

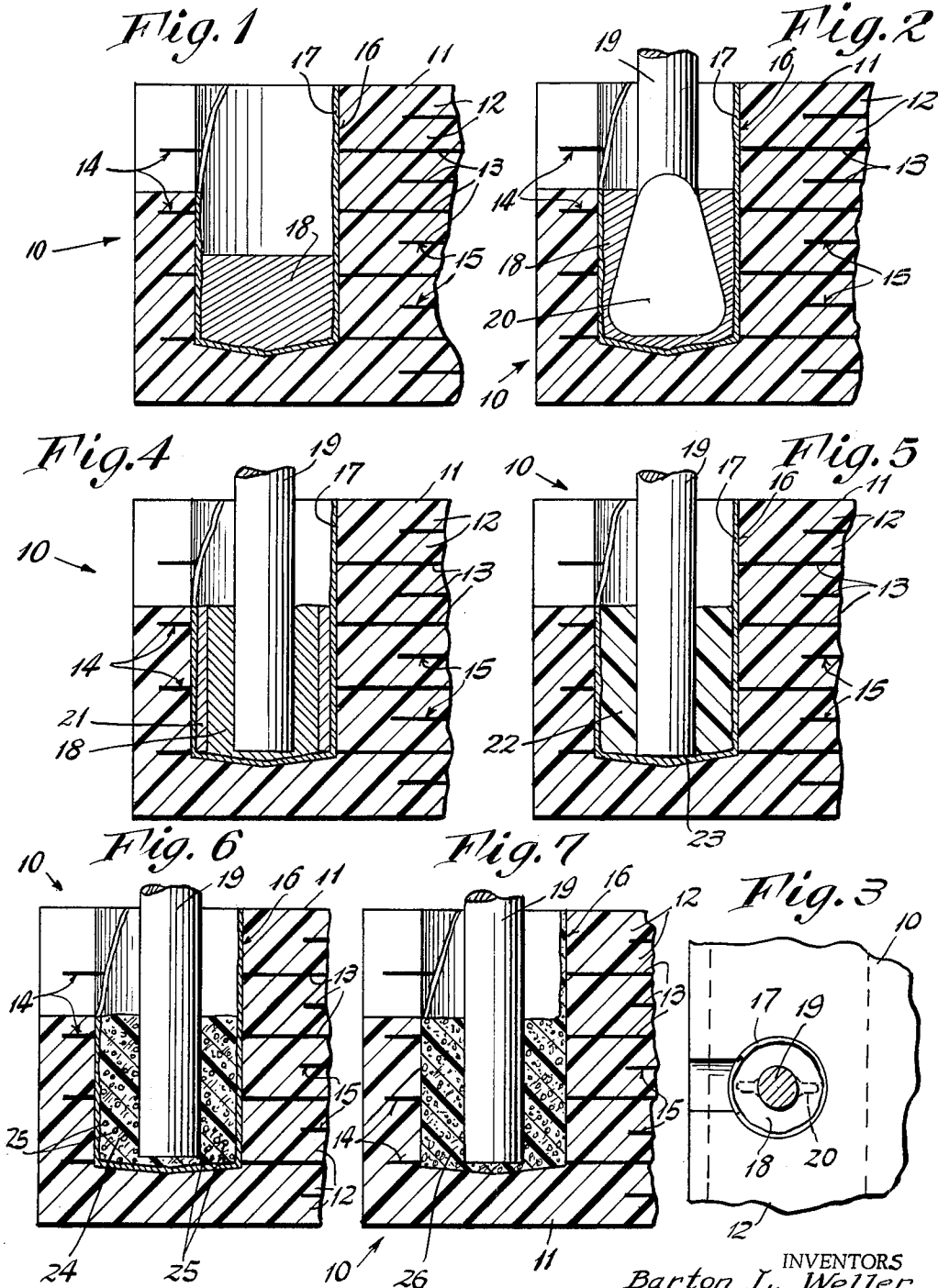
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TERMINAL LEAD CONNECTION AND METHOD OF MAKING THE SAME

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3,221,387 TERMINAL LEAD CONNECTION AND METHOD OF MAKING THE SAME

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This invention relates to terminal lead connections for electrical units and to a method of making the same. More specifically, it constitutes an improvement on the method disclosed in the United States Patent of Barton L. Weller, No. 3,021,589, and the product resulting therefrom.

