Dec. 15, 1964 M. E. BOURNS ETAL 3,161,849

POTENTIOMETERS

Filed Oct. 30, 1961

FIG. 1.

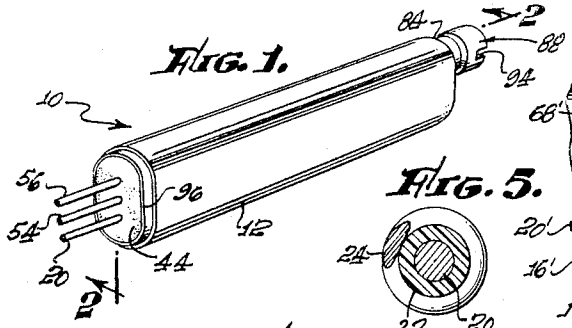


FIG. 5.

FIG. 6.

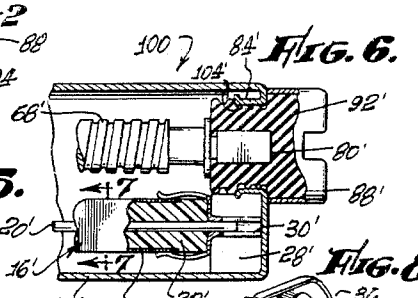


FIG. 8.

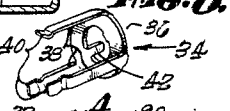


FIG. 2.

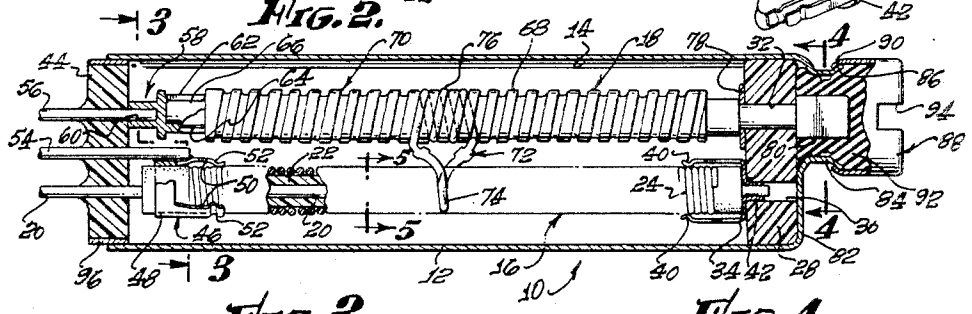


FIG. 3.

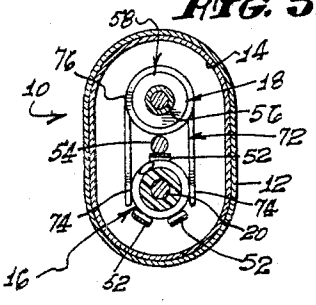


FIG. 7.

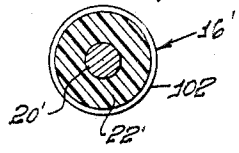


FIG. 4.

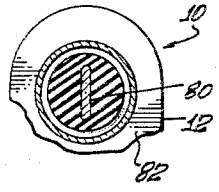


FIG. 9.

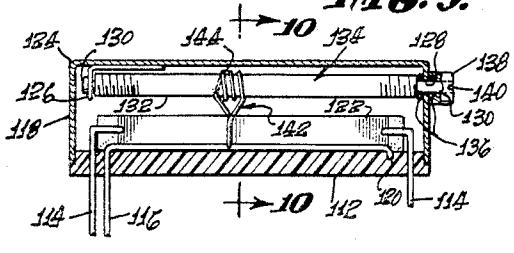


FIG. 11.

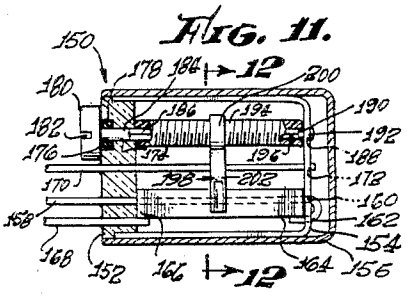


FIG. 10.

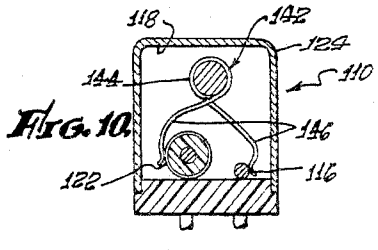
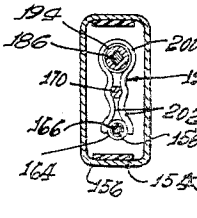


FIG. 12.



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3,161,849
POTENTIOMETERS

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30 Claims. (Cl. 338—183)

This invention relates to new and improved potentiometers.

