United States Patent

[11] 3,568,130

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[21] Appl. No. **813,863**
[22] Filed **Apr. 7, 1969**
[45] Patented **Mar. 2, 1971**
[73] Assignee **KDI Sealtron Corporation**

[54] **ELECTRICAL CONNECTOR FOR ALUMINUM CABLE**
8 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** **339/30,** 339/276
[51] **Int. Cl.** **H01r 13/20,** H01r 11/08
[50] **Field of Search** 339/30, 89, 276, 278; 287/104; 285/187; 174/84, 90, 91, 94; 29/196.2, 199

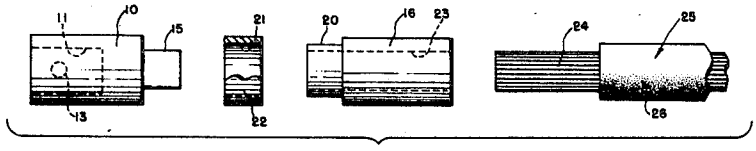
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Assistant Examiner—Terrell P. Lewis
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ABSTRACT: An electrical connector of one material such as a copper alloy may be secured to a cable of a different material such as aluminum in an assembly which will resist loosening under heat, by securing the conductive strands of the cable within the internal bore of a tube of material akin to the material of the cable strands, and also disposing a portion of the connector within such internal bore, while a reinforcing ring is exteriorly disposed about said sleeve in the vicinity where the connector portion is located.