In the aforesaid patent a method is disclosed for making a terminal lead connection in an electrical unit having a substantially rigid laminated body formed of superposed, substantially parallel layers of material having specific electrical characteristics, including at least one electrically conductive layer lying wholly within the body, which comprises inserting a lead into the body transversely of the layers so that it has electrical connection with the electrically conductive layer, the lead being gripped by the body which is shrunk thereon during the final curing of the body.

According to the invention of the said patent, insertion of the lead into the body is achieved by forming a recess in the body, extending at least through the said electrically conductive layer, which is of a diameter sufficient to receive the lead, yet small enough to enable the body to shrink into gripping engagement therewith. As disclosed, the lead has electrical connection with the electrically conductive layer exposed by the recess and, while such connection might constitute direct engagement of the lead and the layer, in the preferred form it is achieved through a lining of electrically conductive material on the wall of the recess. The lining, which bonds to the electrically conductive layer and to the lead, in addition to forming the electrical connection between the two also functions, in units wherein the electrode comprises a plurality of plates, to electrically tie the plates together to form the electrode.

While the method of Patent No. 3,021,589 provides the solution to the problems inherent in making a terminal lead connection to an electrode, having a part thereof at least, disposed wholly within the body of the unit, a number of problems have been encountered, directly affecting the reliability of the unit, which result from reduced mechanical strength and electrical continuity of the lead connection.

It has been found that high stresses, resulting from manipulation of the lead, exist at the juncture or interface of the relatively soft metal lead and the rigid body. These stresses, which are greater than the tensile strength of the malleable lead metal, tend to cause the lead to move and distort at the point of stress, such distortion resulting in a rupture of the electrical connection between the lead and the electrically conductive layer. The rupture, which may occur in the bond between the lead and the layer and/or between the lead and the electrically conductive lining, depending on the construction of the particular unit, is progressive, usually starting at the outermost point of bond and propagating downwardly into the recess with each subsequent stressing of the lead. Consequently, a terminal lead connection, which was originally mechanically strong and electrically reliable, under repeated stressing, will fail as a result of the inability of the bond to absorb the movement of the malleable lead and transmit it to the relatively rigid body of the unit.

The present invention overcomes the problems afore-

noted and has as an important object thereof to provide a method for making a terminal lead connection in an electrical unit which includes providing a bond at the juncture of the relatively soft lead and rigid body that is capable of withstanding normal stressing of the lead without rupturing.

According to the invention, the aforesaid object is achieved by providing a cushion or malleable bond at the juncture of the lead and body, the bond having sufficient malleability to distribute the stress on the lead and spread it around its entire periphery, so that, at any given point, it is held below the tensile limits of the lead and lead to body interface area.

In one form of the invention the provision of the malleable bond is accomplished by forming the lead-receiving recess in the body of substantially greater diameter than the lead to be inserted therein so that a substantial thickness of shock absorbing bonding material can be disposed therearound for absorbing and distributing stresses.

It is also an object of the invention to provide a method of making a terminal lead connection in an electrical unit which includes providing means for distributing stress, resulting from manipulation of the lead, around the entire periphery of the lead the interface area with the unit body so that at any given point in the interface area the stress does not surpass the tensile strength of the lead or the lead to body bond.

Another object of the invention is to provide a method for making a terminal lead connection which provides means for cushioning the bond or connection against rupture while maintaining electrical connection between the lead and the electrode that lies wholly within the body of the electrical unit.

Still another object of the invention is to provide a method for making a terminal lead connection in an electrical unit which includes providing a substantial thickness of shock absorbing bonding material between the lead and the body in the interface area, the bonding material being electrically conductive for electrically connecting the lead to the electrode of the unit while cushioning the juncture of the lead and body against rupture.

Still another object of the invention is to provide a method for making a terminal lead connection in an electrical unit between a relatively soft metal lead and rigid body which is electrically reliable, mechanically strong and free of areas of concentrated stress resulting from lead manipulation.

It is further an object of the invention to provide an electrical unit having a terminal lead connection, made in accordance with the invention, which includes means in the interface area of the lead and unit body adapted to cushion the bond at the interface area against rupture.

It is still further an object of the invention to provide a capacitor unit, having a terminal lead connection according to the invention, and a method of making the same.

