Jan. 3, 1967 L. R. TRAVIS ETAL 3,296,577

ELECTRICAL CONNECTOR ASSEMBLY AND METHOD

Filed Oct. 21, 1964

FIG. 1.

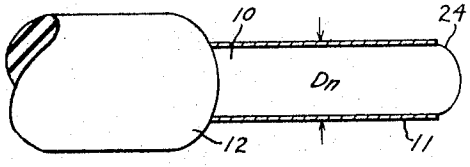



FIG. 2.

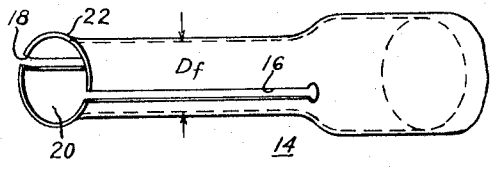



FIG. 3.

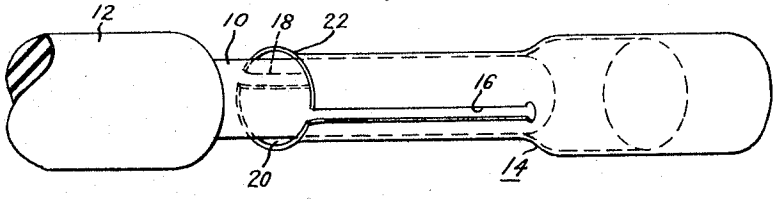



FIG. 4.

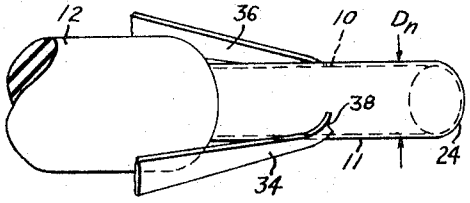



FIG. 5.

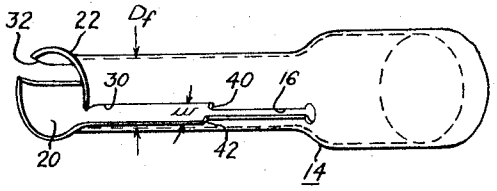
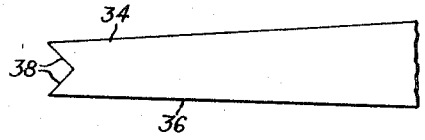



FIG. 6.




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# ELECTRICAL CONNECTOR ASSEMBLY AND METHOD

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6 Claims. (Cl. 339—275)

The present invention relates to electrical connector assemblies, and more particularly to electrical connector assemblies for soldering together an electrical conductor and a female type of connector.

Numerous electrical connector assemblies have been devised for soldering together an electrical conductor, usually a wire having a circular cross-section, and a female type of connector contact or terminal. One of the most common systems is that of inserting a wire into a solder cup type of female connector which has a relatively large cross-section compared to that of the wire and then applying solder and heat to the assembly to complete the connection. The difficulties with this system are: the solder provides the complete connection between the wire and the female conductor, the use of the solder cup type of connector introduces a large amount of solder around the wire which may create voids or pockets in the solder and thereby affect the electrical conductivity of the connection, and a relatively long time is required for making such a connection because of the number of steps involved. Moreover, if a large number of connections are to be made within a limited area difficulty may be encountered in completing the array using the above method. Another frequently used connector assembly is that of a solderless or pressure type of connection in which the conductor and connector are secured together mechanically, for example by crimping, or by placing a band about the conductor and connector. Since the conductor and connector are held together merely by physical pressure contact, a relatively poor electrical connection may be obtained. Moreover, because of forces being applied to the crimped or secured mechanical connection and perhaps thermal cycling of the connection, the pressure of the connection eventually may become reduced to the point of perhaps being open circuited. Various other systems of either providing a solder connection or a mechanical connection between a conductor and a female type of connector have been suggested, however, these also present all or at least some of the attendant problems as discussed above.

Another problem of presently used solder connector assemblies is that of removal of the connection. This is especially prevalent when high density female connectors are utilized. In the solder cup connector, breaking the connection is particularly difficult. With a pressure connector the removal process is easier, however, a relatively unreliable electrical connection is obtained.

It is therefore an object of the present invention to provide a new and improved electrical connector assembly and a method of providing such a connector assembly.

It is a further object of the present invention to provide a new and improved electrical connector assembly utilizing both a solder and a pressure type of connection and a method of providing such a connector assembly.

It is still a further object of the present invention to provide a new and improved electrical connector assembly which provides good electrical conductivity, ease of making and breaking the connection, and high reliability, and also a method of providing such a connector assembly.