This application is a continuation-in-part of application Serial No. 17,099 filed March 23, 1960, now abandoned, which application Serial No. 17,099 is a division of application Serial No. 585,647 filed May 18, 1956, for potentiometers.

For many years the principal requirements for electrical instruments such as potentiometers have involved the accuracy of these instruments, the cost and the ease of their manufacture, and their ability to withstand physical abuse such as rough handling. At the present time potentiometers and other similar electrical instruments are employed in virtually all climates and at extremes of high temperature. Further, they are utilized in many applications, such as, for example, in guided missiles where the size of these instruments is an extremely material consideration. This widespread use of electrical instruments has in effect relegated the cost and ease of assembly of many electrical instruments to matters of secondary importance. The prime objective of many manufacturers is now to provide extremely small, light weight instruments capable of withstanding virtually "anything," apparently irrespective of the cost involved, even though cost and ease of manufacture remain important considerations.

One object of the present invention is to provide a potentiometer capable of being used under extremes of atmospheric or temperature conditions, with retention of accuracy and reliability. Another basic objective of the present invention is to teach the construction of electrical instruments of this category which are of extremely small size and weight. A further basic objective of the invention is to provide potentiometers which are accurate and reliable, and which are extremely resistant to physical abuse. Still further objectives of this invention as well as many advantages thereof will be more fully apparent to those skilled in the art to which the invention pertains from the consideration of the remainder of this specification, the appended claims and the accompanying drawing in which:

FIGURE 1 is a perspective view of a potentiometer of the present invention;

FIGURE 2 is a cross sectional view taken at line 2—2 of FIGURE 1;

FIGURE 3 is a cross sectional view taken at line 3—3 of FIGURE 2;

FIGURE 4 is a cross sectional view taken at line 4—4 of FIGURE 2;

FIGURE 5 is a cross sectional view taken at line 5—5 of FIGURE 2;

FIGURE 6 is a partial cross sectional view similar to FIGURE 2, with a portion removed, showing a modified form of the invention.

FIGURE 7 is a cross sectional view taken at line 7—7 of FIGURE 6;

FIGURE 8 is a perspective view showing a terminal clip employed at the ends of the resistance elements of the forms of the invention shown in the preceding figures;

FIGURE 9 is a view similar to FIGURE 2 of a second modified potentiometer of the invention;

FIGURE 10 is a cross sectional view taken at line 10—10 of FIGURE 9;

FIGURE 11 is a cross sectional view similar to FIGURE 2 of a third modified potentiometer of the invention; and

FIGURE 12 is a cross sectional view taken at line 12—12 of FIGURE 11.

Whenever convenient for purposes of illustration and explanation the same or substantially the same parts of the different potentiometers illustrated are designated by identical numerals. It is to be understood that the accompanying drawing is not to be taken as limiting the invention in any respect inasmuch as the sizes, shapes, and relative positions of certain of the parts shown may be altered in a variety of different ways without departing from the essential nature of this invention. In order that the invention may be more fully comprehended the potentiometer shown in FIGURE 1 is drawn approximately to scale representing an actual potentiometer built in accordance with this disclosure and having a width of approximately ⅛" and a height of approximately 3/16" and a length of approximately ¾".

As an aid to understanding the invention it may be stated in essentially summary form that it concerns potentiometers manufactured so as to have terminal leads hermetically sealed to a non-conductive member and so as to have a housing sealed to this non-conductive member so as to define an envelope within which there are located a resistance element, means serving as an electrical return, contact means connecting the electrical return and the resistance element, and means for moving the contact means. Obviously any summary of this category is essentially cursory in nature, and hence is not to be taken as limiting the invention in any respect.

In order to completely understand this invention it is necessary to refer to the various figures of the drawing illustrating it. In FIGURES 1, 2 and 3 there is shown a potentiometer 10 according to the present invention built so as to include an elongate generally oval-shaped strong metal housing 12 preferably of tubular form so as to avoid any waste space within an envelope 14 or cavity containing a resistance element 16 and a threaded metal shaft 18.

The resistance element 16 is formed so as to extend in a straight path generally parallel with the axis of a conductive metal wire 20 serving as a support and as an electrical element. Around the periphery of this wire 20 there is located, as shown in FIGURE 5, a comparatively thin layer 22 of a non-conductive material such as, for example, a resinous lacquer or a ceramic-resin composition of a category known to the art. Located around this layer 22 is a continuous winding 24 of a resistance wire which preferably is secured to the layer 22 as through the use of a composition serving as an adhesive. Such a material serving to hold the winding 24 in position can, if desired, be omitted.

