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H. E. RUEHLEMAN
METHOD AND APPARATUS FOR BONDING
THROUGH INSULATING MATERIAL

3,418,444

Original Filed Oct. 21, 1963

2 Sheets-Sheet 1

FIG. 1

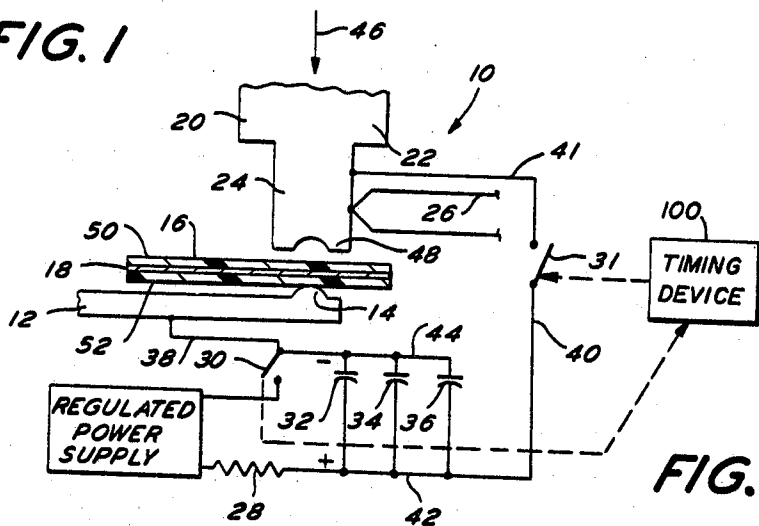


FIG. 2

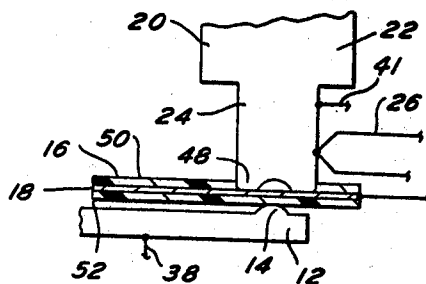


FIG. 3

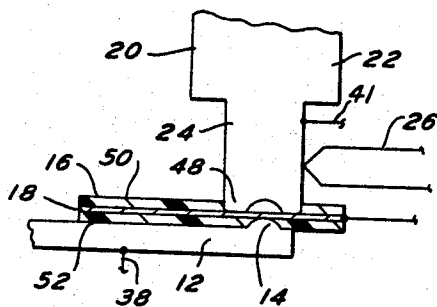


FIG. 4

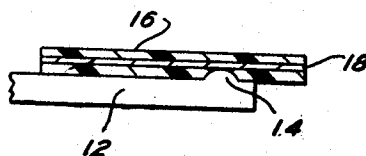
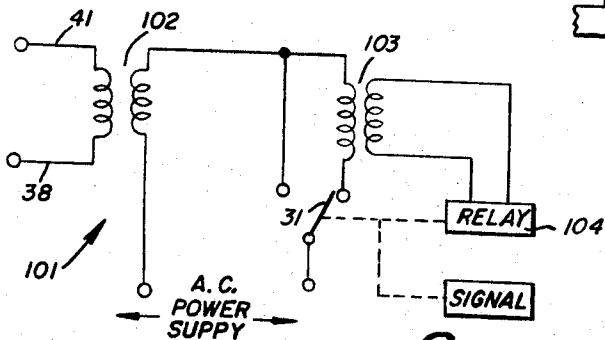


