March 12, 1957 D. M. KITTERMAN 2,784,481

METHOD FOR ATTACHING A WIRE IN END ON RELATIONSHIP TO THE SURFACE OF A BODY

Filed Dec. 1, 1952 3 Sheets-Sheet 1

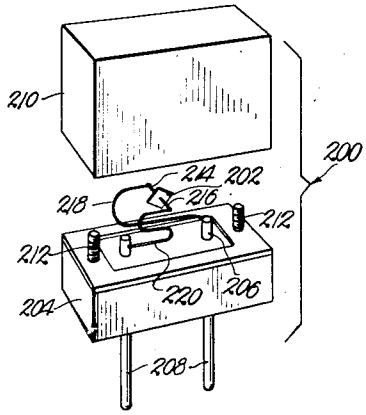


Fig. 1.

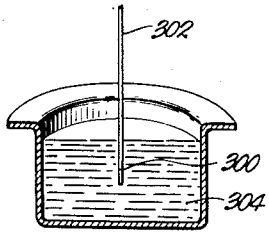


Fig. 2.

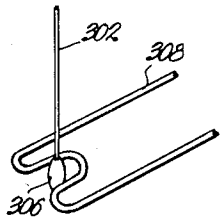


Fig. 3.

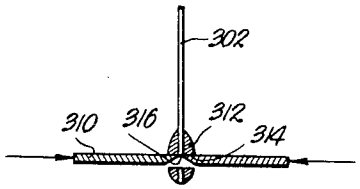


Fig. 4.

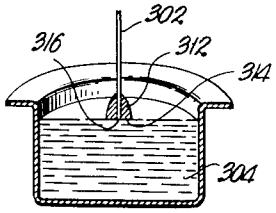


Fig. 5.

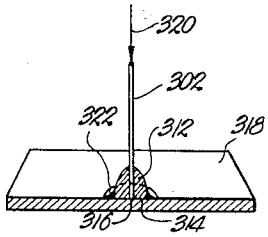


Fig. 6.

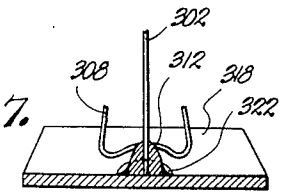


Fig. 7.

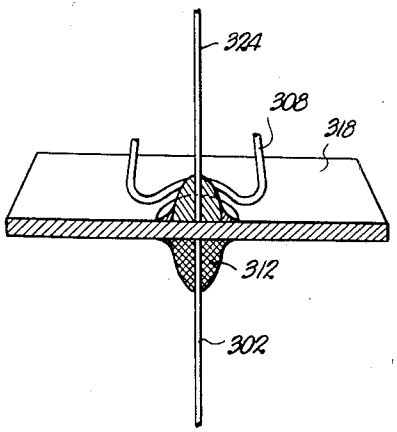


Fig. 8.

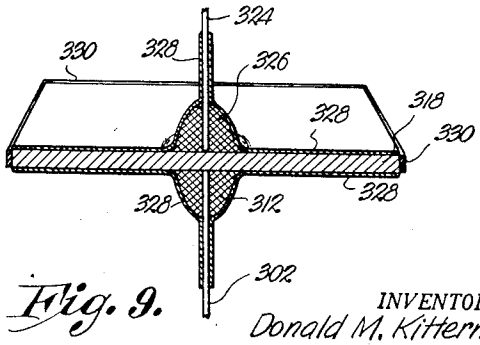


Fig. 9.

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METHOD FOR ATTACHING A WIRE IN END ON RELATIONSHIP TO THE SURFACE OF A BODY

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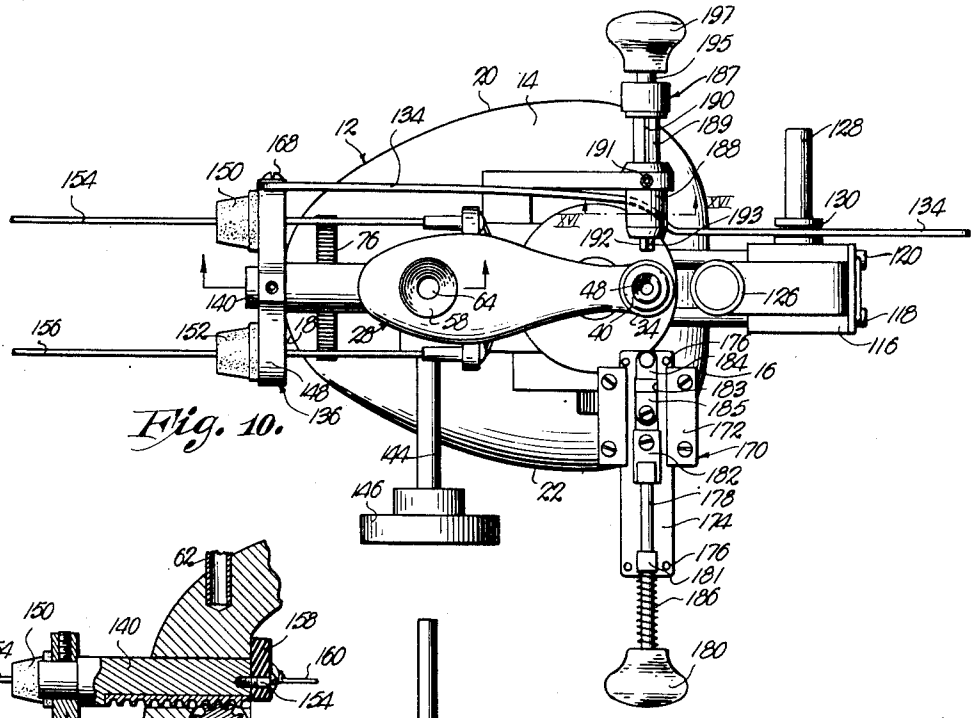


Fig. 10.

