Oct. 25, 1960 W. A. BARDEN ET AL 2,958,062

RECTILINEARLY ADJUSTABLE VARIABLE RESISTOR

Filed June 8, 1959

2 Sheets-Sheet 1

Fig. 1.

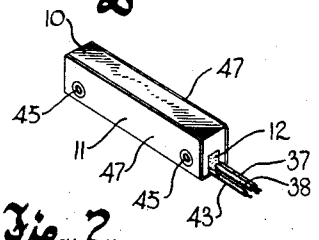


Fig. 2.

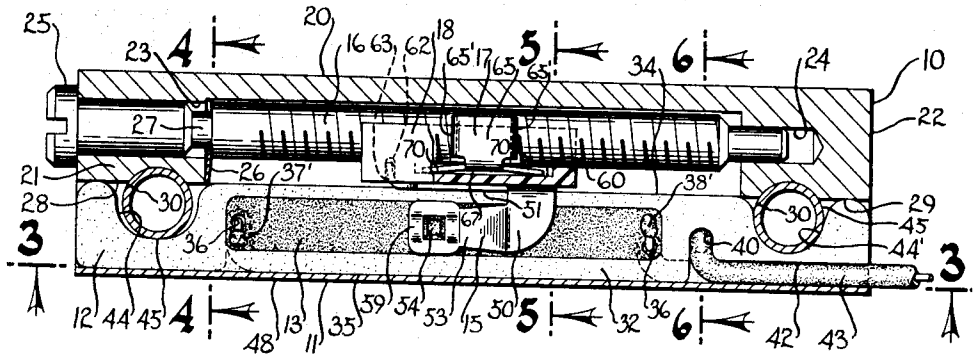


Fig. 3.

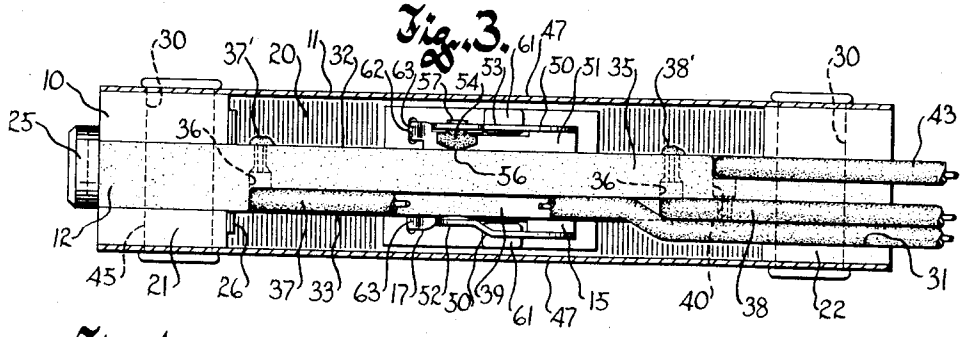


Fig. 4.

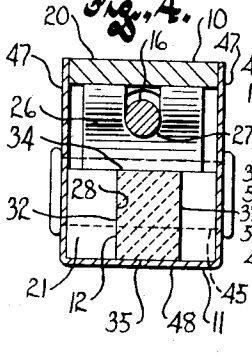


Fig. 5.

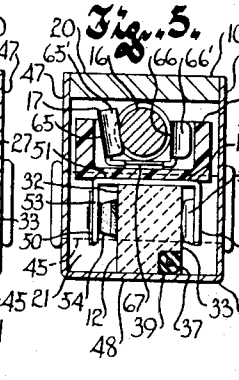
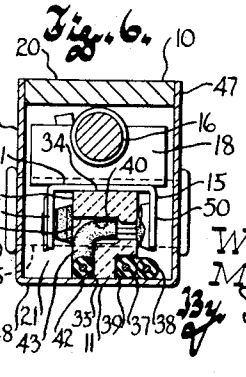


Fig. 6.



Inventors
Wayne A. Barden
Mervin B. Arisman
By Dashutton Jones
Attorney

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Fig. 7.

