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K. F. MILLER ETAL

3,134,085

VARIABLE RESISTOR WITH TERMINAL STRUCTURE

Filed Aug. 17, 1962

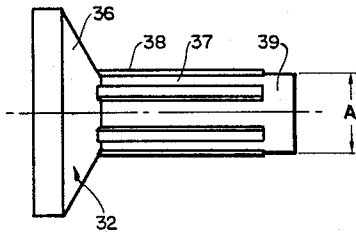


FIG. 2

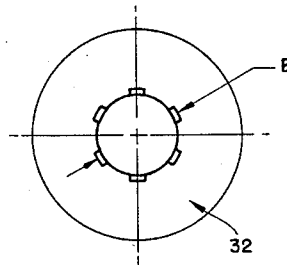


FIG. 3

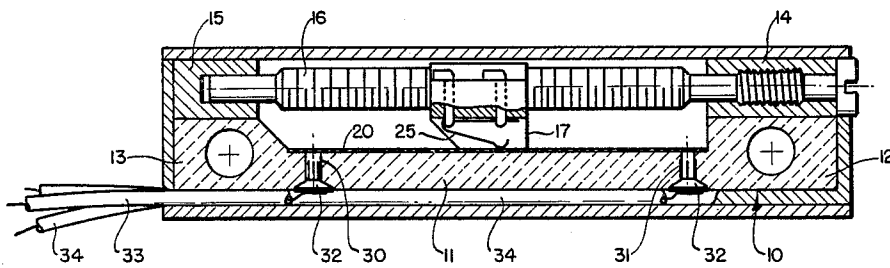


FIG. 1

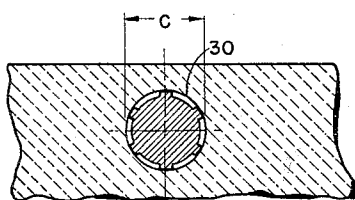


FIG. 5

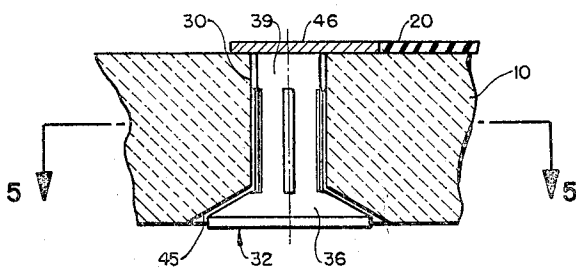


FIG. 4

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1

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VARIABLE RESISTOR WITH TERMINAL STRUCTURE

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10 Claims. (Cl. 338-180)

This invention relates to an improved terminal structure for resistance elements and, more particularly, to a terminal structure for miniature resistance elements such as rectilinear trimmer potentiometers employing a base formed of a refractory material.

The present state of the art relating to rectilinear trimmer potentiometers is highly developed as exemplified by the co-pending application of James F. Gordon, Serial No. 584,008, now Patent No. 2,845,679, entitled "Potentiometer and Method of Manufacturing Same," filed May 10, 1956; the co-pending application of Jack E. Langenbach et al., Serial No. 166,054, entitled "Improved Variable Resistor," filed January 15, 1962; and the co-pending application of William J. H. Thoele, Serial No. 166,199, entitled "Variable Resistance Device," filed January 15, 1962. Each of the foregoing applications are assigned to Beckman Instruments, Inc., assignee of the present invention.

Conventional terminals for trimmer potentiometers comprise a rigid wire inserted through holes provided in the non-conductive base which supports the resistance element. The construction of a typical prior art terminal for a trimmer potentiometer employing a layer type resistance such as a layer of cermet resistance material preferably constructed in accordance with the teachings of U.S. Patent No. 2,950,995, entitled "Electrical Resistance Element," and U.S. Patent No. 2,950,996, entitled "Electrical Resistance Material and Method of Making Same," each of which are assigned to Beckman Instruments, Inc., is as follows:

The cermet resistance layer is preferably supported upon a base formed of a refractory material such as steatite or alumina having holes drilled therethrough proximate the ends of the resistance element. Rigid wires inserted through these holes are electrically connected to respective ends of the resistance element by a silver composition which is silk-screened between the resistance element and the wire. This composition is fired to convert same to a continuous conductive metal film.

One difficult problem associated with this prior art terminal construction is that the wires are secured to the base by an adhesive or cement such as a glass cement which is fired simultaneously with the silver composition. Prior to this firing step, it is necessary to firmly retain the wire by providing an interference fit between the wire and its hole; otherwise, the wire may be dislocated during the silk-screening step. This interference fit, however, frequently results in fracture of the base element, particularly when the base is formed from a refractory material.