Fig. 15.

Fig. 11.

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METHOD FOR ATTACHING A WIRE IN END ON RELATIONSHIP TO THE SURFACE OF A BODY

Filed Dec. 1, 1952 3 Sheets-Sheet 3

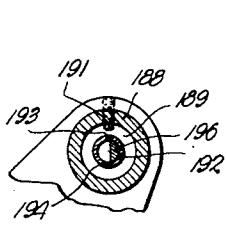


Fig. 16.

Fig. 12.

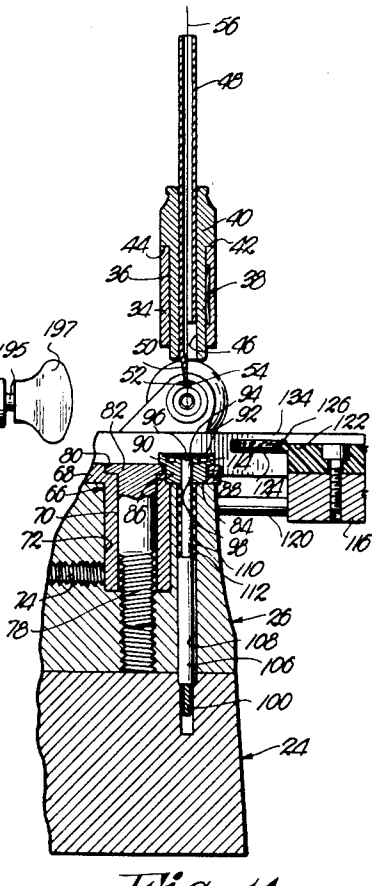


Fig. 14.

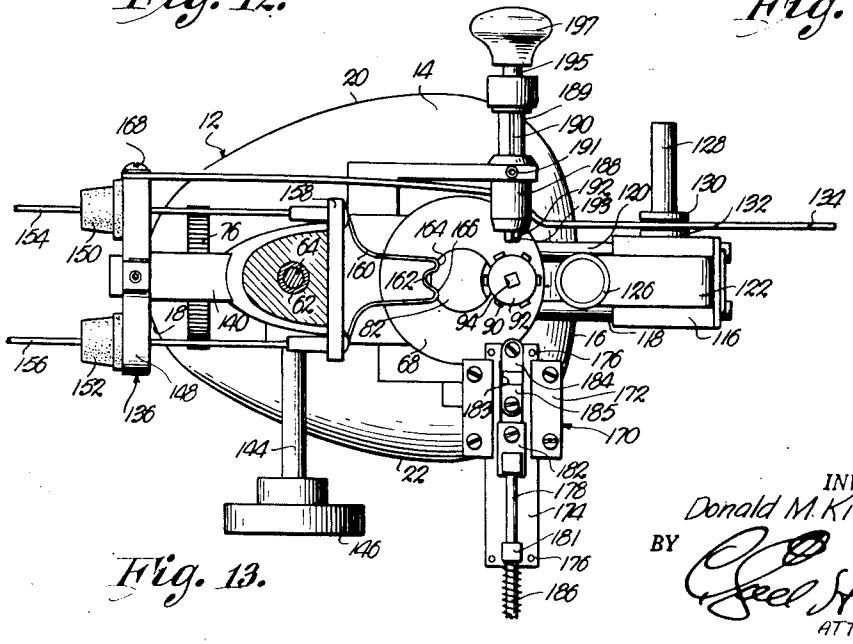


Fig. 13.

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2,784,481

METHOD FOR ATTACHING A WIRE IN END ON RELATIONSHIP TO THE SURFACE OF A BODY

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Application December 1, 1952, Serial No. 323,372

3 Claims. (Cl. 29—25.35)

This invention relates to a method and apparatus for attaching a wire to the surface of a body. More specifically, the method hereof is particularly suited for securing the end of a relatively fine wire in end on relationship to the surface of a body at a predetermined, relatively minute, substantially flat spot on the latter, and the apparatus hereof is particularly adapted for use in practicing the method hereof in cases where the body is relatively small.

Both the method and the apparatus hereof have been found especially advantageous and are currently being used with marked technical and commercial success in the manufacture of certain components for electronic equipment, particularly wire mounted piezo-electric crystals. Other applications for the method and apparatus hereof in the electronics field will be disclosed hereinafter, and still others in both this and other fields will be understood or become readily apparent herefrom to those skilled in the art.

In order to obtain optimum oscillatory performance from a piezo-electric crystal, the electrode and mounting structure therefor must be such as to restrict the vibratory action of the crystal as little as possible. On the other hand, practical considerations require a considerable degree of mechanical strength and ruggedness.