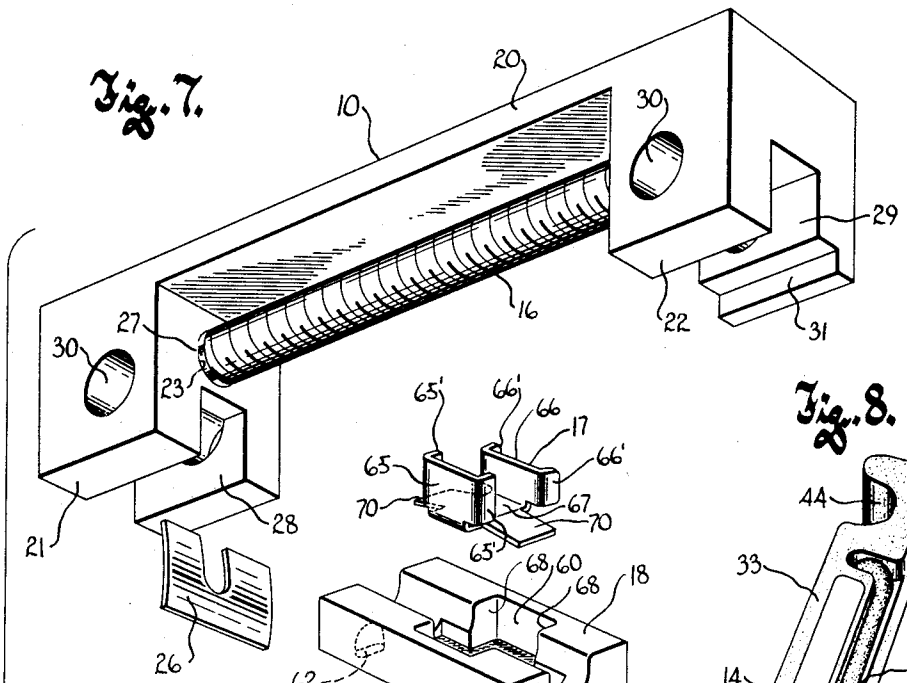
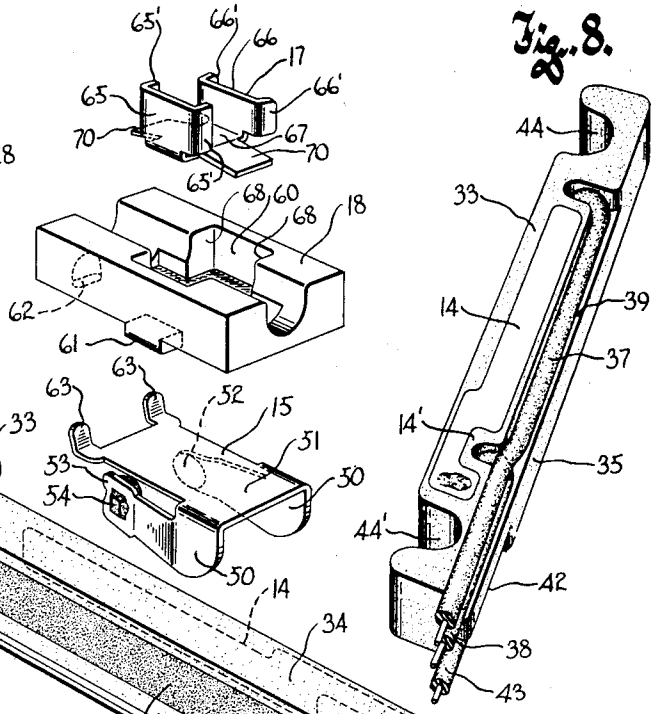


Fig. 8.



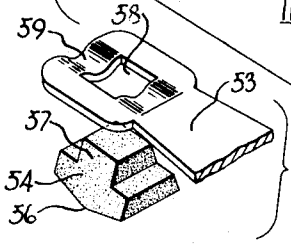


Fig. 9.

Inventors
Wayne A. Barden
Mervin B. Arisman
By Dashiell, Jones & Attorneys

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RECTILINEARLY ADJUSTABLE VARIABLE RESISTOR

Wayne A. Barden and Mervin B. Arisman, Elkhart, Ind., assignors to CTS Corporation, Elkhart, Ind., a corporation of Indiana

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16 Claims. (Cl. 338—180)

This invention relates to variable resistors and/or potentiometers, and refers more particularly to a linearly adjustable potentiometer of the type illustrated in the Bourns Patent No. 2,777,926. These potentiometers are not intended for frequent manual adjustment, but must be capable of extremely fine adjustment and be reliably stable even under highly adverse conditions, since they are intended for use in guided missiles and rockets.

Despite the fact that recently there has been considerable activity in this art, there is considerable room for improvement, and the present invention is directed toward that end.