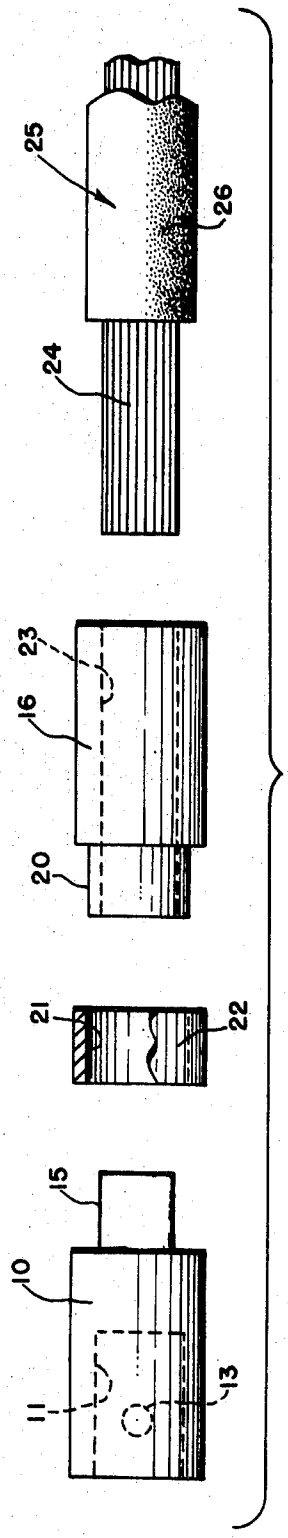


FIG. 1

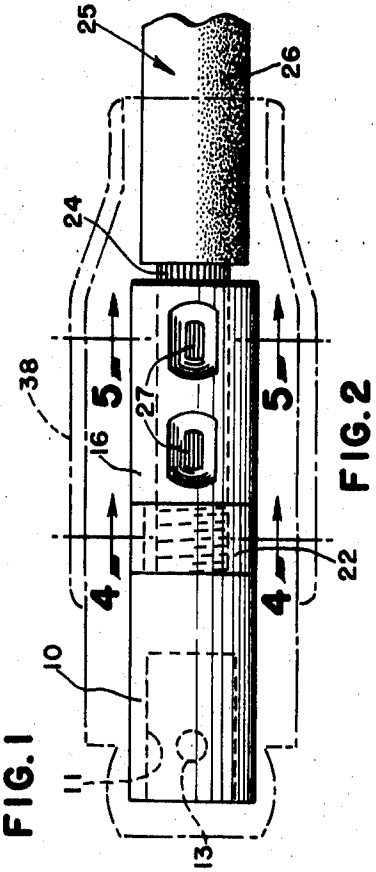


FIG. 2

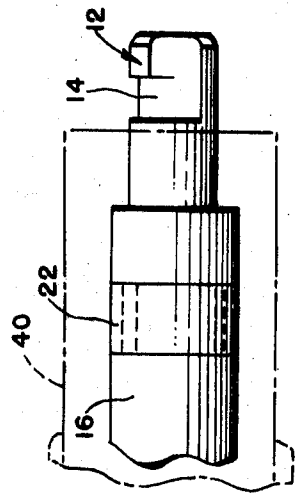


FIG. 3

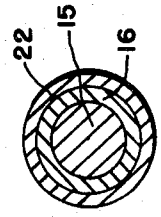


FIG. 4

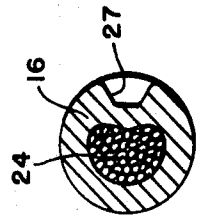


FIG. 5

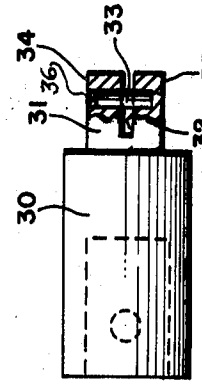


FIG. 6

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ELECTRICAL CONNECTOR FOR ALUMINUM CABLE

This invention relates to connector means for interconnecting separate lengths of electrical cable, and more particularly to connector means which are useful where it is necessary or desirable that the connector and the conductive strands of the cable be of different materials.

Releasable terminal connectors for electrical cables are by now well known and in common use. A well known and highly successful type of connector is illustrated in U.S. Pat. Nos. 2,907,973 and Re. 25,506, both invented by C. H. Stevens, Jr. These connectors are readily attached to the conductive strands of electrical cables by baring a short length of such strands at the end of the cable, then attaching the connector thereto by crimping, soldering, or use of setscrews.

Such connectors are in wide use simply because it is more convenient and less strenuous to carry short lengths of electrical cable to the place of use and connect such short lengths together in order to achieve an overall desired length, rather than carrying a single length of cable to the place of use. So long as there is substantially no sacrifice of efficiency in terms of carrying of current, the use of a number of short lengths of cable is as acceptable as is the use of a single length of cable. Terminal connectors such as those illustrated in the mentioned patents do an excellent job of interconnecting cable lengths without sacrifice of efficiency.

The connectors here being discussed are uniformly made of copper alloy such as brass, for it has been found that by utilizing this material, all of the required characteristics as to appropriate electrical properties, dimensional and shape stability, together with amenability to being formed into appropriate shapes without undue difficulty, may be obtained. Where copper stranded electrical cable is employed, no problem has arisen where terminal connectors as described has been attached to them because of the close similarity in the materials and their respective thermal properties. Where, however, aluminum stranded electrical cable is employed, problems have arisen.

Forming the terminal connectors themselves from aluminum and then connecting them to aluminum cables by crimping, soldering or setscrew in the manner currently used where copper alloy connectors and cables are used, has not proved possible. Connectors of aluminum simply do not stand up in use as do the more durable copper alloy connectors. Moreover, an inherent characteristic of aluminum is the formation of a tough surface oxide which is an inhibiting factor in making good electrical contact between interengaging connectors. Efforts have been made to overcome these difficulties by employing copper alloy connectors and attaching them to aluminum cables, but the usual techniques of joining the connectors to the cables have proved unsatisfactory. For example, attempts to solder aluminum cable to conventional copper alloy terminal connectors have proved far from satisfactory. The problem becomes increasingly acute in view of the obvious desirability inhering in the use of aluminum stranded cable by reason of the lighter weight and lower expense of aluminum by contrast to copper, and the growing desire to supplant copper cable with aluminum.

Limited success in satisfactory connection has been achieved in uniting aluminum cable and copper alloy connectors by means of mechanical bonding between the two. One means of doing this has been to introduce a portion of a copper alloy connector of appropriate configuration into the internal bore of an aluminum tube, the strands of an aluminum electrical cable also being disposed in such bore. The aluminum tube is press fit about the portion of the connector provided, and also may be appropriately deformed, as by crimping, to retain the strands of the cable in place within the tube. It has been found, however, that in use elevated temperatures often develop in the vicinity of the connector, and because of the good heat conduction properties of the copper alloy material of the connector, such temperatures are transmitted

to the situs where aluminum and copper alloy are joined. Where this occurs it has been found that the mechanical bond between the copper alloy connector and the aluminum tube is seriously weakened. It is believed that the reason that this occurs is because of the much greater coefficient of thermal expansion of aluminum by contrast to that of copper. Under heat, then, the aluminum tube will expand at a much greater rate than will that of the copper alloy material of the connector, and the mechanical bond between the two will be adversely affected. There is an additional property of aluminum which is deleterious where elevated temperatures occur, and that is the tendency of aluminum to expand under increasing temperature, but not return to its original dimension as the temperature is subsequently decreased.