It is well known that several types of electrode and mounting structure for crystals have been tried, each effecting some relative compromise between the two primary considerations noted above. Among these are the so-called clamp type, plate type, air gap type and wire type, none of which have proved entirely satisfactory or of universal applicability in the forms heretofore developed.

The clamp type, wherein the faces of the crystal are first plated with a metal and the crystal then clamped between the electrodes, has found limited utility only with certain types of low frequency crystals, due to the damping effect of the clamp upon crystal vibration. The plate type, wherein the crystal is mounted between plates mechanically biased toward each other with one of the plates contacting the crystal at only a few peripheral points, has also found limited applicability to only certain types of crystals, notably those which vibrate in their thickness mode with nodal points about their peripheries, due to the intolerable damping effect of the plates upon other types of crystals. The air gap type, wherein the crystal vibrates between spaced electrodes with certain of its outer edges secured to prevent lateral motion, has similarly proved satisfactory with only a relatively few types of crystals, because of the necessity of securing the edges of the crystal and also the problem of standing supersonic waves encountered with vibrations of certain types and frequencies.

Likewise, the wire type, in the form heretofore used, wherein a glob of metallic cement is first affixed to the face of the crystal, the face then plated with a metal and the wire then soldered to the glob and plating, has proved only partially satisfactory due to the damping

effect of the size and mass of such type of wire mounting and also to the relative lack of mechanical strength manifested by such mounting when effort is made to reduce the mass and size thereof.

It is also well known that considerable difficulty has and is being encountered in the manufacture of devices such as transistors, wherein it is necessary to firmly mount several wires in electrically contacting relationship to minute spots on a small surface at particular points thereon in close proximity to one another. Previous efforts along this line are understood to have either evolved only methods which are too slow for optimum production and too expensive, or to have failed to produce the desired mechanical strength in the wire mountings, or to have unnecessarily broadened the spot of contact between the wire and the surface of the metal body of the transistor, or to have rendered the relative mounting of adjacent wires subject to positional limitations.

It is one of the primary objects of this invention to overcome the above mentioned problems and others well known to those familiar with the art by providing a method for rigidly securing the end of fine contact wires to a body, particularly to crystals, transistors and the like, by an efficient, relatively inexpensive method including steps which produce a mounting that engages only a relatively small spot on the surface of the body, yet provides a fastening of high strength.

Another important object hereof is to provide a method for so securing a fine wire to a surface of a body, with the mounting presenting only a negligible amount of additional mass.

Another important object hereof is to provide a method for so securing a fine wire to a surface, with the end of the wire in positive electrical contact with the surface at only a minute point on the latter.

Another important object hereof is to provide a method for so securing a fine wire to a surface which may conveniently include, when desired, steps for providing electrical contact between the wire and a predetermined portion of the surface in addition to that contacted by the end of the wire without substantially affecting the mechanical characteristics of the body whose surface is so contacted.

It is the other primary object of this invention to provide apparatus for attaching a wire to a body and particularly adapted for use in practicing the method hereof.

Another important object hereof is to provide apparatus for properly and conveniently performing the steps of the method hereof in the manner and order in which same must be performed in successfully practicing the method hereof for obtaining the improved results which the method makes possible.

Another important object hereof is to provide apparatus for such purposes which is simple and practically fool-proof in operation, whereby operators may be rapidly trained to operate the same and, after such training, can produce articles embodying the method hereof in mass production quantities heretofore thought impossible in this field.

Another important object hereof is to provide improved apparatus for use in attaching fine gauge, combination supporting and electrode wires to piezo-electric crystals at nodal points on the latter.

Other objects of this invention include the wide applicability of the method to the manufacture of various products, the economy of practicing the method, the relative simplicity and low cost of construction of the apparatus, and many other more minor objects, including certain details of construction of the apparatus, which will be made clear or become apparent to those familiar with the art as the following specification progresses.

For convenience, the method and aparatus hereof are

illustrated in the accompanying drawings, and the preferred manner of practicing the method and the preferred form of the apparatus are explained in the following specification, with reference to the mounting of contact wires upon piezo-electric crystals. Manifestly, however, other applications of the method and apparatus to the manufacture of other products will be apparent to those skilled in the art, particularly in view of the suggestions in such connection set forth hereinafter. It is to be understood, therefore, that this invention is to be limited only by the scope of the appended claims.

Referring now to the accompanying drawings:

Figure 1 is a perspective view of a piezo-electric crystal mounted on its plug by means of wires attached to the surface of the crystal in accordance with the method hereof, the upper hollow housing portion of the plug being shown removed for clearance and certain parts of the crystal mounting being enlarged for clarity.

Fig. 2 is an enlarged diagrammatical representation of the step of dipping the end portion of a wire into liquid, adhesive material.

Fig. 3 is an enlarged diagrammatical representation of the step of applying heat to the blob of adhesive material which adheres to the wire after dipping.

Fig. 4 is an enlarged diagrammatical representation of the step of severing the blob and the wire.

Fig. 5 is an enlarged diagrammatical representation of the step of touching the flat surface of the remainder of the blob to the adhesive material.

Fig. 6 is an enlarged diagrammatical representation of the step of placing the severed face of the blob upon the surface of the crystal with downward force being applied to the wire.

Fig. 7 is an enlarged diagramatical representation of the step of applying heat to the blob and coating of adhesive material adhering to the severed face thereof.