Other objects and advantages will be apparent from the specification and claims, when considered in connection with the attached sheet of drawings, illustrating one form of the invention, wherein like characters represent like parts and in which:

FIGURE 1 is a fragmentary elevational view, in section, of a capacitor unit made in accordance with the invention and just prior to insertion of the lead therein;

FIG. 2 is the same as FIG. 1, but shows the lead in inserted position;

FIG. 3 is a fragmentary plan view of the capacitor unit of FIG. 2; and

FIGS. 4 through 7 are each fragmentary elevational views, in section, of a capacitor unit having a modified

form of terminal lead connection according to the invention.

Referring now to the drawings for a more detailed description of the invention, in FIGS. 1 to 3 an electrical unit 10 is shown at various stages in the formation of a terminal lead connection according to the invention. While the concepts of the invention are applicable to capacitors, resistors, inductors and similar electrical devices having a porcelain, glass, ceramic or other substantially rigid body in which a part, at least, of the electrodes lie wholly within the body, in the herein illustrated form of the invention, for purposes of description, a capacitor of the type disclosed in U.S. Patent No. 3,021,589 is shown.

Reference may be made to the said patent for particular details of construction of the capacitor, however, for present purposes it is sufficient to note that it comprises a substantially rigid body or laminate 11 of superposed substantially parallel layers of dielectric material 12 and electrically conductive material 13, the latter forming the electrode plates of the unit and lying wholly within the body. While in some instances it may be desired to have additional electrode plates on the exterior of the body and connected to the interior plates, it is presently preferred and herein illustrated as having all of the electrode plates disposed wholly within the body.

The electrically conductive layers or plates 13 of body 11 are, as is well understood in the art, spaced by a layer or layers of the dielectric material 12 and so formed as to define two electrically distinct groups of electrode plates 14 and 15. The groups of electrode plates, which each form one electrode of the capacitor unit may be formed by any means known to the art, including relatively displacing adjacent plates so that alternate plates overlie one another or providing a cut out or the like at the opposite ends of adjacent plates so that the cutouts of alternate plates are in corresponding positions, to facilitate electrically connecting all of the plates of each group to form its respective electrode.

Heretofore, terminal lead connections have been made in the electrical unit 10 with each of the electrodes 14 and 15 of the unit by inserting a terminal lead means into the body for establishing electrical connection with its respective electrode and communicating it outwardly of the body. According to the prior art, insertion of the terminal lead means into the body is achieved by forming a recess in the body sufficient only to receive the lead so that on curing the body it is able to shrink into engagement with the lead for gripping the same. The lead in such prior art constructions had either direct electrical contact with the electrically conductive layer or layers of the body or had electrical connection therewith through an electrically conductive lining disposed on the wall of the recess. As will be readily understood, the electrically conductive lining, in addition to connecting the lead to its respective electrode, functioned to tie the plates forming the electrode together, if required.

It has been found that terminal lead connections of the aforementioned type tended to rupture at the interface or bond between the lead and the body of the unit as the result of stresses due to manipulation of the lead. The stressing of the lead, which is soft and malleable relative to the rigid body of the device, overcomes the tensile strength of the lead and the bond, eventually rupturing the same and causing electrical and mechanical breakdown of the unit.

According to the present invention, this problem is overcome and a highly reliable terminal lead connection is formed by providing a cushion between the lead and the body for distributing the stresses entirely around the periphery of the lead so that at any given point the stress is no greater than the tensile strength of the lead or the interface bond.

In FIGS 1 through 3 one method of providing the desired cushion is shown according to the invention. A

recess 16, which is formed in a manner similar to that disclosed in the prior art, is provided. In the present invention, however, the recess, rather than being of a size only sufficient to receive the lead, is of substantially greater diameter than the lead to be inserted therein for receiving a shock absorbing bonding material between the inserted lead and the wall of the recess, as will be hereinafter described. While the diameter of the recess 16 in relation to the diameter of the lead may vary, depending on the tensile strength of the lead or interface bond, it has been found desirable to form the recess of a diameter approximately twice that of the lead, thereby enabling a cushion of the shock absorbing bonding material to be disposed between the lead and the wall of the recess equal to approximately the radius of the lead.