It is the primary object of the present invention to provide for mechanical bonding between an electrical connector member of copper alloy, and an aluminum electrical cable, the two members being united in a manner which will not suffer though increased temperatures occur where the bond exists. The manner in which this primary object is carried into effect, is to dispose a portion of an electrical connector within an aluminum tube and then exteriorly of the aluminum tube envelope the tube in a restraining member such as a ring, which is of a material having a coefficient of thermal expansion equal to or less than that of the material of the electrical connector. The restraining element is placed exteriorly of the position within the aluminum tube where the portion of the electrical connector is in place.

Another object herein is to provide an electrical connector not drastically different from those which manufacturers are already equipped to produce, so that present facilities may be employed in the manufacture of the novel connectors herein provided. In addition to such connector means, a simple and inexpensive aluminum tubing coupler element, and restraining member, or ring, are employed.

A further object is to provide for ready and releasable interengagement of aluminum stranded electrical cable by simple means which may be applied at field locations if this is desired.

How these and many other objects are to be implemented will become clear through a consideration of the accompanying drawings wherein:

FIG. 1 shows a side view of the elements comprising an aluminum cable connector assembly, the elements being presented in exploded fashion;

FIG. 2 shows the elements of FIG. 1 following assembly, it being noted that such assembly includes a female connector;

FIG. 3 shows the forward portion of a male connector assembly simply for purposes of illustrating how the female connector of FIG. 2 would be utilized;

FIG. 4 is a section at 4–4 in FIG. 2;

FIG. 5 is a section taken at 5–5 in FIG. 2; and FIG. 6 is a side view of another female connector which can be used in the practice of the present invention.

The drawings show the present invention utilized in conjunction with one type of electrical connector elements, it being understood that the invention can equally well be used with electrical connectors of other types. The connector type illustrated was known and in use at the time of the present invention. This type of connector employs a female connector **10** having an internal recess **11**, which connector is affixed at the end of one length of electrical cable. Male connector **12**, which would appear at the end of a second cable length desired to be put into electrical contact with the first length, is illustrated in FIG. 3. Such male connector would be introduced into the internal recess of female connector **10** and rotated to both lock the male connector within the female, and also to bring the surface of male connector **12** into as close electrical contact as possible with the walls of internal recess **11** of female connector **10**. Tightening up would occur upon such rotation because internal pin **13** would be brought into increasingly closer contact with cam surface **14** in male connector **12**.

As has been stated the particular connectors here illustrated are for purposes of illustration only, and the present invention relates to the manner in which a connector is secured in electrical contact with the conductors within an electrical cable. The present invention would apply in exactly the same way to both the male and female connector where the connector of the type above described is employed, and can as well be used with electrical connectors of other types not here illustrated.

The female connector **10** shown in the drawings is made of brass and can be readily machined. A stub portion **15** is turned down from the major diameter of connector **10**. The aluminum sleeve **16** has a turned down end **20**, and the external diameter of turned down end **20** has a slightly smaller dimension than internal diameter **21** of stainless steel ring **22**, so that ring **22** can freely be placed over the turned down end **20**.

The aluminum sleeve **16** has a circular bore therethrough defined by internal wall **23**, and stub **15** is intended to fit into one end of such bore within aluminum sleeve **16**. The stub **15** is slightly oversize with respect to the internal wall **23** of circular bore through aluminum sleeve **16**.

Assembly of the heretofore mentioned elements is carried out by first slipping stainless steel ring **22** over turned down end **20** of aluminum sleeve **16**. The oversized stub **15** is then press-fit into circular bore having wall **23** which extends through aluminum sleeve **16**. The effect of this insertion will be to expand the readily deformable aluminum into tight frictional contact with the internal diameter of stainless steel ring **22**, thereby maintaining such ring and aluminum sleeve firmly united. While the material of ring **22** has been identified as stainless steel in the present description, any material having an equal or lower coefficient of expansion than the material comprising the connector **10** may be employed in making such ring.