Fig. 8 is an enlarged diagrammatical representation of the step of applying heat to the blob of a second wire.

Fig. 9 is an enlarged diagrammatical representation of the step of plating certain surfaces of the crystal, the blobs and a portion of the wires.

Fig. 10 is a top plan view of the apparatus hereof.

Fig. 11 is a side elevation view of said apparatus.

Fig. 12 is a front elevation view of said apparatus.

Fig. 13 is a horizontal section taken on line XIII—XIII of Fig. 11.

Fig. 14 is a fragmentary vertical section taken on line XIV—XIV of Fig. 12.

Fig. 15 is a fragmentary vertical section taken on line XV—XV of Fig. 10, and

Fig. 16 is a fragmentary vertical section taken on line XVI—XVI of Fig. 10.

Referring now to Fig. 1, the numeral **200** broadly indicates a plug of the kind used for housing wire mounted piezo-electric crystals manufactured in accordance with the method hereof, showing such a crystal **202** in place therein. Plug **200** includes a base **204** of insulating material having a pair of metal contact terminals **206** and **208** extending therethrough and a hollow cap **210** adapted for attachment to base **204** by fastening screws **212** to cover the crystal **202** and protect same from dust and physical damage. A pair of fine gauge, combination supporting and electrode wires **214** and **216** (shown enlarged in Fig. 1) are attached to nodal points on the crystal **202** in accordance with the method hereinafter disclosed and are preferably soldered to the upper ends of relatively larger gauge conductors **218** and **220** respectively, the lower ends of conductors **218** and **220** being rigidly connected to the terminals **206** and **208**, respectively, by soldering adjacent the upper ends of the latter.

It will be apparent to those familiar with the art that such form of structure for housing and mounting the crystal **202** and its attached wires **214** and **216** forms no part of this invention and is suggested as merely illustrative for purposes of aiding in the understanding of the ultimate aims of the method hereof when applied to the manufacture of piezo-electric crystals.

Referring now to Figs. 2 to 9, inclusive, there is diagrammatically illustrated certain of the principal types of steps performed in practicing the method hereof. Manifestly, such figures are intended as merely illustrative of the broad aspects of the operations depicted, reference being made to the following description of the method for details.

The method hereof includes the following steps:

First, the end portion **300** of a wire **302** to be thereafter mounted to the surface of a crystal is dipped from above into a pool of suitable liquid, adhesive, thermosetting, cementitious material **304** to a depth of several times the diameter of the wire **302**, as illustrated diagrammatically in Fig. 2, then removed therefrom and held substantially vertically with the dipped portion **300** down. Obviously, the method may be used with a bight of wire **302** rather than an end portion thereof, if desired.

Normally, non-insulated wire or wire from which the insulation has been removed from the portion thereof that receives the cementitious material is used, in order to provide direct bonding contact between the material and the wire, and this is to be preferred unless special considerations otherwise dictate; however, when required, the method hereof may be practiced with wire of the enamel insulated or similar types having a rigid insulating coating rigidly affixed to the wire, due regard being had to the choice of a cementitious material that will have high adhesiveness to the insulating material and which will not be subject to undesirable chemical interaction with the insulating material. Either solid or stranded wire may be used, the former being preferred with crystals, however, because of the relatively smaller gauges available having a desired degree of rigidity.

Likewise, although various applications may require the use of other types or sizes of wire, the preferred kind of wire for mounting average size crystals has been found to be bare copper wire with a diameter of approximately .0025 inch or smaller. It is to be understood, of course, that the method and apparatus hereof are equally usable and advantageous with wires of other materials and sizes.

Various commercially available liquid, adhesive, thermosetting cements may be used in practicing the method hereof, depending, of course, on the particular kind of wire used and the particular material to which it is to be bonded. Cements which are either electrical conductors or dielectrics may be used in practicing the method hereof, although for most purposes in the electronic component field the latter type will be found preferable. It will also be obvious that the preferred type of cement will be one of the kind that is an adhesive liquid at room temperatures, is rendered viscous but still adhesive after heating for a short period, is rendered plastic in form, bonded to objects in contact therewith and substantially non-adhesive to objects thereafter contacted after being substantially but not completely cured by heating for an additional short period, and is then completely settable by curing with heat for a relatively short additional period of time and which, when cured, forms a strong, permanent bond between the particular type of wire used and the particular material to whose surface the wire is mounted. Such a cement for bonding bare copper wire to quartz piezo-electric crystals is an ethoxyline resin bearing the trademark "Araldite" and available on the market from Ciba Company, Inc., New York 14, New York.

It may be noted that when the dipped portion **300** of wire **302** is removed from the cement, a small amount of the liquid cement **304** adheres to the wire and, due to its surface tension and cohesive properties, tends to form a small, circumscribing, ellipsoidal blob or coating, as indicated at **306** in Fig. 3, about the wire **302**

above the lowermost end of the latter, when the wire **302** is held vertically.

Next, the small blob of cement **306** adhering to the wire when the latter is withdrawn from the pool of cement **304** is subjected to heat, diagrammatically represented as available from a heated filament **308**, of a temperature and for a time sufficient to substantially cure the same, as illustrated diagrammatically in Fig. 3. Clearly, any source of heat of the desired temperature may be used for curing the blob **306**. With Araldite, application of heat of a few hundred degrees Fahrenheit for a few seconds will be found sufficient to effect the desired degree of curing.