Broadly, the present invention accomplishes the above cited objects by providing an electrical connector assembly and a method for providing such a connector in which an electrical conductor is soldered to a female type of connector by utilizing in combination a pressure connection and a solder connection. Specialized soldering apparatus is utilized in one embodiment in order to enhance the speed of making and breaking of the connection.



These and other objects and advantages of the present invention will become more apparent when considered in view of the following specification and drawings, in which:

FIGURE 1 is a pictorial diagram of male type electrical conductor as utilized herein;

FIG. 2 is a pictorial diagram of one embodiment of a female connector as utilized herein;

FIG. 3 is a pictorial diagram showing the electrical conductor of FIG. 1 secured to the female connector of FIG. 2;

FIG. 4 is a pictorial diagram of an electrical conductor gripped by a soldering tool;

FIG. 5 is a pictorial diagram of another embodiment of a female connector as utilized herein; and

FIG. 6 is a plan view of the gripping tip portion of the soldering apparatus as utilized herein.

Referring to FIG. 1, an electrical conductor is shown in the form of a wire **10** having a portion of its insulation **12** stripped back from the end thereof. The electrical conductor is shown as a wire having a substantially circular cross section, however, it may take the form of any male type of electrical connector and may also be a single or a multiple strand structure. The exposed portion of the conductor **10** as utilized herein is tinned or solder dipped to form a solder layer **11** on the conductor **10**. The tinning process is performed in order to: (1) provide the necessary solder to secure the conductor to the female connector, (2) add additional mechanical strength to the conductor, and (3) coat the ends of the conductor in the case of a multiple strand wire and prevent corrosion of the copper with the solder. In certain applications, it may not be necessary to tin the conductor **10**. However, in most instances best results will be obtained by tinning.

FIG. 2 shows a female connector **14**, which is tubular in form with a substantially circular cross-section. The female connector **14** may be fabricated, for example, of a spring type of material which is tubular in cross-section, a counterbored rod or a formed stamping. The female terminal **14** has an inside diameter $D_f$ substantially identical or slightly smaller than the diameter $D_n$ of the conductor **10**. Two slots **16** and **18** are cut from the open end **20** of the terminal **14** on opposite sides of the terminal in a plane containing the axis of the terminal. The slots **16** and **18** may be formed by machining, stamping, or other methods, and are cut from the open end **20** a distance at least several times the diameter of the terminal toward the back portion of the connector terminal. At the end **20** the terminal **14** flares out at a flange portion **22** which permits the ready insertion of the conductor **10**. Also the flange portion **22** provides a camming surface to the end **24** of the conductor **10** which will force apart the sides of the slots **16** and **18** as the conductor **10** is inserted into the opening **20**.

To secure the conductor **10** to the female terminal **14**, the conductor **10** is forced into the opening **20** with the end portion **24** thereof engaging the flange portion **22** of the terminal **14**. This forces apart the slots **16** and **18** with the conductor **10** then being forced to its desired insertion length into the terminal **14**. A reactive force will be asserted against the conductor **10** by the terminal **14** since the inside diameter $D_f$ of the terminal **14** between the inside wall, is originally, without insertion of the conductor **10**, substantially the same or somewhat smaller than the diameter $D_n$ of the conductor **10**. Thus, a pressure connection will be established between the inside wall of the terminal **14** and the wire conductor **10**. The spring pressure also serves to ensure a very

thin solder interface between the inside of the connector and the outside of the conductor. The connection process is completed by applying heat to the connector terminal **14** and the conductor **10** in a sufficient amount to melt the solder layer **11** that had been previously applied to the exposed end of the conductor **10**. The solder will thus melt by the well known soldering process and will adhere to the inside wall of the conductor **14** to form an excellent electrical and mechanical connection thereto.

The heat to melt the solder may be supplied by a conventional soldering tool or more favorably with resistance soldering apparatus whereby the workpiece is heated by the flow of current therethrough. Such resistance soldering apparatus is described in copending application Serial No. 358,439, filed April 9, 1964, and assigned to the same assignee of the present application. The use of resistance soldering apparatus will be discussed in more detail with reference to the embodiment of FIGS. 4 and 5.

Considering now the embodiment of FIGS. 4 and 5, the electrical conductor of FIG. 4 is substantially the same as that of FIG. 1 having an electrical conductor **10** with the insulation **12** stripped back from the end portion thereof. FIG. 5 shows the female terminal **14** being substantially the same as that of FIG. 2 except that the slots **16** and **18** have a widened frontal section **30** and **32**, respectively, which extend from the front portion **20** approximately half way back the length of the slots **16** and **18**. The normal unstressed inside diameter $D_f$ of the female connector terminal **14** is again designed to be substantially the same or slightly smaller than that of the diameter $D_n$ of the conductor **10**. The width *w* of the portions **30** and **32** of the slots **16** and **18** is designed to accommodate the tip portion of a resistance soldering apparatus.