It is, therefore, an object of this invention to provide a linearly adjustable variable resistor which possesses greater stability than was heretofore possible and, in addition, is simpler and easier to assemble and produce.

These advantages of the invention flow from the fact that the resistance and conductor paths are on opposite sides of an elongated bar-like ceramic base which is not an integral part of the housing, but instead is mounted therein during assembly of the device. The customary bridging contactor which is adjusted by rotation of a lead screw, transversely embraces this ceramic base and has contact fingers bearing upon the resistance and conductor paths to traverse the same as the conductor is moved along the length of the base.

Since the resistance and conductor paths are on a base separate from the housing, the housing may be made entirely of metal, which makes it stronger and better able to dissipate heat.

This invention also has as an object to simplify the component parts of the resistor, and the manner in which they are structurally related, so that assembly of the resistor is a relatively simple matter.

In general, it may be said that the object of this invention is to provide a variable resistor or potentiometer of the character described which is better and less expensive to produce than those heretofore available, but which, nevertheless, possesses greater stability and accuracy than prior resistors.

With the above and other objects in view, which will appear as the description proceeds, this invention resides in the novel construction, combination and arrangement of parts substantially as hereinafter described and more particularly defined by the appended claims, it being understood that such changes in the precise embodiment of the hereindisclosed invention may be made as come within the scope of the claims.

The accompanying drawings illustrate one complete example of the physical embodiment of the invention, constructed according to the best mode so far devised for the practical application of the principles thereof, and in which:

Figure 1 is a perspective view of a variable resistor or potentiometer embodying this invention;

Figure 2 is an enlarged longitudinal sectional view through the resistor;

Figure 3 is essentially a bottom view of the resistor,

but to the extent that it shows the cover member thereof in section, it is a sectional view taken on the plane of the line 3—3 in Figure 2;

Figures 4, 5 and 6 are cross sectional views through Figure 2 on the lines 4—4, 5—5 and 6—6, respectively;

Figure 7 is an exploded perspective view of the main elements of the resistor, showing the same generally in their relative positions of assembly;

Figure 8 is a perspective view of the ceramic base upon which both the resistance and conductor paths are located, viewing the same from the side opposite the one shown in Figure 7 and with the conductor leads connected and in position; and

Figure 9 is a detail perspective view of the contact pad which rides upon the resistance path, and the end portion of the spring contact finger by which it is carried.

Referring now more particularly to the accompanying drawings, in which like numerals designate like parts throughout the several views, as shown in Figure 1, the variable resistor or potentiometer of this invention in external shape and appearance is an oblong body, almost square in cross section, with its leads projecting from one end thereof and the head of its adjusting screw at the opposite end. Although the dimensions or size of the resistor are unimportant from the standpoint of patentability, to fully appreciate the novel structural features of the invention it may be helpful to know that, in practice, the overall length of the complete resistor is only one and one-quarter inches (1¼") and, in cross section, it measures only one quarter by five sixteenths of an inch (¼" x 5/16").

The components of the resistor are contained within a case formed conjointly by a housing member **10** and a cover **11** which is U-shaped in cross section and embraces the housing member. A ceramic base **12**, having a resistance path **13** on one side thereof, and a conductor path **14** on its opposite side extends lengthwise of the housing member; and a bridging contactor **15** straddles the ceramic base and electrically bridges the resistance and conductor paths. A lead screw **16** is rotatably supported by the housing member parallel with the ceramic base, and upon rotation slides the contactor along the base to effect the desired adjustment of the resistor. To so adjust the contactor, a nut element **17** connects the screw with the contactor through an insulated driver **18** on the contactor.

The housing member **10** is in the form of an elongated bar **20** having integral endwise spaced end walls **21** and **22** projecting from the same side of the bar **20**. Unlike the housing or body members of variable resistors and potentiometers of this type heretofore available, the housing member **10** is made of metal, preferably brass. Its end walls **21** and **22** have coaxial bearings **23** and **24** in which the lead screw is journalled. Both bearings are drilled holes, the hole forming the bearing **23** being larger than that which provides the bearing **24**, and extending all the way through its respective end wall, whereas the hole providing the bearing **24** projects only part way into the end wall **22**.

