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Hartz

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[54] TERMINATING OF ELECTRICAL CONDUCTORS

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[52] **U.S. Cl.** .... **29/503,** 29/470.1, 117/DIG. 8, 339/275 T
[51] **Int. Cl.** **H01r 5/04,** B23k 35/12
[58] **Field of Search** .... 29/DIG. 2, DIG. 46, 492, 29/628, 470.1, 484, 488, 497, 497.5, 502–504; 174/84, 90, 94; 339/114, 116, 275, 276, 278 C; 148/12.9; 117/114, DIG. 8

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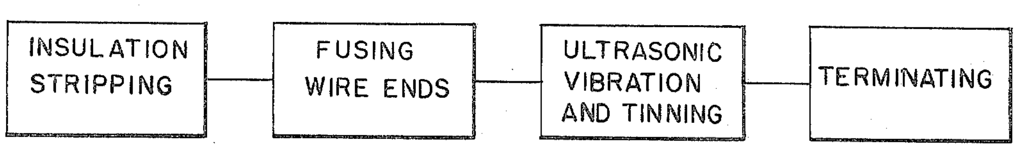
[57] **ABSTRACT**

Terminating an electrical conductor composed of a plurality of conductive strands is accomplished by fusing together the strands at one end of the conductor and immersing the fused end of the conductor in a tinning bath vibrated at ultrasonic speeds, followed by the securing of a terminal to the tinned end of the conductor end preferably under a force sufficient to cause the tinning material to flow and create a metallurgical bond between the conductor and the terminal.

10 Claims, 3 Drawing Figures



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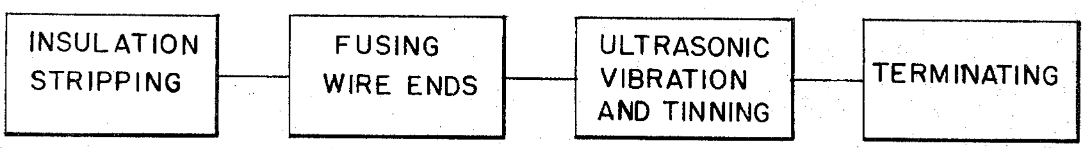

FIG. 1

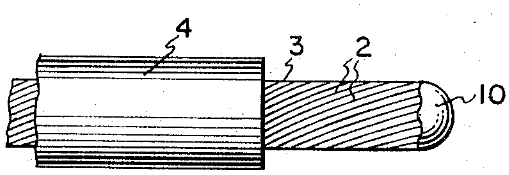

FIG. 2

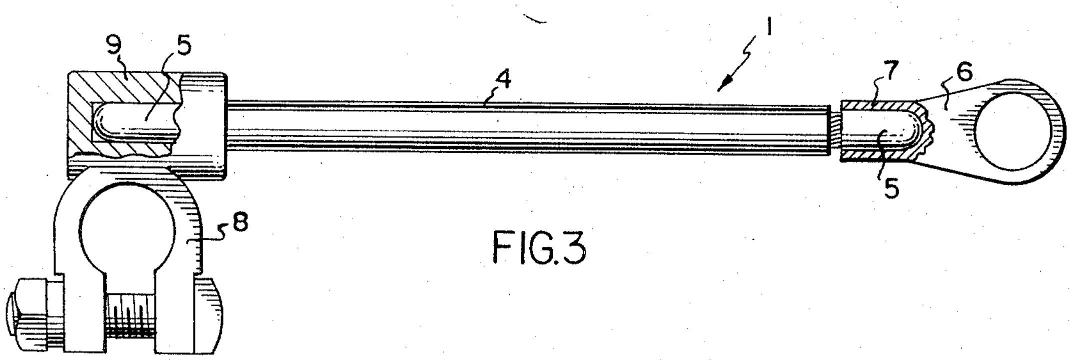

FIG. 3

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TERMINATING OF ELECTRICAL CONDUCTORS

The invention herein disclosed relates to the terminating of electrical conductors and more particularly to the terminating of a conductor composed of a plurality of strands of aluminum wire especially adapted for use in the manufacture of vehicle battery cables.

In the manufacture of a battery cable or the like it is desirable to make use of individual strands of aluminum so that the cable will have the desired strength and flexibility. When the aluminum wire is exposed to air, however, a highly resistant oxide forms on the surface of the wire. Removal of the oxide is necessary if a satisfactory electrical connection between the cable and a terminal is to be made. The necessity of removing the oxide film has been recognized heretofore and it has been the practice to apply a chemcial flux to the aluminum wires to dissolve the oxide film. Such fluxes, however, wick or migrate along the individual strands of the conductor and react in the presence of moisture encountered in the use of the cable to produce corrosive oxides which attack the aluminum and result in failure of the conductor.

An object of this invention is to provide a process especially adapted to obtain an excellent electrical and mechanical connection between an aluminum conductor and a terminal.

Another object of the invention is to provode a process of terminating stranded aluminum conductors which permits the use of conventional terminating equipment and cable processing methods.

A further object of the invention is to provide a stranded aluminum cable having at least one terminal thereon and possessing an excellent electrical and metallurgical interface between the conductor and the terminal.

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

FIG. 1 is a flow diagram illustrating the steps of the preferred process;

FIG. 2 is a fragmentary elevational view illustrating one end of a stranded cable preparatory to its being tinned and terminated; and

FIG. 3 is an elevational view, partly in section, illustrating a typical battery cable constructed in accordance with the invention.

A battery cable produced according to the invention is designated generally by the reference character **1** and comprises a plurality of individual strands **2** of preferably aluminum wire twisted slightly to form an elongate conductor **3** of suitable length and diameter. A typical cable is composed of 127 strands of 27 gauge wire. The conductor conventionally has an outer layer of rubber or other insulation **4** which is stripped from the ends of the conductor by conventional stripping machinery (not shown) so as to expose the ends of the conductor.