Next, the steps discussed above are alternately repeated until a blob **306** of substantially cured cement of the desired size is formed on the wire **302** above the lowermost end of the latter. Normally, with Araldite, three to five repetitions of the dipping and heating steps will be required to produce an ellipsoidal blob approximately .0075 to .0125 inch in diameter at its equator, which has been found to be the preferred size for mounting wires of the above mentioned size to piezo-electric crystals, although within reasonable limits the size of the blob **306** is not at all critical and may be intentionally varied for particular applications.

Next, the wire and the ellipsoidal blob **306** are simultaneously severed with any suitable cutting means **310**, preferably slightly below the equator of the blob **306** and on a plane substantially perpendicular to the longitudinal axis of the wire **302** when the wire is to be attached to a piezo-electric crystal, as illustrated diagrammatically in Fig. 4, thereby presenting a frusto-ellipsoidal blob portion **312** of substantially cured cement with the wire **302** passing thereinto from the top of the portion **312** and extending therethrough substantially on the central vertical axis thereof to the lowermost flat face **314** of the portion **312**, such face **314** being disposed slightly below the equator of the blob **306** and having the lowermost, severed edge **316** of the remaining length of wire **302** disposed in its plane. It may be noted that when the blob is severed below the equator, a maximum of longitudinal bonding surface between the wire and the portion **312** is presented relative to a given cross-sectional area for face **314**.

Next, the face **316** of the frusto-ellipsoidal blob portion **312** is touched to the pool of liquid cement **304**, as illustrated diagrammatically in Fig. 5, and then withdrawn, a certain amount of liquid cement adhering to the face **316** of portion **312** in a thin coating as it is withdrawn.

Next, the frusto-ellipsoidal blob portion **312** with the thin coating liquid cement adhering to the face **314** thereof is subjected to heat of a temperature and for a time sufficient only to render the same viscous rather than substantially free flowing in character. With Araldite, the application of heat of a few hundred degrees Fahrenheit for only two or three seconds is sufficient. This step is not diagrammatically illustrated in the drawings because of its obvious analogy to the step indicated in Fig. 3.

Next, the frusto-ellipsoidal blob portion **312** having the coating of adhesive, viscous cement adhering to the face **314** thereof is touched to the surface of the crystal **318** at a predetermined nodal mounting point on the latter, with the flat face **314** of the portion **312** engaging the surface of the crystal **318** at said point; and sufficient force, indicated at **320**, is then applied to the wire **302** directing it and the portion **312** toward the surface of the crystal **318** to squeeze most of the coating of viscous cement picked up on the face **314** when same was touched to the cement **304** from between the face **314** and the crystal **318** and out to an annular position, as at **322**, with respect to the circumference of the base of the portion **312** and circumscribing the same in adhesive engagement therewith and with the surface of the crystal **318**, as illustrated in Fig. 6. It may be noted that, although same is not ordinarily of importance in the manufacture of piezo-electric crystals in view of the plating step normally used with such crystals and hereinafter referred to, the application of proper force to the wire in a direction toward the surface of the crystal will insure positive seating of the end of the wire **316** for electrical contact with the surface of the crystal **318** or other body to which the wire is mounted. Such fact is of obvious importance in connection with applications of the method wherein the point electrical contact is an objective.

Next, the substantially cured blob portion **312**, and the ring of viscous cement **322** surrounding the base of portion **312** are all subjected to heat of a temperature and for a time sufficient to complete the curing of all of the cement and to permanentize the bonding between the wire **302**, the portion **312** and the crystal **318**, as illustrated diagrammatically in Fig. 7.

The same steps will then be repeated with a second piece of wire **324** for mounting the same in opposed or displaced relationship to the first wire **302** at a predetermined nodal mounting point on the same or another surface of the crystal **318**, the last curing step only being illustrated diagrammatically in Fig. 8.

After both wires **302** and **324** have been so mounted to the crystal **318**, the whole assembly is then normally cleaned by dipping same in a suitable solvent such as alcohol or the like, care being taken to choose a cleaning solvent that will not affect the mounting achieved with the particular cement used.

Then, with piezo-electric crystals, the surfaces of the crystal **318** having wires mounted thereon, the outer surfaces of the blob portions **312** and **326** and a portion of each of the wires **302** and **324** adjacent the curvilinear end of their respective blob portions may be thinly but completely plated with a layer **328** of some conducting metal to provide electrical contact between each wire and substantially the entire area of the particular surface of the crystal **318** upon which such wire is mounted, other portions of the assembly, notably the edges of crystal **318**, being masked, as at **330**, during plating. Any of several metals may be used for the plating, but gold has been found preferable with quartz crystals. Similarly, the plating may be accomplished either by evaporation, sputtering or otherwise, as is well known to those skilled in the art, but the evaporation process has been found most satisfactory with gold and quartz.

It will be readily appreciated by those skilled in the art that, where the method hereof is used in the manufacture of transistors or in many other wire mounting applications, the plating operation last mentioned is unnecessary and does not form a part of the method for the mounting of wires to such surfaces. It will also be recognized that, in many of such applications where electrical connection between the wire and the surface at one minute point only is desired, the positive seating of the wire for electrical contact with a point on the surface during application of force on the wire toward the surface, as discussed above, becomes important to the overall success of the method.