Another problem associated with the prior art terminal structure is the small physical size of the components. Thus, for a typical trimmer potentiometer, the holes in the base have a diameter in the order of 0.03 inch. Placing small wires in such small holes is a very tedious, time consuming manual operation and is normally performed under a microscope. This task is further complicated by the fact that because of the nature of the base material, the terminal receiving holes are not always formed with uniform diameters, thereby necessitating trying several wires of different diameters in order to obtain the required fit.

Accordingly, it is an object of this invention to provide

2

a terminal for resistance elements which may be firmly affixed to a base of refractory material without the need of adhesives or cements.

It is another object of the invention to provide a terminal structure which results in an interference fit between the terminal and its base hole without the necessity of employing different sized terminal structures.

It is a further object of the invention to provide a terminal structure which will not fracture a base formed of refractory material when inserted with an interference fit between the terminal and a hole formed in the base.

It is still another object of this invention to provide a terminal structure which does not require extremely close tolerances, thereby permitting the devices to be easily and inexpensively manufactured.

Another disadvantage of the prior art rigid wire terminal structure is that the wire provides a structurally weak member for attaching thereto the leads extending to the outside of the resistance element. During the soldering or welding operation, the end of the wire terminal is often broken off, thus necessitating discarding the entire element.

It is therefore another object of this invention to provide an improved terminal structure providing a rugged structure for welding or soldering thereto electrical leads.

Other and further objects, features and advantages of the invention will become apparent as the description proceeds.

Briefly, in accordance with a preferred form of the present invention, there is provided a resistance support member having one or more holes therethrough proximate the resistance element. The terminal structure comprises a headed pin formed from a malleable metal. The shank of this pin is serrated or grooved over a major portion of its length with a small cylindrical portion at its outer end for facilitating inserting the pin into the hole of the support base. This pin is then forced into the hole so as to physically deform the serrations thereby rigidly retaining the pin within the hole without the use of cements or adhesives. A conductive material may then be silk-screened on the exposed end of the pin to make contact with the resistance element. The enlarged head of the pin is exposed at the side of the base opposite the resistance element and provides a physically rugged structure for soldering or attaching the lead wires thereto.

A more thorough understanding of the invention may be obtained by a study of the following detailed description taken in connection with the accompanying drawings in which:

FIG. 1 illustrates a longitudinal cross-section of a trimmer potentiometer constructed according to the present invention;

FIG. 2 is an elevation view of a terminal pin constructed according to the present invention;

FIG. 3 is a plan view of the terminal shown in FIG. 2;

FIG. 4 is a partial sectional view of the terminal shown in FIGS. 2 and 3 incorporated in the trimmer potentiometer shown in FIG. 1; and

FIG. 5 is a sectional view taken along the line 5-5 of FIG. 4.

Referring now to FIG. 1, there is shown a trimmer potentiometer having a support member 10 comprising a central portion 11 and upstanding end portions 12 and 13. Bearings 14 and 15 mounted in the end portions 12 and 13 respectively, rotatably support a helically threaded adjustment shaft 16. A movable contact block 17 is engaged by the adjustment shaft and is adapted to be translated along the central portion 11 of the body between the end portions 12 and 13 upon rotation of shaft 16.

An elongated resistance element 20 and an elongated

electrical conducting element (not shown) are mounted side by side on the central portion 11 of the support member 10. Support member 10 is preferably molded or cast from a single piece of electrical insulating material, a ceramic such as steatite being a highly suitable material. The resistance element 20 may be a wire wound resistor, a molded resistor, a deposited layer resistor, or any other suitable type. A deposited layer type of resistance element which is fired on a ceramic base is especially well adapted for use in the embodiment shown. Preferred deposited layer resistance elements comprise cermet resistance elements constructed according to the teachings of U.S. Patent Nos. 2,950,995, entitled "Electrical Resistance Element," and 2,950,996, entitled "Electrical Resistance Material and Method of Making Same." Similarly, the electrical conducting elements may take various known forms, a film of silver fired on ceramic being preferred.

Electrical contact means 25 are carried on the contact block 17 for electrically connecting a point on the resistance element 20 with the conducting element.

The foregoing described structure, including additional specific details thereof is described and claimed in the co-pending application of James F. Gordon entitled "Potentiometer and Method of Manufacturing Same," supra.

The support member 10 incorporates respective holes 30, 31 extending between the bottom and top surfaces of this member. Respective headed terminal pins 32 are retained in each of these holes for making electrical contact between end portions of the resistance element 20 and externally extending leads 33 and 34. As shown, these leads are attached to the head portion of the respective pins 32. These leads are preferably welded to the heads although other techniques such as soldering or conductive cements may be employed.