FIG. 8



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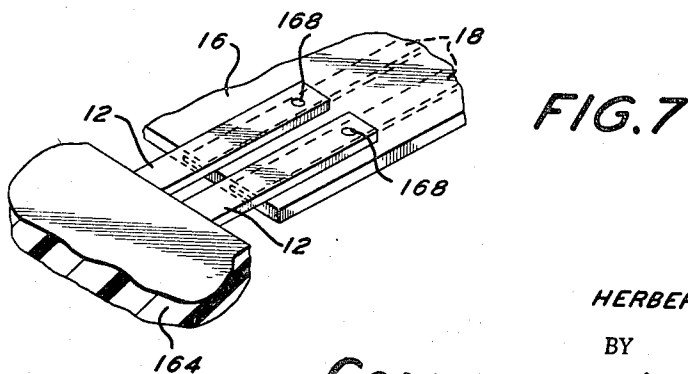
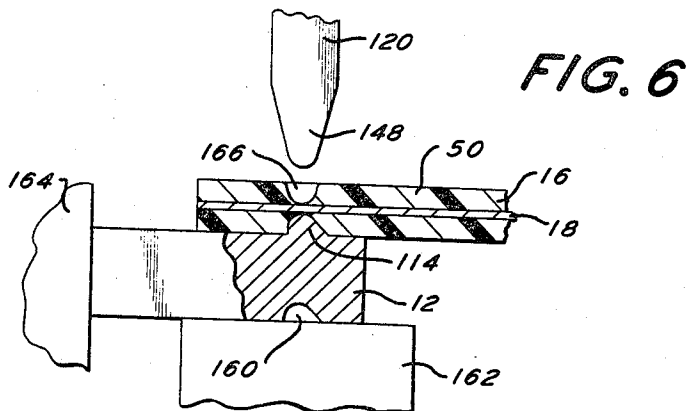
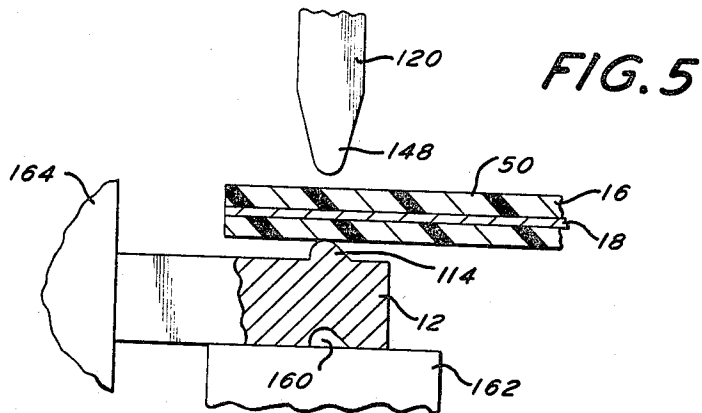
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METHOD AND APPARATUS FOR BONDING THROUGH INSULATING MATERIAL

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Continuation of application Ser. No. 317,617, Oct. 21, 1963. This application Aug. 25, 1967, Ser. No. 663,444 15 Claims. (Cl. 219—113)

This application is a continuation of application Ser. No. 317,617, filed on Oct. 21, 1963, now abandoned.

This invention relates to a method of securing connector terminals to a ribbon cable. More particularly it relates to a new and improved method of this general class.

Ribbon cables are widely used in the electrical and electronic industries since they possess several desirable characteristics including flatness and flexibility.

As used in the present specification and claims, a ribbon cable is basically an elongated strip of plastic having conductive wires or members embedded or printed therein. As many methods of producing ribbon cables involve a softening or embedding process, the plastic strip is generally a thermoplastic material, such as a vinyl plastic or polyethylene.

There are several methods of making the ribbon cable, such as positioning or printing a plurality of spaced conductors upon a first elongated plastic strip and then applying a second plastic layer thereover so that the elongated conductors are sandwiched between two of the plastic strips. Heat and pressure are then applied to the thermoplastic strips in order to consolidate the superimposed members and produce an integral ribbon cable. Another technique for producing the ribbon cable involves a simultaneous extrusion of a plastic strip with a carrying of a plurality of parallel conductors into and away from the extrusion area.

Yet another technique includes the heating of the conductive members and the forcing of the same into the thermoplastic ribbon.

In order that the ribbon cable may be effectively used with or incorporated into circuitry, it is necessary that electrical and mechanical connection may be made between the various conductors of the ribbon cable and outside circuits. Towards this end various techniques have been developed in order to secure connector terminals to the conductors of the ribbon cable. One such technique involves the removal of insulation along a narrow area of one or both sides of the ribbon cable with the connector terminal then being soldered to the bared conductors or printed lines. This method, however, presents problems since the removal of the plastic is a cumbersome procedure which is time consuming and unreliable. Another suggested method involves the use of connector terminals with piercing fingers which may be directly forced through the plastic of the ribbon cable and into electrical and mechanical contact with the conductive members of the ribbon cable. This method also presents problems since it requires accurate alignment between the piercing member and the conductive member.