The bearing **23** is large enough to allow the screw to be passed through it and, when inserted, the screw is held in place with its head **25** bearing firmly against the adjacent end of the housing member by a bowed spring retainer **26**. This retainer is a U-shaped spring blade straddling a reduced neck portion **27** of the screw and confined under tension between the inner face of the end wall **21** and the remote side of the groove which forms the reduced neck.

As best seen in Figure 7, the end walls **21** and **22** of the housing member have aligned longitudinal slots **28** and **29** extending through them, and intersecting these slots there are drilled holes **30**, which pass through the

end walls from one side to the other thereof with parts of the holes below the bottoms of the longitudinal slots. For a purpose to be hereinafter described, the slots 28 and 29 are not exactly centered between the sides of the housing member, and the slot 29 has one side thereof rabbeted or stepped, as at 31, also for a purpose to be later described.

The ceramic base 12 is substantially rectangular in cross section and its length is the same as that of the housing member 10. The end portions of the ceramic base fit the slots 28 and 29, and, in so doing, hold the base against lateral shifting. Being rectangular in cross section, the base has two flat sides 32 and 33, and two other flat faces 34 and 35 which, for convenience, may be considered top and bottom surfaces. The resistance path 13 is on the side 32 and the conductor path is on the opposite side 33 and, preferably, both paths are painted directly on to the ceramic base. The conductor path may be simply a band or stripe of silver, or the like, painted or otherwise applied to the base, and the resistance path may be similarly applied and may be formed in any suitable manner, though it is more preferably a very thin metallic partially conductive film.

As seen in Figures 2 and 7, the resistance path 13 is of uniform width throughout its entire length, and its terminal portions preferably have low resistance hopoffs such as those fully illustrated in the copending application of Clinton W. Hartman et al., Serial No. 729,741, filed April 2, 1958, now Patent No. 2,916,717. Holes 36 pass through the ceramic base in line with the terminal or hopoff portions of the resistance path, to receive the ends of the leads 37 and 38 by which the resistance path may be connected in circuit. The holes 36 have large diameter end portions opening to the side 33 of the base and small diameter end portions opening to the other side 32 of the base.

The leads 37 and 38 are insulated, as is customary, and enter the large diameter ends of the holes 36. The insulation on the leads abuts the abrupt junctions of the large and small diameter portions of the holes and the bared ends of the leads project from the small diameter ends of the holes and are soldered to the terminal or hopoff portions of the resistance path, as at 37' and 38' (see Figure 3).

To accommodate the leads 37 and 38, the bottom side 35 of the base has a groove or rabbet 39 extending from the hole 36 all the way out to the opposite end of the base, this groove or rabbet being of a size to accommodate one of the leads. The lead 37 occupies this groove or rabbet 39 for most of its length, but the lead 38 occupies the end portion thereof between the hole in which the end of the lead 38 is located and the adjacent end of the base, and for this short distance, the leads 37 and 38 lie alongside one another.

The conductor path 14, as best seen in Figure 8, is of uniform width throughout most of its length, but at one end portion it is offset, as at 14', to provide clearance for the lead 38. A hole 40 through the ceramic base in line with the extremity of the offset portion 14' of the conductor path receives the end portion of a third lead 43 which is soldered to the conductor path. The hole 40, like the holes 36, is stepped in diameter to provide a shoulder against which the end of the insulation of the lead abuts, and has its small diameter end opening to the offset portion 14' of the conductor path and its large diameter end opening to a notch or recess 41 in the side of the base at which the resistance path is located. This notch or recess joins with a slot or rabbet 42 at the junction of the sides 32 and 35 of the base in which the third lead 43 is laid.

The slot or rabbet 42, like the slot or rabbet 39, is of a size to receive just one lead. Hence, all three leads lie in a common plane and, except for the outer end portion of the lead 37, which occupies the rabbet or offset 31 in the end portion 22 of the housing member, all three leads are accommodated within the cross sectional contour of the base.

The opposite end portions of the ceramic base have cross slots 44 and 44' therein. Both of these slots are round bottomed and open to the top side or face 34 of the base. The slots are of uniform depth and shape throughout their length, and their ends open to the opposite sides 32 and 33 of the base upon which the resistance path and conductor paths are located. The distance between the slots 44 and 44' corresponds to the distance between the holes 30 in the end portions of the housing member, and, as seen in Figure 2, the cross slot 44' through much of its dimension coincides with the wall of the adjacent hole 30, but the other slot 44 is wider than the diameter of the adjacent hole 30.