After the recess 16 has been formed it is lined with electrically conductive material 17, of any type and in any manner well known to the art, for electrically engaging all of the electrode plates exposed by the recess and tying them together to form one of the electrodes of the unit. Thereafter, the body is cured to harden the layers and secure the lining in position.

After the body has been cured, but not necessarily immediately thereafter, a quantity of silver or other electrically conductive solder 18, of any well known type, is inserted in the recess, as shown in FIG. 1. A lead 19, as shown in FIG. 2, is then inserted in the recess so that it is substantially centered and the solder flows therearound to form a shock absorbing cushion of substantial thickness between the lead and the wall of the recess. While the lead 19, within the concepts of the invention, may be circular or square in cross-section, or of any other configuration, in the form of the invention shown in FIGS. 1 to 3 the lead is spaded, as at 20, to prevent its turning and eliminate piston effect as it is inserted. The solder 18 in addition to cushioning the lead by absorbing stresses imparted thereto, electrically connects the lead to the lining 19 so that the lead has electrical connection with the electrode for communicating it outwardly of the body.

It should here be noted that the foregoing method has the additional advantage of enabling the lead to be inserted in the body after the body is cured thus enabling leads of any desired material to be utilized since the lead will be unaffected by the curing operation. Further, the cured body, prior to insertion of the lead into the recess, may be stored for inventory, shipped or otherwise handled, thereby reducing over-all inventory and cost.

In FIGS. 4 through 7 modified forms of terminal lead connections, within the concepts of the invention, are shown, all being illustrated in connection with a capacitor or electrical unit 10 of the type described in connection with FIGS. 1 to 3. In these embodiments of the invention the lead wire 19 is shown as being circular in cross-section.

In FIG. 4 a sleeve or liner 21 of electrically conductive material is disposed in the recess 16 between the electrically conductive lining 17 and the bonding material 18. The liner, which is adapted to assure reliable, mechanical and electrical connection between the electrically conductive bonding material and the lining on the wall of the recess, is positioned in the recess prior to curing the body so that the body will shrink thereon during the curing operation to grip it and retain it in position. In connection with the liner 21, it should be noted that in many cases the liner has been found necessary for assuring electrical connection between the bonding material and the electrically conductive lining on the wall of the recess since the glaze produced by the flux in the lining has a tendency to interfere with the desired electrical bond; the liner overcomes this problem and provides a readily solderable surface.

In FIG. 5 the terminal lead connection is made in the same manner as was described with respect to FIGS. 1 to 3 through the curing operation. However, at this point a non-conducting shock absorbing bonding material

22, such as any well known epoxide resin is inserted in the recess and the lead is thereafter positioned to bottom in the recess as shown at 23 for physically contacting and engaging the lining 17 on the wall of the recess. In this construction the bonding material 22 serves only to retain the lead in position and cushion it against stress, the electrical contact between the lead and the electrode being independent of the bonding material.

In FIG. 6 the terminal lead connection shown is identical to that described in FIGS. 1 to 3 except that the shock absorbing bonding material, rather than being an electrically conductive silver solder or the like, comprises an electrically conductive epoxide resin 24. The electrically conductive epoxide resin, while it may take any form known to the art, in the illustrated and preferred form of the invention comprises a suspension of silver or similar conducting particles 25 and epoxide resin.

In FIG. 7 the terminal lead connection is made by inserting a quantity of shock absorbing bonding material 26, formed of electrically conductive epoxide resin similar to that described with respect to FIG. 6, in the recess so that a portion, at least, of the wall of the recess is lined with the bonding material, it being necessary that all of the electrode plates exposed by the recess are engaged by the bonding material. Thereafter the lead 19 is inserted in the same manner as was described with respect to the other forms of the invention so that a substantial thickness of the bonding material is disposed around the lead for cushioning the same. In this form of the invention the lead 19 has electrical connection with its respective electrode of the unit through the electrically conductive epoxide resin forming the bonding cushion 26.

Thus, among others, the several objects and advantages of the invention as aforementioned are achieved. Obviously numerous changes in the structure may be resorted to without departing from the spirit of the invention as defined by the claims.

