

Aug. 29, 1961

F. G. BUHRENDORF

2,998,590

ELECTRICAL CONNECTION AND TOOL AND METHOD OF MAKING SAME

Filed Feb. 11, 1957

FIG. 1

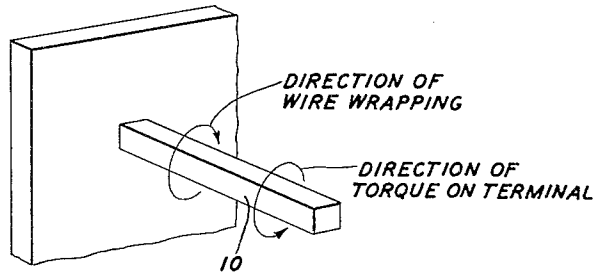


FIG. 2

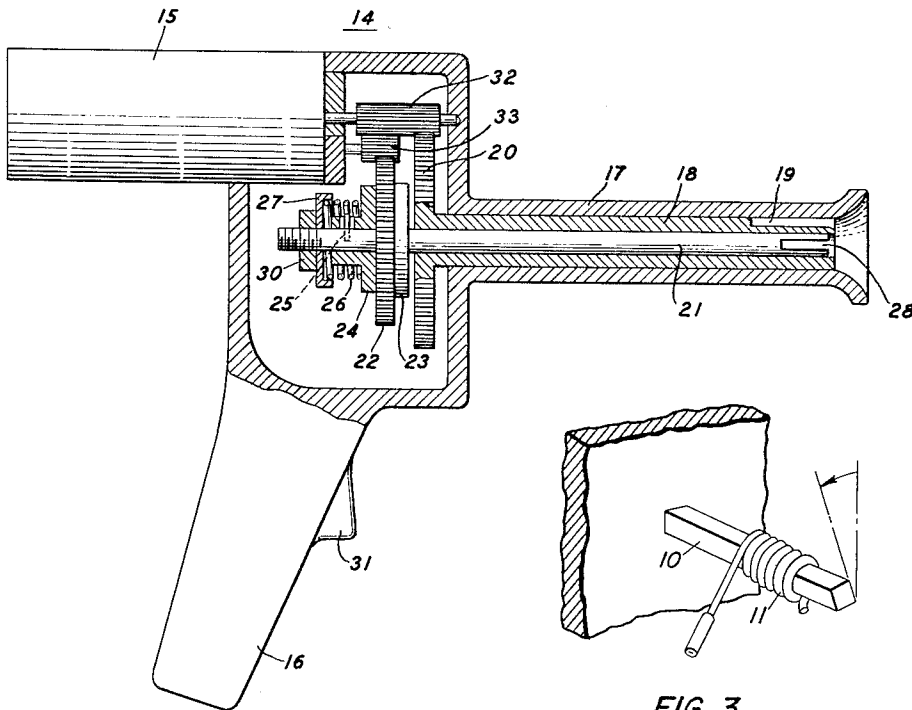


FIG. 3

INVENTOR
F. G. BUHRENDORF
BY *John C. Morris*
ATTORNEY

1

2,998,590

ELECTRICAL CONNECTION AND TOOL AND METHOD OF MAKING SAME

Frederick G. Buhrendorf, Westfield, N.J., assignor to Bell Telephone Laboratories, Incorporated, New York, N.Y., a corporation of New York

Filed Feb. 11, 1957, Ser. No. 639,312

9 Claims. (Cl. 339—276)

This invention relates to wrapped wire connections and more particularly to a method of and apparatus for making an improved wrapped wire connection.