Tubular rivets 45 passing through the holes 30 and the slots 44 and 44', hold the ceramic base against endwise displacement with respect to the housing member, and since they also pass through the flanges 47 of the cover 11, these rivets secure all of the parts of the unit assembled.

The cover 11 is preferably formed of sheet metal and, in cross section, is of a size to just snugly receive therein the assembled housing member and ceramic base, with its flanges 47 overlying the opposite sides of the housing member and its end portions 21 and 22, and the web 48 of the cover lying flat against the bottom side of the base and the adjacent surfaces of the housing member end portions. The flange 48 and the grooves or rabbets 39 and 42 thus coact to form tunnels through which the leads 37, 38 and 43 project.

The heads of the tubular rivets and their rolled over opposite ends, of course, overlie the flanges 47 of the cover, and clamp the same against the end portions 21 and 22 of the housing member.

The bridging contactor 15 is a generally U-shaped sheet metal stamping, having flange portions 50 connected by a web portion 51. It straddles the ceramic base with its web portion 51 seated upon the top side 34 of the base and its flange portions 50 overlying the opposite sides 32 and 33. Spring contact fingers 52 and 53 extend from the flange portions and have smooth surfaced contacts at their extremities to bear upon and traverse their respective paths. The contact of the finger 52 which rides upon the conductor path is simply an integral rounded portion of its finger, but the contact for the finger 53 which rides upon the resistance path is preferably a separate pad 54 of fired carbon graphite or the like.

As shown in Figure 9, the pad 54 is roughly T-shaped when viewed from the side and of trapezoidal shape when viewed from the end. The top of its head is a rather flat V and defines a ridge 56 which extends transversely across the resistance path to have substantially line contact therewith across its full width. The stem portion 57 of the pad is received in an appropriately shaped and sized hole 58 in the free end of the spring finger 53; and to allow the pad to rock, a longitudinally extending ridge 59 is formed in the end of the finger to provide a fulcrum at right angles to the ridge 56 of the head, upon which the underside of the head of the pad bears. The pad is thus free to adjust itself to the surface of the resistance path without interference from the spring finger by which it is carried.

To slide the bridging contactor linearly along the resistance and conductor paths, or in other words along the length of the ceramic base 12, is the function of the nut element 17 and the driver 18 interposed between the nut element and the contactor. The driver 18 is a block of insulating material, preferably steatite, with a flat underside which seats upon the flat web 51 of the contactor and a generally cruciform shaped socket 60 in its top side in which the nut member 17 is received. Transversely spaced lugs 61 projecting down from the underside of the driver engage the opposite side edges

of the web portion 51, and small sockets 62 opening to the flat underside of the driver receive tongues 63 projecting up from the web of the contactor. Hence, the lugs 61 and the engagement of the tongues 63 in the sockets 62 together secure the contactor and its driver against relative movement in diections parallel with the web.

The nut element 17, like the contactor, is a sheet metal stamping substantially U-shaped with flanges 65 and 66 connected by a web 67. The flange 65 has inturned edges 65' which engage between the threads of the lead screw while the opposite flange 66 simply bears against the opposite side of the screw. Its side edges are also flanged, as at 66', but these flanges point away from the screw to have driving engagement with shoulders 68 which form part of the generally cruciform shaped socket 60.

Spring fingers 70 projecting from the opposite sides of the web 67 of the U-shaped nut element, bear against the bottom of the socket 60 and, by their resiliency, serve to hold the driver down onto the web of the contactor and the web of the contactor firmly against the top side of the ceramic base. At the same time, these spring fingers 70 urge the nut element upwardly toward the screw and thereby hold the same in operative engagement with the screw.

An advantage of making the nut element in the form described is that it provides assurance against unduly stressing any part of the control in the event of continued application of torque to the screw after either limit of adjustment has been reached. This follows from the fact that while the flanges 65' of the nut element engage the screw threads positively enough to effect the desired traverse of the contactor, the engagement is nevertheless impositive to the extent that it will simply "ratchet" without damaging anything when the contactor is brought to bear against either end wall (21—22) and rotation of the screw is continued.

As noted hereinbefore, the cross slot 44 in one end of the ceramic base, is wider than the diameter of the tubular rivet received therein. Hence, this end of the base may move slightly in an endwise direction with respect to the housing member. By contrast, the other cross slot 44' snugly receives its respective tubular rivet and, accordingly, at this end the ceramic base is rigidly secured against any endwise displacement with respect to the housing member or cover. The unequal coefficients of expansion and contraction between the housing member and the ceramic base are thus accommodated without imposing stress upon the ceramic base.