Adjacent to and within the front end of the housing 12 there is located a non-conductive support 28 formed of a ceramic or equivalent material, having openings 30 and 32 therein. Over the end of the resistance element 16 adjacent to this support 28 there is positioned a clip 34, the construction of which is best seen in FIGURE 8 of the drawing. This clip includes a central washer-like section 36 designed to bear against an end of the layer 22. It also includes three resilient arms 38 each having a bowed end 40 designed to engage a portion of the winding 24. It is considered obvious that all of these bowed ends 40 engage the winding 24 in the same plane transverse to the axis of the wire 20. If desired they may be welded to this winding or otherwise secured to it. From the center of the section 36 there project two converging extensions 42 both having a curved interior configuration so that when the clip 34 is placed in an

operative position these extensions engage an end of the wire 20 in a secure manner. If desired they may be welded or otherwise attached to this wire. The extensions 42 and the end of the wire 22 are preferably forced into the opening 30 as shown in FIGURE 2 of the drawing so as to securely hold one end of the resistance element 16 in position.

The other end of the resistance element 16 is held in place in part by a portion of the wire 20 projecting through a ceramic end 44. Another clip 46 having a cylindrical collar or ferrule 48 is located around the layer 22 adjacent to this end 44 so that arms 50 similar to the arms 38 projecting from it are located with bowed ends 52 similar to the ends 40 engaging the winding 24 in substantially the manner previously described. These ends 52 may be welded or otherwise secured to the winding 24 and the collar 48 may be attached to the layer 22 as by the use of adhesive. Another wire 54 is welded or otherwise electrically and physically attached to the collar 48 so as to project out through the end 44.

The wires 20 and 54 are preferably united or bonded to the end 44 by any of various expedients known to the art so as to, in effect, be hermetically sealed to this end 44. A third wire 56 is similarly positioned so as to project into the envelope 14. This third wire is attached to a small metallic bearing 58 by being welded or otherwise attached within a closely fitting hole 60 in this bearing. Forming a part of the bearing 58 is a flange-like collar 62 having a slot 64 formed in one side thereof parallel to the axis of this bearing.

This structure is designed so that a generally cylindrical extension 66 of a shaft 68 can fit within the collar 62 in such a manner that it is held by essentially spring tension as the shaft 18 is turned so that an electric current can flow from the wire 56 to the shaft 18. A threaded section 70 is formed upon shaft 18 for the purpose of holding and moving a metal contact member 72. This contact member serves essentially as both a movable element or slider and as a contact member having resilient ends 74 engaging the sides of the resistance winding 24. The ends 74 are connected by means of a coiled section 76 resembling a common coil spring. The individual turns of this section 76 are, as indicated in FIGURE 2, designed so as to fit in the groove of the thread of the threaded section 70; it preferably is of such dimension that the threaded section 70 is engaged by essentially spring tension so as to facilitate electrical contact; the pitch of the coiled section 70 is preferably different from the section 70 for the same purpose.

The end of the shaft 68 adjacent to the front end 26 is provided with a collar 78 which normally rests against the support 28 so that the shaft itself can project through the opening 32. On the side of the support 28 remote from the envelope 14 a flat, non-round head 80 is formed on this shaft 68.

As is best seen in FIGURE 2 of the drawings, the housing 12 is manufactured so as to include an end 82 against which the support 28 rests. Further, this end 82 includes a collar 84 projecting therefrom around the head 80; upon the end of this collar there is provided a small outwardly extending flange 86. A metal cap 88 is positioned so that an inwardly extending flange 90 on it resiliently engages the flange 86 forming a rotary seal. The cap 88 is held in this sealed position by means of an elastomeric retainer 92 of rubber or other similar material. As illustrated this retainer 92 completely engages the head 80 so that as a slot 94 in the cap 88 is actuated by means of a screw driver or the like the shaft 18 is caused to rotate.

It is preferred to form the potentiometer 10 with a small metal band 96 located around and sealed to the end 44 so that this band may be directly welded or soldered to the housing 12 during assembly. It is considered to be obvious from the drawing that the contact

member 72 is preferably formed out of a conductive metal wire having substantially circular cross section. Also, the clips 34 and 46 are preferably formed out of a resilient conductive metal. If desired, the envelope 14 may be evacuated, or may be filled with any desired gas such as, for example, an inert gas incapable of causing corrosion even when the potentiometer 10 is to be operated at an elevated temperature.

It will be realized from the foregoing description that potentiometer 10 is a very compact, efficient device. Units constructed as shown may be operated under humidity extremes such as are found in the tropics without significant danger of damage caused by fungus growth within the envelope 14 or the like. Further, they may be operated where they may be subjected to extremely rapid temperature cycling. In addition, units constructed to be like or similar to potentiometer 10 are resistant to handling damage and other physical abuse, are accurate, and are comparatively easy to assemble and manufacture. Many of these characteristics are, at least in part, a result of the specific seals used to seal the envelope 14. Specific attention is directed to the structure of the retainer 92 and to the fact that this retainer is, in effect, distorted by the collar 84, effecting a seal in addition to that obtained between the flanges 86 and 90.