Solderless, wrapped connections, as disclosed in Patent 2,759,166 to R. F. Mallina, issued August 14, 1956, store mechanical energy in the wire and terminal members during the wrapping process. Such connections employ the stored mechanical energy to maintain satisfactory electrical contact pressures between elements of the wrapped structure. A portion of the supplied mechanical energy is lost after the completion of the connection due to the tendency of the coil turns attempting to unwind from their stressed condition, as explained in the Mallina patent. The compression in the wire, the compression in the edges of the terminal, the locked-in tension in a majority of the longitudinal fibers of the turns of wire, and the torsional stress induced into the terminal, comprise the remaining or locked-in energy of the connection. With the passage of time, a portion of this locked-in energy is lost due to the creep characteristic of the metal involved, and to vibration, shock, etc. which may eventually result in the contact pressures of the connection being reduced to the point where the electrical connection between elements of the wrapped structure is unsatisfactory. By retaining and properly storing substantially all of the mechanical energy supplied during the connection process, a wrapped wire connection may be completed where the useful life of the connection will be substantially increased.

It is an object of the invention to make a wrapped wire connection which will maintain a satisfactory electrical contact over a substantially long interval of time even though lessening of contact pressures due to vibration, shock, creep characteristics, etc. is present to some extent.

It is a more particular object of the invention to make a wrapped wire connection that retains substantially all of the mechanical energy transferred to the wire and terminal during the wrapping operation.

The locked-in mechanical energy of the connection, described above, is determined in part by the balance between the tensile stress of the wire member and the induced torsional resistance of the terminal. A feature of the invention resides in subjecting the terminal to a torsional force in a direction opposite to the tensile stress of the wire or prestressing a predetermined amount during the wrapping process, thereby retaining substantially all of the mechanical energy supplied in making the connection, as well as lessening the reduction of contact pressure from creep due to shock, vibration, etc.

According to the invention, a wrapped wire connection is made by applying to a terminal appropriate tool means which accomplish the operations of prestressing the terminal for a predetermined amount in one direction, and wrapping a tensioned wire about the terminal in the direction opposite of prestressing.

The invention will be more fully apprehended from the following detailed specification taken in conjunction with the appended drawings, in which:

FIG. 1 shows the essential steps in a method of making a wrapped wire connection in accordance with this invention;

FIG. 2 is a tool (partly broken away to show the in-

2

ternal structure) illustrative of the type that may be employed in accomplishing the steps of FIG. 1; and FIG. 3, a perspective view of a wrapped connection incorporating the principles of the present invention.

Succinctly stated, wrapped wire connections as disclosed in Mallina Patent 2,759,166, are made by winding a tensioned wire about a terminal. This technique has been modified by the present invention to obtain additional advantages. As proposed herein, the terminal is subjected to a torsional force in a direction opposite to the direction of wire wrapping, as shown in FIG. 1. The magnitude of the torsional force should not result in the elastic limit of terminal 10 being exceeded such that the terminal would not return to its undeformed condition when the force is removed, as is well understood in the art. This requirement is important since otherwise the mechanical energy storing capacity of the connection will be reduced, as will be explained hereinafter. A completed wrapped connection 11 is shown in FIG. 3.

A description of the mechanical energy balance of the connection will bring out the reasons for obtaining improvements in the connection as a result of the modified wrapping method. In the completed connection the tensioned wire member includes longitudinal fibers whose tendency it is to unwind in a counterwrapping direction and return to an undeformed condition. This unwinding produces a torsional force about the terminal in the counterwrapping direction.

Ordinarily, as disclosed in Mallina Patent 2,759,166, the terminal 10 is twisted by such torsional force until the torsional resistance of terminal 10 balances the tensile stress developed by the longitudinal fibers of the wire attempting to return to an undeformed condition. In the present method the terminal 10 is prestressed before the completion of the connection. The prestressing is in the direction of the torsional force produced by the tensioned wire in unwinding about terminal 10. Since the prestressing is within the elastic limit of the terminal, a countertorsional force is developed by the terminal which attempts to return the terminal to an undeformed condition. The countertorsional force is opposite to the torsional force produced by the unwinding tensioned wire and a balance is obtained between these forces by a transfer of energy between the terminal and tensioned wire. In the event that the magnitude of prestressing is selected so as to produce a countertorsional force in the terminal equal to the unwinding torsional force of the wire, then little or no energy is lost in arriving at this balance. This is the optimum condition for prolonging the useful life of the connection. The conservation of the mechanical energy supplied in making the connection lengthens the time period before the connection is affected by a lessening of contact pressures from shock, vibration, etc., thereby prolonging the useful life of the connection. It should be noted, however, that if the elastic limit of the terminal is exceeded, then the permanent set of the terminal will reduce the amount of unwinding torsional force to which the terminal may be subjected, thereby decreasing the energy storage capacity of the connection.