As noted hereinbefore, the ceramic base is not exactly centered with respect to the housing member. The reason for this off-center disposition of the base will be appreciated from an examination of Figures 5 and 6. It will be seen that the contact pad 54, which rides upon the resistance path, is higher than the contact button at the end of the spring finger 52 which rides upon the conductor path, and since it is desired to keep all portions of the contactor spaced the maximum distance from the side walls of the housing which are provided by the flanges of the cover, more space is needed at one side of the base than at the other. This allows both flange portions of the contactor to be equispaced from the adjacent cover flanges.

From the foregoing description, taken in connection with the accompanying drawings, it will be readily apparent to those skilled in the art, that this invention provides a precision type variable resistor or potentiometer which possesses many advantages not achieved by former resistors or potentiometers of this type and that, among the significant features of the invention is an exceptional durability and stability resulting from the fact that the main housing member, is of metal. It will also be seen that by virtue of the novel structure and design of its various components and the relationship therebetween, assembly of the resistor may be easily and quickly effected by unskilled help.

What is claimed as our invention is:

1. A precision variable resistor of the type wherein a contactor bridging parallel resistance and conductor paths is caused to linearly traverse said paths by rotation of a lead screw with which a nut element connected to the contactor has threaded engagement, characterized by the fact that the resistance and conductor paths are affixed to opposite outwardly facing sides of an elongated base of insulating material capable of withstanding elevated temperatures, so that the base of insulating material lies between the resistance and conductor paths; by the fact that the contactor has contact fingers biased toward one another and bearing upon said paths with the base between the fingers; and means holding the screw and said base in fixed parallel relation.

2. The variable resistor of claim 1, wherein the base is a ceramic bar and the resistance and conductor paths are in the form of films applied to the ceramic bar.

3. The precision variable resistor of claim 2, wherein the means holding the screw and the ceramic base in fixed parallel relation comprises: an elongated housing member having longitudinally spaced end walls provided with coaxial bearings in which the screw is journalled; and interfitting portions on said housing member and the ceramic base.

4. The precision variable resistor of claim 3, further characterized by the fact that the housing member is formed of metal.

5. The precision variable resistor of claim 3, wherein the interfitting portions of the ceramic base and the end walls of the housing member comprise slots extending longitudinally through said end walls of the housing member and in which the end portions of the ceramic base are received.

6. The precision variable resistor of claim 5, further characterized by the presence of a cover channel-shaped in cross section embracing the housing member, screw and ceramic base assembly, with the flanges of the cover at the opposite sides of the housing member and its end walls, and the web of the cover bearing against the ceramic base to hold the base in said slots; and means for securing the cover to the housing member.

7. The precision variable resistor of claim 5, wherein said ceramic base is substantially no wider than the longitudinal slots in the end wall portions of the housing member, so that the opposite sides of the ceramic base are spaced inwardly of the opposite side faces of the housing member, said opposite sides of the base having the resistance and conductor paths thereon.

8. A precision variable resistor of the type wherein a contactor bridging parallel resistance and conductor paths is caused to linearly traverse said paths by rotation of a lead screw with which a nut element connected to the contactor has threaded engagement, characterized by: an elongated ceramic base substantially rectangular in cross section, the resistance and conductor paths being on opposite sides of the base, and the base having a cross slot in each of its opposite end portions, both slots opening to a same third side of the base and having the ends thereof opening to the sides upon which the resistance and conductor paths are located; an elongated housing member having longitudinally spaced end portions, said end portions having coaxial bearings in which the lead screw is journalled, and having longitudinal slots in which the cross slotted end portions of the ceramic base are received, with the open top of the cross slots facing the bottoms of said longitudinal slots; a cover U-shaped in cross section embracing the housing member with its web bearing against the ceramic base and its flanges at the sides of the housing member; and fastening means at the opposite ends of the resistor passing through the flanges of the cover, through the end portions of the housing member and through the cross slots in the end portions of the ceramic base to secure all said parts together.

9. The precision variable resistor of claim 8, wherein

one of said fastening means fits closely in the cross slot in which it is received to firmly hold one end of the ceramic base to the housing member, and wherein the cross slot at the other end of the base is wider than the fastening means received therein to accommodate difference in the coefficients of expansion between the housing member and the base.