Referring now to Figs. 10 to 16, inclusive, there is illustrated one embodiment of the apparatus invented by me for use in practicing the method hereof. It will be appreciated that, although the form of the apparatus shown in the accompanying drawings is particularly suited for applications of the method involving extremely fine gauge wire and correspondingly small bodies such as piezo-electric crystals, the sizes of the various parts of the apparatus may be appropriately varied to accommodate the particular types and sides of wire and bodies which it is desired to act upon. It will be further understood that, when working with wire and bodies of minute dimensions, it is convenient to provide for use in conjunction with the apparatus hereof some form of suitable optical instrument, a part of which is fragmen-

tarily depicted in Fig. 11 and indicated broadly by the numeral **10**, by which the operator may view a magnified image of the field of manipulation of the wire and body being acted upon.

The apparatus itself, all parts of which except as hereinafter otherwise indicated are preferably formed of suitable tool metal, includes a base **12** having a top wall **14**, a front end wall **16**, a rear end wall **18** and a pair of side walls **20** and **22**. As indicated in Figs. 11, 12 and 14, the base **12** is preferably formed by a lower section **24** and an upper section **26** to permit convenient machining of certain internal details of base **12** hereinafter referred to. When the base is so sectionalized, the section **26** may be mounted atop section **24** and secured thereto by any suitable fastening means (not shown).

Mounted on base **12** adjacent the rear thereof is a forwardly bent quill-holding arm **28** having a rearmost, upwardly extending portion **30**, an intermediate, forwardly extending portion **32** overlying top wall **14** in spaced relationship thereto, and a forwardmost, upwardly extending tubular portion **34** having an elongated, vertical bore **36** of circular cross-section extending therethrough.

The bore **36** is provided with an inset leaf spring **38** disposed for frictionally engaging an elongated tubular sheath **40** to hold the latter against accidental movement when the same is in place in bore **36** and extending therethrough. Sheath **40** is provided adjacent its upper end with an outwardly extending, downwardly facing shoulder **42** engagable with the uppermost edge **44** of portion **34**. An elongated bore **46** is formed in sheath **40** and extends longitudinally therethrough in coaxial alignment therewith.

A hollow, elongated, tubular wire carrying quill **48** is normally disposed in bore **46** and has an outer diameter compared to the diameter of bore **46** such that quill **48** may be freely reciprocated and rotated within bore **46** by manipulation of quill **48** by an operator, yet will remain frictionally supported in any position within bore **46** when the operator is not manipulating same. At the lower end of quill **48** is a semiconical section **50** thereof provided at its lowermost apex end with a transverse bead **52** having a threadable, vertical, wire-receiving bore **54** of diameter approximately equal to the outer diameter of the particular size of wire to be used formed therethrough preferably in coaxial alignment with the central longitudinal axis of quill **48**. It is apparent that a length of wire **56** may be passed downwardly through quill **48** and threaded through bore **54** of bead **52** in frictional engagement with the walls of bore **54** to extend downwardly from the lowermost end of quill **48**, and that an operator may from time to time slide wire **56** in either direction through bore **54** to cause wire **56** to extend downwardly for greater or lesser distances from the bottom of bore **54**.

An upstanding tubular tool holder **58** having a vertical bore **60** formed therein and an internal liner **62** of rubber or similar material within bore **60** is provided on arm portion **32** for receiving a diamond-tipped marking tool **64** when the same is not in use. Tool **64** is of the same diameter as quill **48** to permit easy insertion, rotation and withdrawal of tool **64** through bore **46**.

A rotatable table **66**, having a circular, horizontal top **68** provided with an integral, depending tubular collar **70**, is rotatably supported in a veritcal bore **72** formed in base **12**, is releasably held against rotation by a horizontal set screw **74** disposed to engage collar **70** and having a knob **76** thereon disposed to the rear of base **12**, and is held against upward movement by a bolt **78** extending through a central opening **80** in top **68** and through collar **70**, said bolt **78** being threaded into base **12** and having a head **82** overlying a portion of top **68**, as best shown in Fig. 14. Top **68** of table **66** is also provided with a vertical, circular opening **84** formed therethrough and offset from the axis of rotation of table **66** by a distance to dispose opening **84** directly below bore **36** of arm portion **34**, and therefore bead **52** of quill **48**, when table **66** is rotated to a predetermined position.

A cylindrical nest **86** of diameter adapting the same for rotational support within opening **84** of table **66** is releasably held against rotation by a set screw **88** in table **66**. A plurality of integral, upstanding fingers **90** disposed about the circumferential surface of nest **86** adjacent the uppermost end thereof and extending thereabove serve the dual purpose of engaging the uppermost surface of top **68** to support nest **86** against downward movement and of providing a tightly engaging, laterally confining support for holding a circular body-receiving disc **92** having an opening **94** therethrough of shape and size adapted to receive a crystal **96** or other body to which wire **56** is to be attached. An axial bore **98** is provided through nest **86**, bore **98** being of slightly smaller diameter than the smallest lateral dimension of the crystal **96** to be acted upon.