It is, therefore, an object of the present invention to provide a method of securing a connector terminal to a ribbon cable which is simple and yet reliable.

Yet another object of the present invention is to provide a method for securing a connector terminal to a ribbon cable which is economical in practice and which involves the use of a minimum amount of equipment or machinery.

Still another object of the present invention is to provide a method for securing a connector terminal to a ribbon cable which minimizes alignment problems and automatically gives an indication when the connector ter-

minal has been properly joined to the conductive member of the ribbon cable.

The foregoing as well as other objects of the present invention are achieved by providing a method of securing a connector terminal to a ribbon cable which involves the establishment of a welding connection. The method of the present invention basically includes the positioning of the ribbon cable between a source of heat in the form of an electrode and the connector terminal which is to be secured to the ribbon cable. The electrode heat source is positioned directly against the ribbon cable and because the ribbon cable is of a thermoplastic material the electrode heat source will rapidly penetrate into the ribbon cable until it reaches a conductive member of the ribbon cable. The heat from the electrode heat source then penetrates to the connector terminal adjacent opposing surface of the ribbon cable.

The connector terminal easily forces its way through the heat softened insulation until it, too, makes physical contact with the conductor of the ribbon cable to form a tri-partite metallic junction. At this point a condenser discharge is sent through the foregoing metallic junction in order to establish a weld. The condenser discharge may be controlled by a timing device to occur after a predetermined time sufficient to guarantee that the junction between the heat source and the ribbon cable contact is established. As an alternate form of the invention, the timing device may be replaced with an electric sensing device which measures the resistance between the connector terminal and the electrode heat source or between the connector terminal and the particular ribbon cable involved. In this form of the invention the condenser discharge occurs when the resistance becomes low enough to warrant the making of a weld. This also indicates when the weld has been made.

Other objects and many of the attendant advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is a schematic view showing a ribbon cable in section positioned between an elevated electrode heat source and a connector terminal with a condenser discharge circuit being associated with the connector terminal;

FIG. 2 is an enlarged fragmentary view based on FIG. 1 and illustrating an initial step in the present process invention wherein the electrode heat source is brought into contact with the ribbon cable such that the heat source penetrates the front or forward surface of the ribbon cable and comes in contact with a ribbon cable conductor member;

FIG. 3 is a view similar to FIG. 2 but showing a further step in the method of the present invention wherein the heat from the heat source has penetrated beyond the ribbon cable conductive member to soften the insulation on the opposing surface of the ribbon cable and also to heat the connector terminal and particularly a projection extending therefrom so that it will penetrate through the insulation and come in contact with the ribbon cable conductive member;

FIG. 4 is a schematic view partially in section showing the completed securement of the connector terminal to the ribbon cable;

FIG. 5 is a view somewhat similar to FIG. 1 but showing a modified electrode heat source with the connector terminal having a slightly different projection extending therefrom;

FIG. 6 is a view showing the final step in the method of FIG. 5 and is somewhat similar to FIG. 3;

FIG. 7 is an enlarged view of the weld produced by the method of FIG. 5; and

FIG. 8 is a schematic wiring diagram of a modified embodiment of the invention.

Turning now to various figures of the drawing wherein like reference characters refer to like parts the basic set-up illustrating the method of the present invention is generally illustrated at 10 in FIG. 1. As shown in FIG. 1 a connector terminal 12 having an extending projection or dimple 14 is about to be electrically and mechanically united to a ribbon cable 16 having conductor members 18 as also illustrated in FIG. 7.

The projection 14 of the connector terminal 12 facilitates the penetration of the connector terminal into the thermoplastic insulation of the ribbon cable. In a preferred embodiment of the invention the projection 14 is approximately 0.030 inch in diameter and 0.020 inch in height.

In order to carry out the process of the present invention, it is necessary to employ a heated electrode or heat source 20 which is of well known construction and essentially comprises a base 22 from which depends a heating finger 24. Means for conducting heat to the heating finger 24 (not shown) are associated with the heat source 20 and, for instance, may be comprised of electric resistance heating means, induction heating or other techniques well known to the art. A thermocouple 26 with an appropriate thermostat arrangement to maintain the heating finger 24 at a precise temperature is associated with the heating fingers as illustrated in FIG. 1.