10. In a precision variable resistor: a housing member in the form of a solid bar with integral endwise spaced upstanding end portions having coaxial bearings therein; a lead screw journalled in said bearings and extending lengthwise across the housing member; an elongated ceramic base separate from the housing member and also extending lengthwise thereof from one to the other of its upstanding end portions; means securing the ends of the ceramic base to the end portions of the housing member with the ceramic base parallel to but spaced from the screw; a resistance path on one side of the base; a conductor path on the side of the ceramic base opposite that upon which the resistance path is located; said reesistance and conductor paths extending lengthwise of the base; a U-shaped bridging contactor embracing the ceramic base with the bight thereof between the lead screw and the adjacent side of the base, said contactor having spring fingers biased toward one another and bearing upon the resistance and conductor paths; and a nut element connected with the contactor and engaging the lead screw to cause the contactor to linearly traverse said resistance and conductor paths as the screw is turned.

11. The precision variable resistor of claim 10, wherin said housing member is formed of metal.

12. The precision variable resistor of claim 10, wherein the means for securing the ends of the ceramic base to the end portions of the housing member includes a cover which is U-shaped in cross section and which embraces the housing member with the web of the cover bearing upon the ceramic base and the flanges of the cover receiving the housing member therebetween.

13. In a precision variable resistor of the character described: an elongated ceramic base having at least two opposite substantially parallel sides; means affixed to one of said sides forming an elongated resistance path; means affixed to the other of said opposite sides forming an elongated conductor path; a contactor in the form of a substantially U-shaped metal stamping having opposite flange portions connected by a web portion, said contactor embracing the ceramic base with its flanges overlying said opposite sides of the base and its web engaging the adjacent intervening side of the base; spring contact fingers on the flange portions yieldingly urged toward one another and having contacts at their free ends bearing upon the resistance and conductor paths; a lead screw in spaced parallel relation to said intervening side of the base; a driver of insulating material for the contactor seated upon and drivingly connected with its web portion so that the driver is between the contactor and the screw; and a nut element carried by the driver and engaging the lead screw.

14. The precision variable resistor of claim 12, wherein the driver is a block of insulation and the driving connection between the driver and the contactor is in the form of a finger on one of said parts engaging in a socket in the other, and wherein said nut element is in the form of a substantially U-shaped metal stamping, the flanges of which embrace the lead screw and the web of which is between the driver and the screw and has a portion thereof sprung outwardly and pressing against the driver to thus hold the driver and contactor properly assembled with the contactor seated upon the ceramic base and also maintain the nut element in operative engagement with the screw.

15. A precision variable resistor comprising: a metal housing member having an elongated middle portion, and upstanding end portions integral with the ends of said middle portion and projecting in the same direction therefrom, the sides of said upstanding end portions being flush with the sides of the middle portion; coaxial bearings in the end wall portions; a lead screw journalled in said bearings and supported thereby in spaced parallel relation to the elongated middle portion of the housing member; means restraining the lead screw against relative endwise movement with respect to the housing member; a ceramic bar spanning the distance between the end wall portions; interengaging locating means on the ceramic bar and the end wall portions holding the ceramic bar spaced from the elongated middle portion of the housing member and from the lead screw with the longitudinal surfaces of the bar parallel to the axis of the screw, and with the screw lying between the base and the elongated metal portion, said interengaging locating means holding the bar secure against shifting endwise with respect to the screw; a sheet metal cover U-shaped in cross section embracing the housing member with its flanges flatwise engaging the flush sides of its end and middle portions, and its web in surface-to-surface engagement with the top of said end wall portions and overlying the ceramic bar to thereby maintain the bar in place with said locating means interengaged; means securing the cover and the housing member together; means forming resistance and conductor paths on the ceramic bar both of which are parallel to the axis of the screw; a bridging contactor having spring contact fingers bearing upon said resistance and conductor paths and constrained to linear movement lengthwise of said paths; a nut member engaging the lead screw; and an insulated connection between the nut member and the bridging contactor.

16. The precision variable resistor of claim 15, wherein the interengaging locating means comprises a male member at each end portion of the housing member, fixed with respect thereto, and an opening in each end portion of the ceramic bar, each opening receiving one of the male members, one of said openings fitting its respective male member snugly in the direction lengthwise of the bar and the other fitting its respective male member loosely in said direction.

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