In FIGURE 6 of the drawing there is shown a modified potentiometer 100 which is structurally similar to the potentiometer 10 except for several minor differences. One of these differences is that the resistance element 16′ shown in FIGURES 6 and 7 does not utilize a winding such as the winding 24 but instead employs a very thin resistance film 102, such as, for example, a pyrolytic boro-carbon film, a metal resistance film, or the like. By virtue of the sealed nature of the potentiometer 100, films which are apt to change resistance characteristics in conventional potentiometers where the resistance element is open to the atmosphere can be satisfactorily employed with this invention. Obviously either of the resistance elements 16 or 16′ can be interchanged with the other.

The potentiometer 100 also differs from the previously described unit in that a support 28′ is employed which is only half the size of previously mentioned support 28. With this construction the opening 32 is replaced in the same general area by a head 80′ embedded in an elastomeric retainer 92′. Portions of the retainer 92′ within the housing 12′ are compressed by an inwardly turned collar 84′ so as to form an efficient seal. A cap 88′, as previously indicated, is held by the retainer 92′. If desired, a plurality of annular ridges 104 can be formed within the collar 84′ upon the retainer 92′ so as to aid in establishing effective sealing at several locations. The collar 84′ in the potentiometer 100 also serves to compress the retainer 92′ so as to firmly hold the shaft 68′ in position.

In FIGURES 9 and 10 of the drawing there is shown a modified form or embodiment of potentiometer 110 according to the invention, which embodiment includes an elongated ceramic base 112 through which there are passed portions of wires 114 and 116. These wires are fused to the base 112, with the preferred construction of this embodiment of this invention being substantially as previously indicated. The wire 116 extends along the surface of the base 112 within an envelope 118 and is provided with a bent over end 120 which may be fused directly to the base so as to securely hold the wire 116 against movement. The entire wire 116 may, if desired, have the part of its surface that is disposed within this envelope fused to the base 112, or may be attached to it by means of an appropriate adhesive. If either of the latter are done it is possible to omit the end 120.

The other wires 114 are attached as by welding or the like to the ends of a resistance element 122 which may be of conventional construction in such a manner as to hold this element upon the surface of the base 112

within the envelope 118. If desired the resistance element 122 may also be in part fused to the base 112 or may be secured thereto by the use of an adhesive. Hermetically sealed to the sides of the base 112 is a metal cover 124 which may, if desired, be termed a housing. It is considered obvious that this cover defines the complete envelope 118 in conjunction with the base 112. Supported upon cover 124 within the envelope 118 is a small bracket 126 having an end opening (not shown) formed therein. An opening 128 aligned with the opening in bracket 126 is provided in the cover 124. These two openings serve to hold cylindrical extensions 130 of reduced diameter extending from the ends of a threaded section 132 of a shaft 134. This shaft is, as indicated, parallel to both the resistance element 122 and the adjacent part of wire 116. Small elastomeric O-rings 136 are positioned around the cylindrical extension 130 projecting through the opening 128. A cap 138 having a slot 140 formed therein is attached as by welding or the like to this extension 130 so as to hold the O-rings 136 constantly under compression forming a double seal.

When the shaft 134 is turned the opening in the bracket 126 and the opening 128 serve essentially as bearings supporting this shaft so that a contact member 142 is moved with respect to the resistance element 122 and the wire 116. This wire serves as an electrical return in the structure shown. The contact member 142 is preferably formed similar to the contact member 72 out of a resilient wire so as to include a spring-like coiled section 144 similar to the coiled section 76 engaging the threads on the threaded section 132 of the shaft 134. Ends 146 of the contact member 142 lead from the coiled section 144 as indicated in FIGURE 10 of the drawing so as to resiliently engage the wire 116 and the furthest removed side of the resistance element 122. By virtue of the configurations and relative dispositions of the ends 146 this contact member engages portions of the resistance element 122 and the wire 116 so as to be incapable of turning as the shaft 132 is rotated.

In FIGURES 11 and 12 there is illustrated a third modified form of potentiometer, indicated generally by ordinal 150, according to the present invention, which employs a non-conductive ceramic base member 152 to the ends of which there is attached a generally U-shaped, rigid, non-conductive yoke 154. This yoke may be attached to the base 152 by means of an adhesive or any other equivalent means known to the art. It is covered by means such as a metal cover or housing 156 which is secured to the base 152 in substantially the same manner in which the housing 12 is secured to the end 44 in the potentiometer 10. A wire 158 corresponding to the wire 20 passes through the base 152 and thence to the extremity of the yoke 154 remote from the base where it passes through an opening 160, and then is bent so as to pass through another opening 162. The end of this wire 158 is secured as by welding or the like to a resistance winding 164 positioned around a non-conductive layer 166.