To insert the conductor **10** into the female terminal **14**, the conductor **10** is gripped approximately at its midpoint between the end **24** and the insulation **12** by a pair of gripping tip portions **34** and **36** of a resistance soldering tool as described in the above copending application. The gripping tip portions **34** and **36** may have a contacting portion **38**, as better shown in FIG. 6, which is V-shaped to act as a self-centering device as well as gripping the conductor **10**. Of course, other configurations for the gripping portion **38** may be utilized depending upon the particular application. The gripping tip portion shown in FIG. 6 has such a cross-sectional dimension to permit passage through the portions **30** and **32** of the slots **16** and **18**, and thus must be somewhat smaller than the width *w*, shown in FIG. 5.

With the gripping tip portions **34** and **36** gripping the conductor **10**, the conductor **10** is inserted into the opening **20** of the female terminal **14**. The front portion **24** of the conductor **10** engages the flange portion **22** of the terminal **14**, which acts to permit the ready entrance of the terminal **10** and also as a camming surface to force the slots **16** and **18** apart. The conductor **10** is then inserted into the terminal **14**, the gripping tip portions **34** and **36** being so aligned to enter into the widened portions **30** and **32** of the slots **16** and **18** respectively. The conductor **10** is forced into the female terminal **14** until the tip portions **34** and **36** engage the back portions **40** and **42** of the slots **16** and **18**. At this time, the resistance soldering apparatus is energized which will cause current to flow through the tip portions **34** and **36** and the conductor **10** which will heat the conductor **10** and the female terminal connector **14** to melt the solder **11** which had previously been applied to the conductor **10** as described above. The melted solder will adhere to the inside wall of the female terminal **14** and provide a good electrical and mechanical connection thereto. Moreover, a good pressure connection will be provided by the cantilever action of the female terminal **14** pressing against the outside surface of the conductor **10**.

The use of the resistance soldering tool provides a highly localized heat in a short time. The conductor **10** is gripped at substantially its midpoint in order to have a relatively equal distribution of heat in each direction without excessive heat being applied to the insulator portion **12** of the conductor. After the soldering process has been completed, which will be a relatively short time because of the rapid action of resistance soldering techniques, the soldering apparatus is deenergized and the gripping portions **34** and **36** removed from the conductor **10** out and away from the portions **30** and **32** of the slots **16** and **18**.

As in the embodiment of FIGS. 1, 2 and 3, the embodiment of FIGS. 4 and 5 provides a highly reliable connection having a large contacting area using a combination of pressure and solder connection. The amount of solder surrounding and connecting the conductor **10** to the inner surface of the female terminal **14** is relatively small to avoid the problem of voids or pockets in the solder. Moreover, the time necessary to make the connection is relatively small, particularly if resistance heating is employed.

In the embodiment of FIGS. 4 and 5, a one-hand soldering process can be employed by inserting the wire with the gripping tip portions **34** and **36** into the female terminal **14** and then energizing the soldering apparatus. This method is particularly advantageous when the terminals are closely spaced together at the rear portions of a connector array. If it is desired to remove the conductor **10** from the female terminal **14** all that is necessary that the gripping portions **34** and **36** be inserted through the slots **30** and **32** to engage the conductor **10**. Then, the resistance heating apparatus is energized to melt the solder. The conductor **10** is removed from the female connector terminal **14** with the gripping portions **34** and **36** passing through the portions **30** and **32** of the slots **16** and **18**. It should also be noted that in the embodiment of FIGS. 1, 2 and 3, a removable structure is provided by heating the female terminal **14** with a suitable soldering tool and then removing the conductor **10** when the solder has melted.

The embodiments described above have pre-tinned or solder-coated the conductor **10** before insertion into the female terminal **14**. However, of course, other methods of providing the solder material could be utilized. In particular, if the female terminal is a formed stamping, the inside surface of the stamping itself could be solder coated. Also, as another alternative, the conductor **10** could have a solder foil disposed therearound.

Although the present invention has been described with a certain degree of particularity it should be understood that the disclosure has been made only by way of example and that numerous changes in the details of construction and fabrication and the combination and arrangement of parts, elements and steps of the method may be resorted to without departing from the scope and the spirit of the present invention.

We claim as our invention:

**1.** A connector assembly to be secured with resistance soldering apparatus having a gripping tip portion, said assembly comprising, a male conductor, a female connector including a pair of elongated slots oppositely disposed thereon in a plane and extending through an open end thereof at which the male conductor is to enter, said pair of slots having a wider width portion at the open end of said female connector compared to the rest of the slot, said wider width portion extending a predetermined length along said slot, an abutting portion being defined in said slot at the end of said wider width portion, said wider width portion being large enough to receive the gripping tip portion of said resistance soldering apparatus, solder disposed at the desired connection area, said male conductor being inserted into said female connector by grasping said male conductor with the gripping tip portion of said resistance soldering apparatus, the gripping tip portion passing through the wider width portion of said slots in said female con-

nector and when the gripping tip portion abuts said abutting portion of said slots said resistance soldering apparatus being energized to melt the solder to secure said male conductor and said female connector.

