-conductive material throughout which conductive particles **43** are dispersed. The inserts **41** are so positioned as to be interposed between confronting terminals **18** and **39** and are rendered conductive when the inserts are compressed between the terminals be an amount sufficient to cause the conductive particles to establish a conductive path through the insert. At the marginal edge of the pad **41** is an enlargement **43** which acts as a seal around the periphery of the pad **41**. The use of the elastomeric member **40** compensates for any difference in the height or level of any of the terminals. The connector body parts **35** and **36** may be maintained in assembled relation with the inserts **41** properly compressed by any suitable and conventional means.

The disclosed embodiments are representative of presently preferred forms of the invention, but are intended to be illustrative rather than definitive thereof. The invention is defined in the claims.

We claim:

1. An electrical conductor comprising an electrically conductive, metal member joined at least at one end to a terminal integral with said member, said terminal having a smooth surface at least at its free end and a cross-sectional area greater than the cross-sectional area of said member and being constituted by the metal of said member; insulation surrounding said member but terminating short of said terminal whereby that portion of said member between said terminal and said insulation forms a neck of less cross-sectional area than that of said terminal and less than that of the combined insulation and member; and a sleeve of insulating material surrounding said neck and the adjacent portions of said insulation and said terminal, said sleeve snugly engaging said neck whereby movement of said sleeve axially of said terminal is restrained by the latter and the end of said insulation, the free end of said terminal projecting beyond said sleeve.

2. The construction according to claim **1** wherein said member is composed of a plurality of parallel strands.

3. The construction according to claim **1** wherein said member comprises a single filament.

4. The construction according to claim **1** wherein said terminal has a convex free end.

5. The construction according to claim **1** wherein said terminal has a concave free end.

6. The construction according to claim **1** wherein said terminal has a substantially flat free end.

7. The construction according to claim **1** including compressible retaining means carried by said sleeve and projecting outwardly thereof.

8. The construction according to claim **1** wherein the juncture between said terminal and said member presents a smoothly arcuate, outwardly concave surface.

* * * * *