The construction of the resistance winding 164, the layer 166 and the wire 158 corresponds to the construction of the resistance element 16 and will not be described in detail. The end of the resistance winding 164 adjacent to the base 152 is attached to another wire 168 as by welding; this other wire also passes through the base 152. A third wire 170 passes through the base 152 and through an opening 172 in the yoke 154 in such a manner as to be supported against movement by this yoke. The wires 158, 168, and 170 are all sealed with respect to the base 152 in the manner previously indicated.

Within the base 152 there is provided an opening 174 which is surrounded by a circular depression 176 within which there is located a common O-ring 178 formed of an elastomeric material. A head 180 having a slot 182 formed therein is positioned against this O-ring so as to

normally deform it forming a seal; a short, round shaft section 184 extends from the head 180 through the O-ring 178 and through the opening 174 where it is supported in such a manner that it may be readily rotated. A non-round shaft section 186 extends from the round shaft 184 to be immediately adjacent to an opening 188 in the yoke 154. There a small, round shaft section 190 is provided so as to extend from the non-round section 186 through this opening 188 in order for the opening to serve essentially as a bearing. A head 192 is provided on the end of the section 190 so as to bear against the yoke 154 holding the head 180 firmly in position at all times.

Around the non-round shaft section 186 there is provided a cylindrical, non-conductive, externally-threaded sleeve 194 having an opening 196 in the center thereof corresponding in shape and dimension to the non-round shaft section 186. A contact member 198 having the configuration best shown in FIGURE 12 of the drawings is snapped into place around the sleeve 194 so that threads (not shown) on the center section 200 of this contact member engage the threads on the exterior of the sleeve 194. Bowed, curved extensions 202 from the sides of the center section 200 resiliently engage the sides of the wire 170 and the resistance winding 164 so as to establish electrical communication between these two parts. By virtue of this construction the contact member 198 is very easy to assemble and is capable of "riding up" on the threads on the sleeve 194 when the shaft construction shown has been turned too far in either direction, so as to prevent damage. This contact member 198 may be conveniently formed by simple metal stamping operations. By virtue of the fact that it is bowed where it engages the resistance element and the electrical return so as to, in effect, establish point contact along a line through its center on both sides of these two members there is little danger of it "catching" so as to prevent uniform movement during the operation of the potentiometer 150.

The difference in the operation of the contact member 198 and the contact members 72 and 142 should be specifically noted. The contact member 198 tends to spring apart so as to override the threads upon which it is normally carried when adjusted to either end of the potentiometer 150. As opposed to this the contact member 72 in the potentiometer 10 is threaded off of the ends of the shaft 18 and is compressed against either of the adjacent members in this unit when moved to either end of the unit. Therein the contact member 72 compresses essentially as a coil spring. When the direction of the shaft's rotation is reversed this contact member 72 reverses itself and, by virtue of the compression within it, rethreads itself upon the shaft 18. The contact member 142 can be formed so as to operate in a similar manner. It is also possible to utilize this contact member so that the turns of the coiled section 144 spread apart overriding the threads upon the shaft, although this is not generally preferred. Both of these methods of operation of contact members are considered to be advantageous; with either of these methods damage resulting from turning the shaft too far is prevented. The previous description of contact member 72, for example, makes evident the fact that the contact member is inherently resilient and has spaced-apart convolutions or elements that engage the screw-threaded shaft (such as shaft 18) at longitudinally spaced-apart locations and around at least substantially the entire periphery of the shaft thereat. The convolutions or elements are collectively and individually resilient and are thus adapted to individually or collectively disengage from the thread of the shaft in the manners hereinbefore explained. Further, in the case of either type of disengagement, the member is so constructed and arranged that due to stressing of one or more of the elements of the coiled part of the member automatically re-engages with the thread of the shaft incident to reverse rotation of the shaft. During the limited rotation of the shaft

the contact member (either 72 or 142) is traversed longitudinally along the shaft and thus its contact is traversed along and in contact with a portion of the resistance element. The housing and support means (such as 14, 44, 28, etc.) which house and support the resistance element and screw-threaded shaft are so constructed and arranged as to limit traversing movement of the contact member to that effected during only a limited rotation of the shaft; and further or "excessive" rotation of the shaft results in yielding of one or more of the convolutions or elements of the contact member (radially in the case of a shaft such as 134 and longitudinally in the case of a shaft such as 18) so that "jamming" and damage to parts of the resistor are avoided. As noted, subsequent reverse rotation of the shaft permits the convolutions or elements of the contact member to re-engage the thread of the screw, that action being automatic due to the stress in the resilient convolutions of the contact member. It further is evident that a screw-threaded shaft of the type illustrated in FIG. 2 (shaft 18) may be employed with a contact member such as member 114 (FIG. 9); and that the shaft depicted in FIG. 9 could be modified in the manner suggested by FIG. 2, that is, could be provided with non-threaded end-portions onto which the contact member is traversed at either end of its travel.