A body-lifting lever **100**, partially housed in a slot **102** formed in base **12**, is pivoted to the base **12** at **104** and engages the lowermost end of vertically reciprocable, elongated lifting rod **106**, which is disposed in vertical bore **108** of base **12**, to reciprocate the rod **106** as the lever **100** is shifted. Rod **106** is downwardly biased by coiled spring **110** seated in bore **108** and bearing against an upturned shoulder **112** on rod **106**, as shown in Fig. 14. The uppermost end of rod **106** extends through bore **98** of nest **86** and is provided at its uppermost end with a plurality of upstanding, spaced, crystal-engaging teeth **114**. When lever **100** is actuated to move rod **106** upwardly against the action of spring **110**, teeth **114** engage crystal **96** to lift the latter upwardly from its seat in opening **94** of disc **92**, such action being used during the step of finally curing a blob of cement attaching wire **56** to crystal **96** to prevent undue dissipation of the heat applied into the metal parts normally in proximity to crystal **96**.

A horizontally reciprocal cement carrier **116** is mounted for sliding movement along parallel, horizontal tracks **118** and **120** rigidly mounted upon base **12**. Carrier **116** is provided with an extension **122** secured thereto, the extension **122** having an opening therein for receiving a cement carrying pan **124**, which is supported in the opening of extension **122** by an outturned flange **126**. Pan **124** is thereby rendered reciprocably movable to and from a position underlying bore **36** of arm portion **34** and overlying opening **94** of disc **92**. Carrier **116** is also provided with a laterally extending, shaft-like operating handle **128** having a pair of spaced guides **130** and **132** thereon for receiving an elongated, reciprocable link **134** operably connected with a heating assembly broadly indicated by the numeral **136**. Link **134** has a notch **138** formed in its lower edge intermediate its ends, notch **138** being adapted for engagement with handle **128** to move the latter and thereby reciprocate carrier **116** and pan **124** as link **134** is reciprocated.

Heating assembly **136** includes a horizontally reciprocable, elongated rack **140** passing through arm portion **30** and engaging a pinion **142** on a shaft **144** rotatably journalled in arm portion **30**, there being an operating knob **146** on shaft **144**. A cross-member **148** is mounted at the rear of rack **140** and carries a pair of feed-through insulators **150** and **152** through which pass conducting power lines **154** and **156**. Lines **154** and **156** are supported forwardly of arm portion **30** by a cross-bar **158** of insulating material mounted on the forwardmost end of rack **140**. A heating element **160** in the nature of a filament of nichrome wire is connected in series with lines **154** and **156** adjacent cross-bar **158**. It will be noted from Fig. 13 that element **160** includes a forwardmost portion of double-humped shape presenting a rear-turned bight **162** between a pair of forwardly extending bights **164** and **166**, such construction having been found preferable for maintaining uniformity of the heat being applied to a small blob of cement on wire **56**. Bight **162** is obviously movable to and from a position

underlying bore 36 of arm portion 34 and overlying opening 94 of disc 92 as rack 140 is reciprocated.

The rear end of link 134 is pivotally connected to crossmember 148 as at 168, so that notch 138 of link 134 may drop by gravity into engagement with handle 128 whenever the same are aligned. Notch 138 is so located along the length of link 134 that notch 138 will be aligned with handle 128 whenever either of pan 124 or bight 162 of element 160 is in its operating position underlying bore 36 of arm portion 34 and the other is in its fully withdrawn reciprocated position. Pan 124 and element 160 are thereby rendered reciprocable together forwardly or rearwardly of base 12, but oppositely relative to their respective operative positions, when notch 138 of link 134 is engaging handle 128. Link 134 may, of course, be manually lifted to free handle 128 from notch 138 when it is desired to position pan 124 independently of element 160 by manipulation of handle 28.

A cutter mechanism broadly designated by the numeral 170 includes a parallel grooved assembly 172 mounted on base 12 adjacent the left side thereof, and a horizontally reciprocable, rectangular plate 174 slidably mounted for movement from left to right relative to base 12 in the grooved assembly 172, the plate 174 having stops 176 at either end thereof to limit the extent of reciprocation thereof in either direction. A horizontally reciprocable, elongated rod 178 having a knob 180 on the left end thereof passes through a bracket 181 mounted on plate 174 adjacent the left end of plate 174 and is slidingly held by the bracket 181 against lateral movement. The right end of rod 178 is connected to a reciprocable, horizontally grooved rider 182 slidably mounted, tongue and groove fashion, in an elongated, rectangular slot 183 in plate 174. A first cutting blade 184 is mounted on the plate 174 adjacent the right end of the latter, and a second cutting blade 185 is mounted on the rider 182, blades 184 and 185 being disposed for cutting engagement when rod 178 and the rider 182 connected thereto are reciprocated to the right by manipulation of knob 180 against the action of a coiled spring 186 disposed about rod 178 and bearing against knob 180 and bracket 181. It may be noted that the application of left-to-right pressure on knob 180 will first, because of spring 186, reciprocate plate 174 to the right through assembly 172, until stops 176 on plate 174 engage assembly 172 placing plate 174 at a position where cutter blades 184 and 185 are in their operative position underlying bore 36 of arm portion 34; and then further application of such pressure on knob 180 will move rod 178 and rider 182 to the right against the bias of spring 186, until blade 185 engages blade 184 for severance of wire 56 and a blob of cement thereon.