The terminal pin 32 is shown in the enlarged views of FIGS. 2 and 3. This pin is preferably formed from a malleable metal having a temperature coefficient of expansion similar to that of the support member 10 and the electrically conductive silver layer. The pin must also resist firing temperatures of approximately 1000° F. to which it is subjected after its insertion in the support member. A representative material having the desired coefficient of expansion is an alloy comprising 29% nickel, 17% cobalt, 40% iron, 0.5% manganese, 0.2% silicon, 0.06% carbon, 0.10% aluminum, 0.10% titanium, 0.10% zirconium and 0.10% magnesium. The pin is preferably formed by a cold heading operation using a die and punch in a manner well known in the art after which it is gold plated to prevent deleterious oxidation during a succeeding firing operation. The pin may also be entirely constructed of a heat resistant alloy, examples of which are some stainless steels; platinum iridium alloy; platinum gold palladium alloy; platinum rhodium alloy; and an alloy comprising 76% nickel, 0.20% copper, 7.5% iron, 15.5% chromium, 0.25% silicon, 0.25% manganese, 0.08% carbon, and 0.007% sulphur.

As shown in FIGS. 2 and 3, the terminal pin 32 includes an enlarged head portion 36 integrally attached to a shank portion 37. A plurality of longitudinal serrations 38 are provided on the surface of the shank 37, six being shown in the figure although more or less may be employed.

The portion 39 at the extreme end of the shank is formed as a substantially cylindrical member for facilitating the insertion of the pin into the holes formed in the support base.

During the manufacture of the representative trimmer potentiometer which is shown in FIG. 1, the support base 10 is formed with openings 30, 31 and a resistance element 20 on its upper surface. Referring now to FIG. 4, the pin 32 is inserted through the opening 30 until the top surface of the pin is approximately flush with

the opposite surface of the support member. As shown, the bottom of the hole 30 is countersunk at 45 to accommodate the taper of the terminal head 36. It will be apparent that the cylindrical end portion 39 of the terminal pin will serve as a pilot in cooperation with the countersink 45 to locate the terminal pin 32 in the hole. As the pin is inserted further into the hole, the dimensions of the pin relative to the hole are such that the serrations will be deformed, usually beyond the elastic limit of the malleable material of the terminal, but retaining sufficient residual resiliency, in cooperation with the minor resiliency of the base 10 to firmly hold the terminal in position without the aid of adhesives or cements.

In order to achieve the desired attachment of the end to the resistance base, the pin dimensions should be related to the diameter of the hole as follows: Referring to FIGS. 2, 3 and 5, the dimension "A" is the minor diameter of the pin and is the diameter of the outer pilot the hole. This insures that the pilot diameter of the pin is the diametric dimension of the serrated portion. The diameter of the hole in the base element is the dimension "C." The dimensional relationship between the hole 30 and the terminal pin 32 must be such that the diameter "A" of the terminal must always be smaller than the diameter "C" of the hole, and the major diameter "B" of the pin must always be larger than the diameter "C" of the hole. This insures that the pilot diameter of the pin will facilitate inserting the pin into the hole while the serrations will be deformed so as to rigidly retain the pin within the hole.

The next step in the potentiometer construction is that of electrically connecting the end of the pin 32 to the resistance element 20. This connection is conveniently formed by silkscreening or otherwise depositing a metallic terminating means 46 upon the surface of the support member 10 between the resistance element 20 and covering the end of the pin 32. This termination is preferentially a metallic paste comprising 1%–10% silver and 90%–99% platinum powders added to a conventional paste binder. The metallic paste is applied to a thickness approximating that of the resistance element 20 as shown in FIG. 4. The assembly is again fired to convert the metallic paste to a continuous conductive metal film which tenaciously adheres to the base 10 and electrically joins the resistance element and the terminal. The temperature coefficient of expansion of the terminal pin 32 should be similar to that of this metal film so that heating of the resistance element caused by high ambient temperatures will not destroy the bond between the film and the top surface of the pin. While other metallic pastes may be employed, it is essential that the temperature required to convert the metallic paste to a conductive film be lower than the temperature of conversion for the resistance layer 20.

The electrical leads 33, 34 may then be joined to the head 36 of the terminal by soldering, welding or otherwise attaching leads thereto. Optionally, the terminal 32 may be formed with an elongated body (not shown) when, for example, the resistance element is to be mounted upon a printed circuit board.

The terminal pin described above provides a greatly improved termination for resistance elements employing bases formed of a refractory material. The serrated construction is such that its maximum dimension (dimension "B") may be such as to form an interference fit with holes of several different sizes since the pin by nature of its being formed malleable material and its serrated construction deforms without causing a fracture of the resistance base.

Another advantage of the invention is that the tolerances are substantially reduced since the major diameter "B" of the pin may vary (so long as the dimensional criteria described above are maintained) while still permitting its use in holes of different diameters. Thus, the

pin may be inexpensively manufactured in quantity by a non-precision technique such as a cold heading operation.