The construction of the potentiometer 150 is considered to be particularly advantageous for many purposes since all of the operative elements of this instrument can be assembled and tested for proper functioning prior to the attachment of the cover 156 to the base 152. Such attachment is preferably by various means effecting a hermetic seal such as are employed with the potentiometers 10 and 110. Obviously this type of construction employing a yoke or support may be employed with a conductive shaft, omitting the wire 170 serving as an electrical return. In this case, one of the bends in the contact member 198 can be omitted.

In describing the potentiometers 10, 110 and 150 reference has been made to the ceramic end 44, the ceramic base 112, and the ceramic base 152. The term "ceramic" used here is used in its broadest possible sense so as to cover any fused oxide composition of an impermeable nature. Thus, this term covers various ceramic compositions of a category known to the art as well as various glass compositions that are, according to a few references, classified as ceramic. Such glass compositions are on many occasions not classified as ceramic. This explanatory notation is inserted herein in order to prevent any confusion as to the meaning of the terms employed. For the end 44 and the bases 112 and 152 it is possible to substitute other non-conductive materials having properties similar to those of ceramics, which materials can be used for a hermetic seal. As an example of this, certain epoxy resin compositions and the like can be utilized, although inorganic materials are preferred because of their physical and other properties.

It is to be noted that all of the instruments herein described can be considered to be, in effect, hermetically sealed, although in actuality a true hermetic seal is not employed where a shaft is connected to the outside of the units in this invention. The shaft seals are, however, of a construction and arrangement sufficient to withstand moisture penetration, physical shock, etc., and the various shaft seals shown are in many respects the equivalent of a true hermetic seal. The true hermetic seals used to seal the other parts of the instruments of this invention so as to form an envelope are very advantageous as previously indicated.

Those skilled in the art to which this invention pertains will realize that all of the constructions shown have the basic advantageous characteristics found in the potentiometer 10, although with variation in degree in certain cases. Many of the individual features shown herein are applicable to other than what may be considered to be hermetically sealed units. Thus, for example, any of the contact members described can be used with potentiometers of a more conventional construction, even though in certain cases minor variations in structure may be required. Since the structures shown can be varied without departing from the essential nature of this invention, and since many of the features of these structures have separate utility, this invention is to be considered as being limited only by the appended claims.

We claim:

1. In a potentiometer of the type having a housing defining a cavity wherein there is an elongated resistance element, a rotatably supported threaded shaft, a contact element slidably engaging said elongated resistance element and carried by said threaded shaft to be moved along said resistance element with rotation of said shaft, and terminal means affording external connections with said elongated resistance element and said contact element, the improvement comprising means forming walls including an end wall having therein an opening, said shaft being disposed principally in said cavity and with one end thereof extending into the opening defined by said end wall, an elastomeric ring extending through said opening and disposed in part in said cavity and in part outside thereof and having end dimensions larger than the opening and at said opening being of a diameter sufficiently large to be under compression by said end wall at said opening and constructed and arranged to hold said one end of said threaded shaft which extends into said elastomeric material ring.

2. In a potentiometer as recited in claim 1 wherein said wall having an opening is bent to form a collar defining said opening in which said elastomeric retaining ring is held in compression.

3. In a potentiometer as recited in claim 2 wherein said ring has a plurality of annular ridges within said collar for establishing a seal at a plurality of locations at said opening.

4. A variable resistor, comprising, in combination: a nonconductive base member, a resistance element positioned on said nonconductive member, two terminal means for said resistance element extending therefrom through said nonconductive base member and said terminal means being sealed to said nonconductive base member; an electrical return wire extending along and sealed to said nonconductive base member and disposed parallel to said resistance element and having a terminal, said electrical return wire terminal extending through and being sealed to said nonconductive base member, housing means sealed to said nonconductive base member so as to define a sealed envelope containing said resistance element and said electrical return wire, said housing means having an opening therein, a shaft extending into said housing through said opening and arranged generally parallel to said resistance element; resilient contact means carried by said shaft within said envelope, said contact means engaging said resistance element and said electrical return wire so as to establish electrical communication therebetween; and means sealing said opening around said shaft to prevent passage of foreign matter into said envelope.