A second cutter broadly designated by the numeral 187 includes a tubular sheath 188 mounted upon the base 12 adjacent the right side of the latter, and a horizontally reciprocable, elongated, tubular member 189 having a straight, longitudinal groove 190 formed therein, member 189 being slidably mounted within sheath 188 for reciprocation from right to left relative to base 12. Member 189 is restrained from rotation within sheath 188 by a pin 191 mounted within sheath 188 and extending into groove 190.

Member 189 is provided at its left end with an elongated, tubular, relatively thin walled, coaxial extension 192 of smaller diameter than the remainder of member 189, there being a pair of opposed, relatively narrow cutting slots 193 and 194 formed in extension 192 at the top and bottom thereof respectively. A rotatable, elongated rod 195, having a semicircular shearing element 196 at its left end adjacent slots 193 and 194 of extension 192, is rotatably journalled within member 189 and has an operating knob 197 mounted thereon at its right end. By applying right-to-left pressure to knob 197, member 189 is reciprocated to the left, disposing slots 193 and 194 below bore 36 of arm portion 34 with wire 56 passing through such slots 193 and 194. Then, when the knob 197 is rotated to move shearing element 196 in a clockwise direction with reference to Fig. 16 and from the position therein shown, the wire 56 is severed between the edge of the element 196 and the edge of the slot 194. It may be noted that sheath 188 is so mounted on the base 12 that the path of reciprocation of slot 194 of extension 192 is above the paths of reciprocation of pan 124, heating element 160 and blade 185 and is a predetermined distance above the crystal 96 when the latter is seated in disc 92.

It will now be apparent that the above apparatus is ideally suited for use in practicing the method hereof. Such apparatus is both simple and convenient to operate, thereby making possible more rapid and positive performance of the operations for which it is intended than any known previous type of equipment.

Such variations and modifications of the method or apparatus hereof as may fairly come within the scope of this invention are manifestly contemplated hereby, and it is therefore desired to be limited only by the spirit thereof as defined by the scope of the appended claims.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. A method of attaching a length of wire in end abutting, electrically contacting relationship to a surface of a body which includes the steps of placing a blob of initially liquid and adhesive, thermosetting, cementitious material upon a wire for adherence thereto; applying heat to the blob to partially cure the same until the blob is sufficiently set to be non-adhesive to objects thereafter coming in contact therewith yet sufficiently plastic to be yieldable within limits relative to the wire; severing the blob through the wire to remove a portion of the blob and a length of the wire and to present a remaining portion of the blob adhering to the remaining length of the wire and having a face including the severed end of said remaining length of the wire and of contour substantially complementary to said surface of the body; placing a relatively thin coating of substantially uniform thickness of said material upon said face for adherence thereto; placing said face carrying said coating upon said surface for adherence of the coating thereto; applying force to said remaining length of the wire in a direction to press said severed end thereof against the yielding resistance offered by said remaining portion of the blob into positive abutting engagement with said surface; and applying heat to said remaining portion of the blob and said coating while the application of said force is maintained to completely cure the same until said remaining length of the wire, said remaining portion of the blob, the coating and the surface are rigidly bonded together with said severed end of the remaining length of the wire in physical abutment and electrical contact with said surface.

2. A method of attaching a wire in end on, abutting, electrically contacting relationship to a flat surface of a body which includes the steps of alternately and successively dipping an elongated, substantially straight section of a wire into a pool of initially liquid and adhesive, thermosetting, cementitious material, withdrawing the section from the pool with the longitudinal axis of the section disposed substantially vertically, and applying heat to the adhesive material adhering to said section after each dipping thereof, said steps being repeated until a substantially ellipsoidal blob of said material having its longitudinal axis coincident with said axis of the section is deposited upon the wire in circumscribing relationship to an elongated portion thereof, said applications of heat being of temperature and duration to partially cure the blob until the same is sufficiently set to be non-adhesive to objects thereafter coming in contact therewith yet sufficiently plastic to be yieldable within limits relative to the wire; severing the blob through the wire in a common plane disposed transversely of the blob and the wire to remove a portion of the blob and a length of the wire and to present a remaining elongated, frusto-ellipsoidal portion of the blob adhering to the remaining length of the wire and having

a flat face including the severed end of the remaining length of the wire; touching said face to said pool of material for adherence of a relatively thin coating of said material to said face; applying heat to the coating to partially cure the same until the coating is rendered viscous but still adhesive; placing said face carrying said coating upon said surface for adherence of the coating thereto; applying force to said remaining length of wire in a direction to squeeze a portion of the coating from between said face and said surface and to press said severed end of the remaining length of the wire against the yielding resistance offered by said remaining portion of the blob into positive abutting engagement with said surface; and applying heat to said remaining portion of the blob and said coating while the application of said force is maintained to complete the curing of same until said remaining length of the wire, said remaining portion of the blob, the coating and the surface are rigidly bonded together with said severed end of the remaining length of the wire in electrical contact with said surface.

3. In the method as set forth in claim 2, wherein said severing of the blob is carried out by slicing the blob and the wire below the equator of the latter to render said remaining portion of the blob a major portion thereof.

References Cited in the file of this patent

UNITED STATES PATENTS

540,683	Oberlin	June 11, 1895
2,602,872	Ziegler	July 8, 1952
2,606,960	Little	Aug. 12, 1952
2,612,567	Stuetzer	Sept. 30, 1952
2,624,853	Page	Jan. 6, 1953
2,625,663	Howatt	Jan. 13, 1953