The mechanical energy stored in the prestressed terminal also maintains the high contact pressure required for satisfactory electrical connection between elements of the wrapped structure. In nearly all instances the terminals may be formed from metals having better creep characteristics, etc. than that of the wire. As the tensile stress of the wire falls off, as a result of creep due to shock, vibration, etc., the terminal will stress the wire by releasing a portion of its stored energy to the wire. Thus, the rate at which the tension in the wire falls off from shock, vibration, etc. is greatly decreased as a result of the fea-

ture of properly storing energy in the terminal, thereby further prolonging the useful life of the connection.

To simplify the execution of the proposed method a suitable wire wrapping tool has been developed, and it will be described in detail in the remaining portion of the specification.

Turning now to FIG. 2, an exemplary embodiment of such tool is disclosed as follows. (It is to be understood that various other embodiments may be produced which accomplish the steps of the modified wrapping method disclosed herein.) A housing 14 includes a motor 15, a handle 16, and a wire-handling head 17. It should be noted that a number of types of motor devices; i.e., pneumatic motors, etc. with appropriate switching means, may be employed in the tool, but an electric motor has been arbitrarily selected for convenience in explanation of the tool. The wire-handling head is flared out at the opening end of the tool. Positioned inside the head is a hollow rotatable wiring spindle 18 and a first drive gear 20 which is located at the rear of the spindle. The spindle and drive gear form a unitary member. The spindle includes a slot 19 at the opening end for receiving the conductor to be wrapped about a terminal. The head 17 also includes a terminal chuck 21 positioned inside of the spindle and first gear. The chuck passes through a second drive gear 22 which is supported between a collar 23 attached to chuck 21 and slip clutch 24 which slides on the chuck. The slip clutch is held to chuck 21 through pin 25 and is caused to move along the shaft by a helical spring 26 which is cradled inside a retaining ring 27. The chuck has a slot 28 at the open end of the tool, and at the opposite or rear end the chuck is threaded. A clutch adjustment nut 30 is threaded onto the chuck and abuts against ring 27 for holding it in position. It should be noted that a number of types of torque producing mechanisms could be employed and that a spring loaded friction clutch has been arbitrarily selected for convenience. A conventional switch (not shown) is mounted in handle 16 and operated by trigger 31 for energization of motor 15. The motor is connected to first drive gear 20 by way of pinion 32 and to second drive gear 22 by way of pinion 32 and idler pinion 33. The idler pinion is held in position by a cantilever mounting in housing 14. Pinion 32 is directly connected to motor 15 at one side and supported by the housing at the other side. It is apparent that the pinion gear arrangements to the first and second drive gear will produce rotation of the drive gears in opposite directions.

To use the tool, the terminal is inserted into slot 28 of chuck 21 and a stripped portion of a conductor is inserted into slot 19. Actuation of trigger 31 causes motor 15 to impart rotary motion of one direction to wiring spindle 18 and rotary motion of the opposite direction to terminal chuck 21. The conductor in slot 19 is wrapped about the terminal in accordance with the principles outlined in Patent 2,585,010 to C. N. Hickman et al., issued February 12, 1952.

At the same time the conductor is being wrapped about the terminal the chuck 21 has subjected the terminal to a torsional force in the counterwrapping direction. In a manner well understood in the tool art, the setting of the clutch adjustment nut 30 determines the amount of torque that will be applied from motor 15 to chuck 21 via pinions 32 and 33 and second drive gear 22. The setting is made through an appropriate entrance to the interior of the housing (not shown) and should be selected to produce a torsional force equal to the unwinding torsional force of the conductor but not to exceed the elastic limit of the terminal. The tool may be withdrawn and stopped after the conductor has been wrapped about the terminal.