5. A variable resistor as defined in claim 4, wherein said resilient contact means is formed of a single piece of material having a helically coiled portion resiliently engaging said shaft and having ends resiliently engaging respective ones of said electrical return wire and said resistance element so as to establish electrical communication therebetween and effective to prevent rotation of said contact means.

6. In a potentiometer of the type having an elongated resistance element, an electrical return conductor coextensive with spaced, from and parallel to said elongated resistance element, a rotatably supported threaded shaft, an improved contact element comprising a resilient flat strip having a central portion wound around said threaded shaft to be in operative engagement with the thread there-

of and movable along said threaded shaft with rotation thereof, and having one end extending to slidably engage said elongated resistance element and the other end extending to slidably engage said electrical return conductor.

7. A variable resistor comprising, in combination: a nonconductive member having an opening formed therein; a yoke-shaped nonconductive support member attached at its ends to said nonconductive member so as to extend therefrom; a housing sealed to said nonconductive member so as to extend over said support member, said housing defining in conjunction with said nonconductive member an envelope; an electrical resistance element positioned within said envelope so as to extend between said nonconductive member and said support member; an electrical return positioned so as to extend within said envelope between said nonconductive member and said support member; a shaft positioned so as to extend through said opening into said envelope, an extremity of said shaft being supported by said support member; a contact member including resilient electrically conductive means engaging said resistance element and said electrical return, said contact member being carried by said shaft within said envelope; and terminal means for the ends of said resistance element, and other terminal means for said electrical return all passing through and sealed to said nonconductive member.

8. An electrical instrument as defined in claim 7 wherein said electrical return and one of said terminal means are formed of a single piece of wire.

9. An electrical instrument as defined in claim 7 wherein said shaft includes a nonround portion located within said envelope and wherein a nonconductive sleeve having a threaded exterior and a nonround interior corresponding to the shape of said nonround portion is positioned around said nonround portion and wherein said contact member is formed of a single piece of resilient conductive metal so as to include a center section which is positioned so as to engage the threads on said sleeve and so as to include ends engaging the sides of said electrical return and the sides of said resistance element.

10. An electrical instrument as defined in claim 9 wherein one of said terminal means comprises a wire extending from said nonconductive member to said support member and wherein said resistance element includes a nonconductive layer deposited upon all but extending ends of said extending wire and a resistance winding positioned upon said nonconductive layer, one end of said extending wire ends being bent around to contact said resistance wire at one end.

11. In a potentiometer of the type having an elongated resistance element, a rotatably supported threaded shaft spaced therefrom and an electrical return conductor between and aligned with said threaded shaft and said elongated resistance element, an improved contact device comprising a resilient wire having end portions and a central portion substantially encircling said threaded shaft and operatively engaged with the thread of the shaft, said resilient member having legs extending from either side of said central portion, the end of one of said legs being constructed and arranged to engage said elongated resistance element, and a portion of said legs between the ends and the central portion being bent to slidably engage said electrical return conductor.

12. A variable resistor of the leadscrew actuated type, comprising, in combination:

first means, comprising an elongate resistance element and a conductive leadscrew having first and second ends and said first means including a contact device, said first means being constructed and arranged for wiping movement of the contact device along the resistance element to effect variable electrical interconnection of the resistance element and leadscrew incident to rotation of the latter;

second means, comprising insulative base means and electrical terminal means extending through and sealed to said base means, a terminal device comprised in said terminal means being constructed and arranged as a bearing to rotatably support the first end of said leadscrew and serving to conduct electrical current conducted by the leadscrew;

and third means, including support means for said resistance element and the second end of said leadscrew and including housing means constructed and arranged to enclose said contact device and said resistance element, constructed and arranged for electrical and mechanical operation of the variable resistor.

13. In a variable resistor of the leadscrew actuated type having an elongate resistance element and a contact device responsive to operation of a leadscrew to wipe along an extent of the resistance element, the improvement comprising:

first means, including elongate housing means comprising insulative base means and casing means having a portion providing a tubular opening communicating with the interior of the housing;

and second means, including bearing means and leadscrew means operatively engaging the contact device and rotatively mounted on the bearing means, said leadscrew means comprising a leadscrew having a head portion including an elastomeric member and a rigid body portion terminated by an end portion formed for rotative cooperation with the elastomeric member and engaged therewith, said elastomeric member being disposed in part in said tubular opening and constructed and arranged for rotation therein for rotating the body portion of the leadscrew and for sealing said opening against passage of foreign material.

14. A variable resistor as defined in claim 13, including on said elastomeric member a rigid cap means engaging the elastomeric member for rotation thereof, said cap means being constructed and arranged for cooperation with said casing means.