Aluminum sleeve **16** also serves as means to receive and retain the conductive aluminum strands **24** of electrical cable **25**. Prior to insertion of the aluminum strands **24** of the cable **25**, a portion of the insulation **26** of cable **25** is stripped away to leave an extended portion of the aluminum strands bare. After insertion of such strands **24** within walls **23** of aluminum sleeve **16**, the wall of such aluminum sleeve is deformed by crimps indexed **27**.

It will be understood that the connectors **10** and **12** in use will be protected by insulating sleeves which are shown in FIGS. **2** and **3** in section lines, and identified by numerals **38** and **40** respectively.

The structure of a connector **10** such as shown in FIG. **1** may be modified in the manner illustrated in FIG. **6** in order to enhance the union between stub and aluminum sleeve under the adverse influence of heat. In FIG. **6** a female connector **30**, preferably made of brass, is shown having stub portion **31**. The stub **31** has a slot **32** and a zinc plug **33** is retained within said stub across said slot. Slot **32** divides said stub into arms **34** and **35**. One end of zinc plug **33** bears against a fixed wall in arm **34**. A setscrew is threaded into place in arm **35** after insertion of plug **33** to provide a second fixed wall against which plug **33** may bear. Thus, expansion of the zinc plug **33** will result in a forcing apart of the arms **34** and **35** on either side of slot **32**.

Female connector have would be integrated into an assembly as illustrated in FIG. **2** in the same manner as would female connector **10**. If heat were to arise in the connector assembly employment of a connector such as illustrated in FIG. **6** would enhance the effect which would obtain in the assembly illustrated in FIG. **2** in that not only would the stainless steel ring **21** be acting to restrain expansion of the material of aluminum sleeve **16** under heat, but in addition the heating of zinc plug **33** would cause such plug to expand at a greater rate than the brass of female connector **30**, thereby causing arms **34** and **35** of stub **31** to separate and forcing such arms into the deformable material of aluminum sleeve **16**. There would thus be restraint on the outside of the aluminum sleeve imposed by stainless steel ring **22**, and enhanced expansion within such aluminum sleeve by means of force exerted by the zinc plug **33**.

While I have described specific embodiments of my invention, it is apparent that changes and modifications may be made therein without departing from the spirit thereof.

I claim:

1. An electrical connector for terminating an electrical cable having conductive strands, comprising:

connector means for electrical interengagement with mating connector means, said connector means being of a first conductive material and having a stub portion:

sleeve means having an internal bore therethrough, said sleeve means being of a second conductive material, said second material having a coefficient of thermal expansion greater than that of said first conductive material, said stub portion and said conductive strands of said cable being secured within said internal bore;

a collar snugly disposed about the exterior of said sleeve means at the portion thereof within which said stub portion is disposed, said collar being of a material having a coefficient of thermal expansion not greater than that of said first conductive material; and

said stub portion of said connector element being slightly oversize relative to said internal bore so that upon pressing said stub portion into said internal bore, the material of said sleeve will be expanded outwardly against said collar.

2. An electrical connector as claimed in claim **1** wherein the surface of said stub portion is roughened.

3. An electrical connector as claimed in claim **1** wherein said first conductive material is copper alloy and said second conductive material is comprised substantially of aluminum.

4. An electrical connector as claimed in claim **3** wherein the material of said collar is stainless steel.

5. An electrical connector as claimed in claim **1** wherein said stub portion includes a pair of arms separated by a slot and plug means extending across said slot and being in contact with each of said arms.

6. An electrical connector as claimed in claim **5** wherein the material of said plug means has a coefficient of thermal expansion greater than that of said first conductive material.

7. The method of interconnecting an electrical connector made of copper alloy having an engaging portion and a stud portion, and an electrical cable having conductive strands of aluminum, comprising disposing a restraining collar about an aluminum sleeve having an internal bore therethrough, said stub portion of said electrical connector being slightly oversize with respect to said internal bore, then press fitting said stub portion into said internal bore, said collar being disposed exteriorly of that portion of said sleeve within which said stub portion is situated, and also securing said conductive strands of said cable within said sleeve.

8. The method of interconnecting an electrical connector as claimed in claim **7** wherein said conductive strands of said cable are secured within said sleeve by crimping said sleeve.