We claim:

1. In the method of making an electrical component which comprises the steps of building a substantially rigid monolithic body formed by successive substantially parallel layers of materials having specific electrical properties, at least one of said layers being electrically conductive and lying wholly within said body, inserting a flexible lead of electrically conductive material into said body for electrical connection to said electrically conductive layer, and bonding the inserted lead to said body, said lead projecting outwardly of the body for connecting said electrically conductive layer into an electrical circuit; the improvement in the inserting and bonding steps of the method comprising forming a recess in the body extending at least into the electrically conductive layer thereof for receiving an inserted lead, said recess having a diameter approximately twice the diameter of the lead to be inserted therein for providing an annular space between the lead and the body approximately equal to the radius of the lead for receiving a shock absorbing bonding material, and inserting a lead and an electrically conductive malleable shock absorbing bonding material into said recess so that the bonding material substantially fills the annular space around the lead, said lead having electrical connection with said electrically conductive layer through said bonding material and said bonding material bonding the lead in position and forming a malleable annular cushion therearound for substantially increasing the surface area of the bond relative to the surface area of the bonded portion of the lead, whereby stress resulting from flexing of the lead is dissipated.

2. In the method of making an electrical component which comprises the steps of building a substantially rigid monolithic body formed by successive substantially parallel layers of materials having specific electrical properties, at least one of said layers being electrically conductive and lying wholly within said body, inserting a flexible

lead of electrically conductive material into said body for electrical connection to said electrically conductive layer, and bonding the inserted lead to said body, said lead projecting outwardly of the body for connecting said electrically conductive layer into an electrical circuit; the improvement in the inserting and bonding steps of the method comprising forming a recess in the body extending at least into the electrically conductive layer thereof for receiving an inserted lead, said recess being of substantially greater diameter than the lead to be inserted therein for providing an annular space between the lead and the body for receiving a shock absorbing bonding material, and inserting a lead and an electrically conductive malleable shock absorbing bonding material into said recess so that the bonding material substantially fills the annular space around the lead, said lead having electrical connection with said electrically conductive layer through said bonding material and said bonding material bonding the lead in position and forming a malleable annular cushion therearound for substantially increasing the surface area of the bond relative to the surface area of the bonded portion of the lead, whereby stress resulting from flexing of the lead is dissipated.

3. In the method of making an electrical component which comprises the steps of building a substantially rigid monolithic body formed by successive substantially parallel layers of materials having specific electrical properties, at least one of said layers being electrically conductive and lying wholly within said body, said layers being of a semi-hard consistency, inserting a flexible lead of electrically conductive material into said body for electrical connection to said electrically conductive layer, and curing the body for hardening the same and bonding the inserted lead to said body, said lead projecting outwardly of the body for connecting said electrically conductive layer into an electrical circuit; the improvement in the step of inserting the lead and bonding the same to said body comprising forming a recess in the body prior to said curing step, said recess extending at least into the electrically conductive layer for receiving an inserted lead and being of substantially greater diameter than the lead to be inserted therein for providing an annular space between the lead and the body for receiving a malleable shock absorbing bonding material, lining the wall of said recess with electrically conductive material, said lining engaging said electrically conductive layer, thereafter curing the body for hardening said layers and lining and then inserting a lead and a malleable shock absorbing bonding material into said recess so that the bonding material substantially fills the annular space around the lead, said lead having electrical connection with said electrically conductive lining and therethrough with said layer, said bonding material bonding the lead in position and forming a malleable annular cushion therearound for substantially increasing the surface area of the bond relative to the surface area of the bonded portion of the lead, whereby stress resulting from flexing of the lead is dissipated.

4. The invention as defined in claim 3, wherein said wall and bottom of said recess are lined with said electrically conductive material and said lead is inserted in said recess to bottom therein against said lining, said bonding material being electrically non-conductive and said lead having electrical connection with said electrically conductive layer through said lining.

5. In the method of making an electrical component which comprises the steps of building a substantially rigid monolithic body formed by successive substantially parallel layers of thermoshrinkable materials having specific electrical properties, at least one of said layers being electrically conductive and lying wholly within said body, said layers being of a semi-hard consistency, inserting a flexible lead of electrically conductive material into said body for electrical connection to said electrically conductive layer, and curing the body for hardening the