It is to be understood that various modifications to the invention may occur to persons skilled in the art and for this reason the invention should not be limited to the exact steps of the method or to the precise details of construction of the apparatus herein shown.

What is claimed is:

1. A method of making a wrapped wire connection which retains substantially all of the mechanical energy supplied in making the connection comprising the steps of stressing a terminal of rectangular cross section a predetermined amount in one direction and simultaneously wrapping a tensioned wire about the terminal in the direction opposite of stressing.
2. A method of making a wrapped wire connection which retains substantially all of the mechanical energy supplied in making the connection comprising the steps of subjecting a terminal of rectangular cross section to a torsional force of a predetermined amount in one direction and wrapping a tensioned wire about the terminal in the direction opposite to the torsional force.
3. A method of making a wrapped wire connection which retains substantially all of the mechanical energy supplied in making the connection comprising the steps of subjecting a terminal of rectangular cross section to a torsional force in one direction where the amount of torsional force does not result in the elastic limit of the terminal being exceeded, and wrapping a tensioned wire about the terminal in the direction opposite to the torsional force.
4. A method of making a wrapped wire connection which retains substantially all of the mechanical energy supplied in making the connection comprising the steps of prestressing a terminal of rectangular cross section within the elastic limit of the terminal by subjecting said terminal to a torsional force in one direction, and wrapping a wire about the terminal in a direction opposite to the torsional force where the wire is under a tension substantially equal to the stress of the terminal.
5. A method of making a wrapped wire connection which retains substantially all of the mechanical energy supplied in making the connection comprising the steps of applying tool means to a terminal of rectangular cross section for simultaneously subjecting the terminal to a torsional force of a predetermined amount in one direction and wrapping a tensioned wire about the terminal in the direction opposite to the torsional force, and removing said tool means from the terminal.
6. A wiring tool for making a wrapped wire connection comprising means for wrapping a wire around an elongated terminal, cooperating means for simultaneously twisting the terminal a preassigned amount in a direction counter to that of the wire wrapping, and means for driving said wrapping means and cooperating means in opposite directions.
7. A wiring tool for making a wrapped wire connection comprising a wire wrapping spindle rotatable in one direction to wrap a wire around a terminal, a counter-rotational terminal gripping means, means for driving simultaneously said wire wrapping spindle and counter-rotational gripping means to cause said wire to be wrapped about the terminal while the terminal is subjected to a torsional rotation by said counter-rotational gripping means and means for limiting the degree of rotation of the gripping means.
8. A wiring tool for making a wrapped wire connection comprising a housing having handle and wiring head portions, the wiring head including a hollow rotatable shaft with means for receiving a conductor, a terminal chuck positioned inside the spindle and having means for receiving a terminal, driving means for rotating the spindle and chuck in opposite directions to cause said conductor to be wrapped about the terminal while the terminal is subjected to a torsional force in the counterwrapping direction, means for limiting the magnitude of the torsional force, and means for starting and stopping the driving means.
9. A wrapped wire electrical connection comprising an elongated terminal having longitudinal surfaces intersecting at an angle defining a relatively abrupt edge, and a coil of tensioned wire tightly wrapped around the ter-

minal, said terminal having a residual elastic torsional displacement in a direction to provide energy equal in amount to that lost by relaxation of the wire.

References Cited in the file of this patent

UNITED STATES PATENTS

695,705 Batchelor ----- Mar. 18, 1902
2,420,754 MacFadden ----- May 20, 1947

5

2,546,489
2,635,819
2,643,446
2,648,356
2,652,621
2,743,503
2,759,166
2,870,241

Wright ----- Mar. 27, 1951
Bennett ----- Apr. 21, 1953
Matthysee et al. ----- June 30, 1953
Beaulieu et al. ----- Aug. 11, 1953
Nelson ----- Sept. 22, 1953
Mallina ----- May 1, 1956
Mallina ----- Aug. 14, 1956
Mason ----- Jan. 20, 1959