As also shown in FIG. 1, a condenser discharge circuit is associated with the connector terminal 12 and ribbon cable conductor member 18. The conductor discharge circuit basically involves a regulated power supply, a resistor 28, a switch 30 which may incorporate a timer or a resistance measuring device via switch 31 and three 100 m.f.d. capacitors 32, 34 and 36 connected in parallel. A conductor 38 connects the switch 30 to the terminal 12 and conductors 40 and 41 connect the electrode heat source 20 and the switch 31 to the resistor side of the regulated power supply. Capacitors 32, 34 and 36 are connected to the resistor side of the regulated power supply by means of conductor 42 and are connected to the switch side of the regulated power supply by means of conductor 44.

In carrying out the process of the present invention the electrode heat source 20 is brought to a desired temperature depending upon (a) the softening and scorching point of the thermoplastic insulation of the ribbon cable, (b) the thickness of the cable, (c) the pressure to be applied to the heat source and (d) the desired time of the operation.

In a preferred embodiment of the invention the ribbon cable is comprised of a polyethylene insulation material with a total thickness of 0.010 inch including a conductor thickness of 0.004 inch. The heat source 20 was maintained at approximately 250% C. which will not cause scorching of the polyethylene in the relatively short contact time of five seconds with a pressure of seven pounds being applied by the electrode heat source.

As shown in FIG. 1, the heat source 20 is moved downwardly in the direction of arrow 46 so that the nose 48 of the hot finger is about to come in contact with the insulation on the outer face 50 of the ribbon cable 16.

As shown in FIG. 1, the nose 48 of the hot finger 24 may be of a bifurcated nature in order to provide two penetrating points.

As the hot nose 48 of the hot finger 24 comes in contact with the outer surface 50 of the ribbon cable 16, it immediately heats the neighboring insulation with the combination of heat and pressure of the nose 48 causing the insulation to move sideways under the pressure of finger 24. This permits the heat source 20 to readily penetrate through the outer surface 50 until it reaches the ribbon cable conductive member as illustrated in FIG. 2. At this point the heat source continues to emit heat which penetrates through the conductive member 18 and then

finally to the inner face 52 of the ribbon cable thereby softening the insulation adjacent the projection 14 of the contact 12. The combination of the softened insulation adjacent the inner surface 50 and the pressure imposed by the electrode heat source 20 enables the projection 14 readily to penetrate through the inner surface 52 until it comes in contact with the ribbon cable conductive member 18. When this occurs a metallic junction between the metallic heat source 20, the ribbon cable conductive member 18 and the connector terminal 12 is established.

At this point a condenser discharge is sent through the foregoing metallic junction in order to establish a weld. The condenser discharge is produced through the combination of the regulated power supply, the capacitors 32, 34 and 36 and the other circuitry of FIG. 1.

As previously discussed a timer may be associated with the switch 30 in order to complete the circuit of FIG. 1 after a predetermined time long enough to guarantee that a metallic junction between the heat source, ribbon cable conductive member and connector terminal has been established. This is done by providing switch 31 which is wired (not shown) to switch 30 with the timer closing switch 31. Appropriate relays may be employed if desired. In a preferred embodiment of the invention the switch 30 may be closed manually or by a microswitch arrangement whereby downward movement of electrode heat source 20 closes a microswitch. Closing of switch 30 actuates the timer 100 which closes switch 31 after a predetermined time to complete the power circuit. The condenser discharge can occur in a "dumping" arrangement with switches 30 and 31 then opening to complete the cycle.

While a condenser discharge is preferably utilized to establish the weld, it is also contemplated that other power-arrangements may be utilized. For example, a conventional welding current transformer could be used in conjunction with a device 101 for measuring the resistance between the connector terminal and the particular ribbon cable involved. A suitable arrangement is shown in U.S. Patent No. 1,933,936 issued on Nov. 7, 1933 in the name of S. Schnetzer and is shown schematically in FIGURE 8, wherein leads 41 and 38, connected to electrode 20 and contact tail 12 respectively as shown in FIGURE 1, are connected across the secondary of welding transformer 102 whose primary is connected across an A.C. power supply. Switch 31 is in the position shown in FIGURE 8 when relay 104 is not energized, this state existing when the secondary of transformer 102 is open-circuited. In such case, a low value of pilot current flows through the primary of pilot transformer 103 whose secondary constitutes the coil of relay 104. When, however, electrode 20 is electrically connected to tail 12 of the through conductor 18, the secondary of welding transformer 102 is short circuited causing an increase in the flow of pilot current through the primary of pilot transformer 102. This increase in pilot current flow induces sufficient current flow through the secondary of the pilot transformer to energize relay 104 which moves switch 31 to its other position connecting the full power supply across the primary of transformer 102 which induces a large surge of welding current in the secondary. This surge achieves the desired weld. The movement of switch 31 can be coupled to signal means 105 as indicated.