same and bonding the inserted lead to said body, said lead projecting outwardly of the body for connecting said electrically conductive layer into an electrical circuit; the improvement in the step of inserting the lead and bonding the same to said body comprising forming a recess in the body prior to said curing step, said recess extending at least into the electrically conductive layer for receiving an inserted lead and being of substantially greater diameter than the lead to be inserted therein, lining the wall of said recess with a thin coating of electrically conductive material so that said coating engages said electrically conductive layer, inserting a sleeve of electrically conductive material in said recess, said sleeve having an outer diameter substantially conforming to the diameter of said recess so that said sleeve electrically engages said coating and having a bore therethrough of a diameter substantially greater than the diameter of the lead to be inserted therein for providing an annular space between the lead and the sleeve for receiving a malleable electrically conductive bonding material, thereafter curing the body to harden said layers and shrink the body upon said sleeve for retaining the same, and then inserting a lead and an electrically conductive malleable bonding material into the bore of said sleeve so that the bonding material substantially fills the annular space around the lead, said lead being electrically connected through said bonding material to said sleeve and thence through said lining to said electrically conductive layer, said bonding material bonding the lead in position and forming a malleable annular cushion for substantially increasing the surface area of the bond relative to the surface area of the bonded portion of the lead, whereby stress resulting from flexing of the lead is dissipated.

6. In the method of making an electrical capacitor which comprises the steps of building a substantially rigid monolithic body formed by successive substantially parallel layers of materials having specific electrical properties, a plurality of said layers being electrically conductive and lying wholly within said body, said electrically conductive layers being separated by layers of dielectric material and alternate electrically conductive layers being offset to form two distinct groups, said layers being of a semi-hard consistency, inserting a flexible lead of electrically conductive material into said body transverse to said layers for electrical connection to each of said electrically conductive groups of layers, and curing said body for hardening the same and bonding the inserted lead to said body, said leads projecting outwardly of the body for connecting their respective groups of electrically conductive layers into an electrical circuit; the improvement in the steps of inserting the leads and bonding the same to said body comprising forming a recess in the body for each lead prior to the curing step which extends through at least the electrically conductive layers of its respective group of layers for receiving an inserted lead, said recesses extending transverse to said layers and each being of substantially greater diameter than the lead to be inserted therein for providing an annular space between the lead and the body for receiving a shock absorbing bonding material, lining the wall of each recess with a thin coating of electrically conductive material so that all of the electrically conductive layers of the respective group are electrically connected thereby, thereafter curing the body to harden said layers and coatings, and then inserting a lead and a malleable electrically conductive shock absorbing bonding material into each recess so that the bonding material substantially fills the

annular space around the lead, said leads each having electrical connection with said electrically conductive layers of its respective group through said bonding material and said coating, said bonding material bonding the leads in position and forming an annular cushion therearound for substantially increasing the surface area of the bond relative to the surface area of the bonded portion of the lead, whereby stress resulting from flexing of the lead is dissipated.

7. In the method of making an electrical capacitor which comprises the steps of building a substantially rigid monolithic body formed by successive substantially parallel layers of materials having specific electrical properties, a plurality of said layers being electrically conductive and lying wholly within said body, said electrically conductive layers being separated by layers of dielectric material and alternate electrically conductive layers being offset to form two distinct groups, said layers being of a semi-hard consistency, inserting a flexible lead of electrically conductive material into said body transverse to said layers for electrical connection to each of said electrically conductive groups of layers, and curing said body for hardening the same and bonding the inserted lead to said body, said leads projecting outwardly of the body for connecting their respective groups of electrically conductive layers into an electrical circuit; the improvement in the steps of inserting the leads and bonding the same to said body comprising forming a recess in the body for each lead prior to the curing step which extends through at least the electrically conductive layers of its respective group of layers for receiving an inserted lead, said recesses extending transverse to said layers and each being of approximately twice the diameter of the lead to be inserted therein for providing an annular space between the lead and the body approximately equal to the radius of the lead for receiving a shock absorbing bonding material, lining the wall of each recess with a thin coating of electrically conductive material so that all of the electrically conductive layers of the respective group are electrically connected thereby, thereafter curing the body to harden said layers and coatings, and then inserting a lead and a malleable electrically conductive shock absorbing bonding material into each recess so that the bonding material substantially fills the annular space around the lead, said leads each having electrical connection with said electrically conductive layers of its respective group through said bonding material and said coating, said bonding material bonding the leads in position and forming an annular cushion therearound for substantially increasing the surface area of the bond relative to the surface area of the bonded portion of the lead, whereby stress resulting from flexing of the lead is dissipated.

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