The exposed ends of the aluminum cable conventionally are provided with a coating **5** of solder or a zinc-tin alloy for the purpose of minimizing the electromotive potential between the aluminum cable and terminals formed of different metal and adapted to be mounted at opposite ends of the conductor. In the disclosed embodiment, a conventional copper-bearing terminal **6** has a socket **7** secured at one end of the conductor and a lead-tin alloy battery post clamp **8** having a socket **9** mounted at the opposite end of the cable. The battery cable construction thus far described is conventional.

An aluminum wire or cable exposed to air will oxidize rapidly and form a highly resistant oxide film on its surface. It is known that vibrating a rigid wire or strip of aluminum at ultrasonic speeds will abrade and remove a film of aluminum oxide from the wire or strip. It is also known that ultrasonic vibration of a rigid aluminum wire immersed in a bath of molten solder or zinc-tin alloy not only will abrade aluminum oxide from the wire, but also will enable the latter to be coated with the molten solder or alloy with an extremely good metallurgical bond therebetween. These processes heretofore have not been applicable to conductors formed of a plurality of strands of wire as fine as required in battery cables, however, because the fine strands simply resonate or vibrate with the result that the oxide film is not abraded. Consequently, a high resistance aluminum oxide film remains on the strands of a stranded conductor, and heretofore has necessitated use of the aforementioned chemical flux to remove the film.

A battery cable constructed according to the invention enables the advantageous effects of ultrasonic vibration of the conductor in a bath of molten solder or zinc-tin alloy to be achieved without the necessity of using a corrosive flux. This result is obtained by fusing or welding the ends of the individual strands **2** together so as to produce at each end of the conductor **3** a solid tip **10**. The fusing of the strands at the ends of the conductor may be accomplished by a conventional carbon arc device which generates sufficient heat to puddle the individual strands. As soon as the strands are puddled, the conductor is removed from the carbon arc device whereupon the puddled strands solidify to form the tip **10** at which all of the strands are joined.

The ends of the exposed conductor may be tinned by immersion in an ultrasonically vibrated bath of molten solder or zinc-tin alloy having a temperature lower than the melting point of the aluminum strands **2**. The vibration is achieved by a conventional vibrating device such as that manufactured by Branson Ultrasonic Instrument Company, of Stamford, Connecticut. The conductor is immersed in the molten metal bath to a depth just short of the insulation and vibrated at an ultrasonic frequency in excess of 20 kilohertz. The thermal and chemical action thereby produced efficiently abrades the oxide film from the conductor and permits the tinning alloy to be bonded metallurgically to the aluminum strands. The fused end of the conductor provides adequate mechanical rigidity for the individual strands of the conductor so as to prevent their oscillating individually in response to the applied ultrasonic frequency, thereby enabling the individual strands to be scrubbed clean of the oxide film and bonded metallurgically to the tinning alloy.

Following tinning of the ends of the conductor the terminals **6** and **8** may be applied thereto. Application of the terminals may be by conventional means such as die casting or by sweating or shrinking a pre-tinned brass type terminal onto the conductor under sufficient force as to cause the coating **5** to flow or become somewhat plastic and thereby form a metallurgical bond between the terminal and the conductor.

Another advantage of fusing the ends of the strands 2 is that, since all of the strands are joined at their ends, all of the strands are capable of carrying current regardless of whether the aluminum oxide is removed from the interior strands of the cable.

This disclosure is illustrative of presently preferred embodiments of the invention, but is not intended to be definitive thereof. The invention is defined in the claims.

I claim:

1. A method of terminating an electrical conductor formed of a bundle of strands of conductive metal twisted so that all of said strands are engaged with one another over the length of said conductor, said method comprising fusing the ends of the strands to form a solid tip at least at one end of said conductor; immersing said one end of said conductor in a bath of molten, electrically conductive metal having a temperature lower than the melting temperature of the metal of said strands; vibrating said one end of said conductor at a frequency sufficient to abrade oxides from the immersed end of said conductor and to coat the immersed end of said conductor with said molten metal; removing the coated end of said conductor from said bath; and solidifying the metal of the coating.

2. The method set forth in claim 1 wherein said one end of said conductor is vibrated at ultrasonic frequency.

3. The method set forth in claim 1 including securing a terminal to said coated end of said conductor.

4. The method set forth in claim 3 wherein said terminal is secured to said coated end of said conductor under such force as to cause the metal of said coating to flow and form a metallurgical bond with said conductor and said terminal.

5. The method set forth in claim 1 wherein conductive metal is a zinc-tin alloy.

6. The method set forth in claim 1 wherein conductive metal is solder.

7. The method set forth in claim 1 including die casting a terminal onto said one end of said conductor.

8. The method set forth in claim 1 wherein the strands of said conductor are formed of aluminum.

9. A method of terminating an electrical conductor formed of a bundle of strands of conductive metal twisted so that all of said strands are engaged one with another over the length of said conductor, said method comprising melting and puddling the ends of all of said strands at least at one end of said conductor; solidifying the ends of said strands to form a solid tip at said one end of said conductor; immersing said one end of said conductor in a bath of molten, electrically conductive metal having a temperature lower than the melting temperature of the metal of said strands; vibrating said one end of said conductor at an ultrasonic frequency sufficient to abrade oxides from the immersed end of said conductor and to coat the immersed end of said conductor with said molten metal; removing the coated end of said conductor from said bath; and solidifying the metal of the coating.

10. The method set forth in claim 9 including metallurgically bonding via said coating a temrinal to said one end of said conductor.

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