In the embodiment of FIGS. 5, 6 and 7, the nose 148 of electrode heat source 120 has but a single tip and is not bifurcated as the nose 48 of FIG. 1. Also, the projection or dimple 114 is punched as indicated by depression 160. As shown in FIG. 5, the electrode heat source 120 possesses a slightly convex arc so that the center thereof will penetrate more readily into the insulation.

The electrode heat source 120 acts upon ribbon cable 16 with conductors 18 much in the manner of the heat source 20. A support base 162 is provided and may also be utilized in the method of FIG. 1. Also, the contact

12 can be secured in an insulating causing 164 although this is usually done subsequent to welding.

The last step in the process is shown in FIG. 6 wherein a depression 166 is created by the action of the electrode 120. Two depressions 166 are also created by electrode 120. However, the depression or depressions may be filled in with epoxy or other sealing materials.

An enlarged view of the underside of a completed assembly is shown in FIG. 7 with welds 168 having been produced by the method of the present invention.

It is clear that the process of the present invention produces a weld connection between the connector terminal and the ribbon cable conductive member in a simple and efficient manner. Such a weld connection may not be strong enough physically to withstand the stresses imposed upon the ribbon cable in use. Therefore, mechanical means may be associated with the welded joints of the present invention in order to protect them. Such mechanical means may involve well known mechanical strain release techniques or may utilize epoxy materials in order to strengthen the weld joints. Epoxy is also used to fill in depression 166 as previously noted.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

I claim:

1. A process for welding together a pair of electrical conductors separated by an insulating material comprising:
 - (a) applying a preselected pressure for a preselected interval of time to said pair of conductors to urge said conductors toward each other whereby at least one of said conductors penetrates said insulating material to contact the other of said conductors to thereby form a metallic junction;
 - (b) detecting the end of said preselected interval of time; and
 - (c) sending an electrical charge through said junction in response to the detection of the end of said preselected interval of time to achieve welding of said pair of conductors in the region of said metallic junction.
2. The process according to claim 1, including applying heat to at least one of said pair of conductors during said preselected interval of time to soften said insulating material between said conductors.
3. The process according to claim 1, including providing a projection on at least one of said conductors to facilitate the penetration of said at least one of said conductors into said insulating material.
4. A process for welding together a pair of electrical conductors separated by an insulating material comprising:
 - (a) applying pressure to said pair of conductors to urge said conductors toward each other whereby at least one of said conductors penetrates said insulating material to contact the other of said conductors to thereby form a metallic junction;
 - (b) detecting a predetermined value of an electrical characteristic associated with said junction; and
 - (c) sending an electrical charge through said junction in response to the detection of said predetermined value of said electrical characteristic to achieve welding of said conductors.
5. The process of claim 4, including applying heat to at least one of said pair of conductors during the pressure applying step to soften said insulating material between said conductors.
6. The process of claim 4, including providing a projection on at least one of said conductors to facilitate the penetration of said at least one of said conductors into said insulating material.
7. The process of claim 4 wherein the electrical char-

acteristic which is detected is the impedance of said junction.

8. A method of securing a connector terminal to a ribbon cable which has spaced electrical conductors embedded in thermoplastic insulation, said method comprising positioning said ribbon cable between said connector terminal and an electrode heat source capable of exerting pressure, urging said electrode heat source against a first face of said ribbon cable with said connector terminal being thereby forced against a second face of said ribbon cable, allowing the heat from said electrode heat source to penetrate through said ribbon cable to soften said cable whereby said electrode heat source penetrates through said first face to contact one of said ribbon cable conductors and said connector terminal penetrates through said second face to contact said one ribbon cable conductor thereby forming a metallic junction between said one ribbon cable conductor and said connector terminal, detecting a predetermined value of an electrical characteristic associated with said junction, and sending an electrical charge through said junction to achieve welding thereof in response to the detection of said predetermined value of said electrical characteristic.