2. A connector assembly to be secured with resistance soldering apparatus having a gripping tip portion, said assembly comprising, a male conductor being predipped in solder for physical strength and for providing solder at the desired connection area, a female connector including a pair of elongated slots oppositely disposed thereon in a plane and extending through an open end thereof at which the male conductor is to enter, said female connector having such a diameter so that with said male conductor being inserted therein said slots being forced apart to insert a force against said male conductor, said pair of slots having a wider width portion at the open end of said female connector compared to the rest of the slot, said wider width portion extending a predetermined length along said slot, an abutting portion being defined in said slot at the end of said wider width portion, said wider width portion being large enough to receive the gripping tip portion of said resistance soldering apparatus, said male conductor being inserted into said female connector by grasping said male member with the gripping tip portion of said resistance soldering apparatus, the gripping tip portion passing through the wider width portion of said slots in said female connector and when the gripping tip portion abuts said abutting portion of said slots said resistance soldering apparatus being energized to melt the solder to secure said male conductor and said female connector.

3. A method of making an electrical solder connection with soldering apparatus between a male conductor and a female connector having at least a pair of elongated slots disposed thereon and extending through an open end thereof at which the male conductor is to enter, said method comprising the steps of: providing solder at the desired connection; grasping the male conductor at the opposite sides thereof with a gripping tip portion of the soldering apparatus; inserting said male conductor into said female connector with said soldering apparatus; passing said soldering apparatus while grasping said male conductor through said slots a predetermined distance; and energizing said resistance soldering apparatus to melt the solder and secure said male conductor and said female connector.

4. A method of making an electrical solder connection with soldering apparatus between a male conductor and a female connector having at least a pair of elongated slots oppositely disposed thereon and extending through an open end thereof at which the male conductor is to enter, said method comprising the steps of: providing solder at the desired connection; grasping the male conductor at the opposite sides thereof with a gripping tip portion of the soldering apparatus; inserting said male conductor into said female connector so that the slots thereof are forced apart to apply a reactive force to said male conductor, the slots being lined up with the gripping tip portions of said soldering apparatus; passing the gripping tip portions of said soldering apparatus while grasping said male conductor through said slots a predetermined distance; energizing said soldering apparatus to melt the solder and secure said male conductor and said female connector; deenergizing said soldering apparatus; and disengaging said soldering apparatus from said male conductor.



5. A method of making an electrical solder connection with resistance soldering apparatus between a male conductor and a female connector having at least a pair of elongated slots oppositely disposed thereon in a plane and extending through an open end thereof at which the male conductor is to enter, said method comprising the steps of: providing solder at the desired connection; grasping the male conductor at the opposite sides thereof with a gripping tip portion of the resistance soldering apparatus; inserting said male conductor into said female connector so that the slots thereof line up with the gripping tip portions of said resistance soldering apparatus; passing the gripping tip portions of said resistance soldering apparatus while grasping said male conductor through said slots a predetermined distance until said gripping tip portions abut against a portion of said slots; energizing said resistance soldering apparatus to melt the solder and secure said male conductor and said female connector; deenergizing said resistance soldering apparatus; and disengaging said resistance soldering apparatus from said male conductor.

6. A method of making and breaking an electrical solder connection with resistance soldering apparatus between a male conductor and a female connector having at least a pair of elongated slots oppositely disposed thereon in a plane and extending through an open end thereof at which the male conductor is to enter, said method comprising the steps of: providing solder at the desired connection; grasping the male conductor at the opposite sides thereof with a gripping tip portion of the resistance soldering apparatus; inserting said male conductor into said female connector so that the slots thereof line up with the gripping tip portions of said resistance soldering apparatus; passing the gripping tip portions of said resistance soldering apparatus while grasping said male conductor through said slots a predetermined distance until said gripping tip portions abut against a portion of said slots; energizing said resistance soldering apparatus to melt the solder and secure said male conductor and said female connector; deenergizing said resistance soldering apparatus; disengaging said resistance soldering apparatus from said male conductor; re-engaging said male conductor through said slots with said resistance soldering apparatus at any subsequent time; energizing said resistance soldering apparatus to melt the solder; deenergizing said resistance soldering apparatus; removing said male conductor from said female connector with said resistance soldering apparatus; and disengaging said resistance soldering apparatus from said male conductor.


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