Although exemplary embodiments of the invention have been disclosed and discussed, it will be understood that other embodiments may be constructed employing the teachings of this invention. Thus, the serrated portion of the pin may be formed as longitudinal projections as shown and described, or, for example, they may be formed as a series of tangential projections making an oblique or right angle with the longitudinal axis of the pin. Alternatively, the serrations may be formed as a helical thread or portions of a helical thread upon the surface of the pin shank. Further changes, modifications and substitutions which may be made without departing from the spirit of the invention will be apparent to those skilled in the art.

Also, other applications of the invention are possible. By way of specific example, the terminal will find wide application in any miniature electrical component utilizing a refractory base element.

We claim:

1. A conductive termination for a resistance element comprising:

- a support member for said resistance element having a hole extending therethrough proximate said resistance element, said hole having a diameter C;
- a terminal for said resistance element which is rigidly retained to said base without any cement or adhesive including a pin formed of a malleable conductive material inserted in said hole, said pin comprising:
 - a generally cylindrical member of minor diameter A having a plurality of serrations formed upon the outer surface thereof, the major diameter of said terminal being B,
 - said dimension A being smaller than dimension C and said dimension B being slightly larger than the dimension C wherein said serrations are deformed upon insertion of said terminal into said hole;
- and means electrically connecting said terminal to said resistance element.

2. The conductive termination defined in claim 1 wherein:

- said terminal includes an enlarged head and wherein said hole formed in said support member includes a countersunk opening opposite the surface upon which said resistance element is retained, said countersunk accommodating said enlarged head;
- said head providing an enlarged physical structure for facilitating attaching electrical leads thereto.

3. The conductive termination defined in claim 1 wherein:

- said terminal includes a cylindrical portion at one end thereof for providing a pilot for locating said terminal within the hole formed in said support member.

4. The conductive termination defined in claim 1 wherein:

- said terminal is formed of a material having a temperature coefficient of expansion similar to that of said support member and said means electrically connecting said terminal to said resistance element.

5. The conductive termination defined in claim 4 wherein:

- said terminal is formed of an alloy substantially comprising 29% nickel, 17% cobalt, 40% iron, 0.5% manganese, 0.2% silicon, 0.06% carbon, 0.10% alu-

minum, 0.10% titanium, 0.10% zirconium and 0.10% magnesium.

6. The conductive termination defined in claim 5 wherein:

- said terminal is gold plated to prevent oxidation under relatively high temperature.

7. The conductive termination defined in claim 4 wherein:

- said terminal is formed of an alloy taken from the group consisting of platinum iridium alloy; platinum gold palladium alloy; platinum rhodium alloy; and an alloy comprising 76% nickel, 0.20% copper, 7.5% iron, 15.5% chromium, 0.25% silicon, 0.25% manganese, 0.08% carbon and 0.007% sulphur.

8. The conductive termination defined in claim 1 comprising:

- a conductive paste applied over the exposed end of said terminal pin for electrically interconnecting said resistance element to said terminal, said paste being subjected to a firing temperature for converting said paste to a continuous metallic layer, said terminal being constructed so as to be resistant against oxidation due to said firing temperature.

9. A variable resistor comprising:

- a support means;
- a resistance element mounted to the upper surface of said support means;
- means for movably contacting said resistance elements, said means including an adjustment shaft rotatably mounted upon said support means;
- said support means having first and second holes proximate the respective ends of said resistance element; and
- a terminal formed of a malleable conductor material inserted in each of said holes, said terminal having a cylindrical end slightly smaller than the diameter of said hole and another portion provided with a plurality of serrations which are deformed upon insertion of the pin within said opening, the diameter of said serrations being such that the pin is rigidly retained within said hole without fracturing the support base.

10. The conductive termination for an electrical component comprising:

- a support member for said electrical component, said member being formed of a refractory material and having a hole extending therethrough proximate said component;
- a terminal formed of a malleable conductor material inserted in said hole, said terminal having a cylindrical end slightly smaller than the diameter of said hole and another portion provided with a plurality of serrations having a diametric dimension slightly larger than said hole, said serrations being deformed upon insertion of the pin within said opening so that said pin is rigidly retained within said hole without the use of cement or adhesives and without fracturing the support base; and
- means electrically connecting said terminal to said electrical component.

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2,962,691	Mande et al.	Nov. 29, 1960
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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,134,085

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Kenneth F. Miller et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 20, strike out "the hole. This insures that the pilot diameter of the pin" and insert instead -- portion 39 thereof. "B", the major diameter of the pin, --; line 28, for "thatt he" read -- that the --.

Signed and sealed this 29th day of September 1964.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents

UNITED STATES PATENT OFFICE
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