9. A process for welding a thermoplastic insulated conductor to the tail of a contact comprising the steps of: providing a projection on one surface of the tail of the contact; placing the insulated conductor between said one surface of the tail of the contact and a movable electrode so that the electrode and the projection are urged into the thermoplastic insulation when the insulated conductor is squeezed between the electrode and the tail of the contact; heating the electrode while applying a preselected pressure for a preselected interval of time to such electrode to squeeze the insulated conductor between the electrode and the tail of the contact for softening the thermoplastic insulation between the electrode and the conductor to permit the electrode to penetrate the insulation and engage the conductor, and for softening the thermoplastic insulation between the conductor and the projection on the tail of the contact to permit the projection to penetrate the insulation and engage the conductor, thereby establishing a metallic junction between the conductor and the projection on the tail of the contact; detecting the end of said preselected interval of time; and causing welding current to flow through the electrode, and the metallic junction between the conductor and the projection on the tail of the contact, in response to the detection of the end of said preselected interval time to thereby weld the conductor and contact together.

10. A process according to claim 9 wherein the electrode has a point that is aligned with the projection on the tail of the contact when the insulated conductor is squeezed between the electrode and the tail of the contact.

11. Apparatus for welding the tail of a contact to a thermoplastic insulated conductor, said apparatus comprising a movable welding electrode adapted, when pressure is applied thereto, to be urged into the thermoplastic insulation as the insulated conductor is squeezed between the electrode and the tail of the contact; heating means for heating and thereby softening the thermoplastic insulation in a region adjacent the electrode; means for applying a preselected pressure to the electrode for a preselected interval of time whereby the electrode penetrates the insulation and engages the conductor, and the tail of the contact penetrates the insulation and likewise engages the conductor to establish a metallic junction; detecting means for detecting the end of said preselected interval of time; and welding control means responsive to the detection of the end of said preselected interval of time for causing welding current to pass through the metallic junction at the end of said preselected interval of time to thereby weld the tail of the contact to the conductor.

12. Apparatus for welding the tail of a contact to a thermoplastic insulated conductor, said apparatus comprising a movable welding electrode adapted, when pressure is applied thereto, to be urged into the thermoplastic insulation as the insulated conductor is squeezed between the electrode and the tail of the contact; means for applying pressure to said electrode; heating means for heating and thereby softening the thermoplastic insulation in a region adjacent the electrode whereby pressure applied to the electrode, until a predetermined value of an electrical characteristic is detected, permits the electrode to penetrate the insulation and engage the conductor and the tail of the contact to penetrate the insulation and likewise engage the conductor thus establishing a metallic junction; means for detecting said predetermined value of the electrical characteristic; and welding control means for causing welding current to pass through the metallic junction in response to the detection of said predetermined value of the electrical characteristic thereby welding the tail of the contact to the conductor.

13. The apparatus of claim 11 wherein the impedance is the electrical characteristic which is detected.

14. An apparatus for welding together a pair of electrical conductors separated by an insulating material comprising:

(a) means for applying a preselected pressure for a preselected interval of time to said pair of conductors to urge said conductors toward each other whereby at least one of said conductors penetrates said insulating material to contact the other of said conductors to thereby form a metallic junction;

(b) means for detecting the end of said preselected interval of time; and

(c) means for sending an electrical charge through said junction in response to the detection of the end of said preselected interval of time to achieve welding of said pair of conductors in the region of said metallic junction.

15. An apparatus for welding together a pair of electrical conductors separated by an insulating material comprising:

(a) means for applying pressure to said pair of conductors to urge said conductors towards each other whereby at least one of said conductors penetrates said insulating material to contact the other of said conductors to thereby form a metallic junction;

(b) means for detecting a predetermined value of an electrical characteristic associated with said junction; and

(c) means for sending an electrical charge through said junction in response to the detection of said predetermined value of said electrical characteristic to achieve welding of said conductors.

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U.S. Cl. X.R.

219—91, 78