15. A variable resistor of the leadscrew-adjusted type, comprising:

first means, comprising an elongate resistance element, and means including electrical connections to end portions of the resistance element;

second means, comprising housing and support means, constructed and arranged for supporting said resistance element;

third means, comprising an elongate screw-threaded shaft supported by said second means in substantially parallel disposition relative to said resistance element; and

fourth means, comprising a contact device having resilient portions yieldingly engaging said screw-threaded shaft around a substantial portion of the periphery thereof at at least two longitudinally spaced-apart locations along the shaft for traverse of the device along the shaft incident to limited rotation of the shaft and whereby the device may yield relative to the thread of the shaft and may discontinue traverse incident to excessive rotation of the shaft, said contact device comprising means for electrically contacting said resistance element, whereby limited rotation of said shaft within a range of rotation thereof causes a change of resistance to be exhibited between said device and either of said end portions of said resistance element and whereby during excessive rotation of said shaft said device slips relative to the shaft and does not cause a change of resistance to be exhibited as stated.

16. A variable resistor according to claim 15, said device and said shaft being both electrically conductive and said terminals including a terminal electrically connected to said shaft.

17. A variable resistor according to claim 16, said shaft having a driving end, and driving means including

insulation means in which said driving end is embedded whereby rotation of said shaft may be effected by rotation of said insulation means.

18. A variable resistor according to claim 15, said screw threaded shaft comprising a non-threaded portion at an end of the threaded portion thereof, upon which non-threaded portion said device is forced incident to continued rotation of said shaft.

19. A variable resistor according to claim 15, said contact device comprising a coil spring having a plurality of convolutions engaged with the thread of said shaft.

20. A variable resistor comprising:

first means, comprising housing and support means;

second means, comprising an elongate resistance element housed and supported by said first means, said second means comprising electrical terminal and connection means supported by said first means and providing electrical connections to respective end portions of said resistance element;

third means comprising a screw-threaded shaft housed and supported by said first means, said shaft being disposed substantially parallel to said resistance element; and

fourth means, comprising a contact device having a helically coiled wire portion having the convolutions thereof engaged with the thread of said shaft for traverse therealong incident to shaft rotation, and said device having a contact bearing on said resistance element for traverse therealong incident to traverse of said device.

21. A potentiometer which comprises: a ceramic member; a metal housing sealed to said ceramic member so as to define an envelope; three electric wires passing through said ceramic member, said wires being sealed to said ceramic member and being insulated from one another, one of said wires extending through said envelope; a non-conductive coating positioned upon said wire extending through said envelope within said envelope; a resistance element positioned upon said non-conductive coating; means electrically connecting the ends of said resistance element with said wire extending through said envelope and with another of said wires; a conductive shaft positioned so as to extend through said envelope, said shaft including a threaded portion within said envelope; means establishing electrical connection between said threaded shaft and the third of said wires; a contact member carried by said threaded portion of said shaft and engaging said resistance element, said contact member being electrically conductive; and means for rotating said shaft so as to move said contact member within said housing.

22. An electrical instrument which comprises: a first non-conductive member; a metal housing sealed to said first non-conductive member so as to define an envelope; three electric wires passing through said first non-conductive member, said wires being sealed to said first non-conductive member and being insulated from one another, one of said wires extending through said envelope; a second non-conductive member positioned within said envelope so as to support the end of said wire extending through said envelope remote from said first non-conductive member; a non-conductive coating positioned upon said wire extending through said envelope within said envelope; a resistance element positioned upon said non-conductive coating; means electrically connecting the ends of said resistance element with said wire extending through said envelope and another of said wires; an electrically conductive shaft positioned so as to extend through said envelope, said shaft including a threaded portion within said envelope; means establishing electrical connection between said threaded shaft and the third of said wires, said means being located within said envelope; a resilient metal contact member carried by said threaded portion of said shaft and engaging said resistance element, said contact member being capable of being disengaged from the threaded portion of said shaft when said shaft is turned so as to move said contact member beyond either end of said threaded portion; and means projecting into said envelope for rotating said shaft.

23. An electrical instrument which comprises: a non-conductive member; a metal housing sealed to said non-conductive member so as to define an envelope; three electric wires passing through said non-conductive member, said wires being sealed to said non-conductive member and being insulated from one another, one of said wires extending through said envelope; a non-conductive member positioned within said envelope so as to support the end of said wire extending through said envelope remote from said first non-conductive member; a non-conductive coating positioned upon said wire extending through said envelope within said envelope; a resistance element positioned upon said non-conductive coating; means electrically connecting the ends of said resistance element with said wire extending through said envelope and another of said wires; an electrically conductive shaft positioned so as to extend through said envelope, said shaft including a threaded portion within said envelope; means establishing electrical connection between said threaded shaft and the third of said wires, said means being located within said envelope; a resilient metal contact member carried by said threaded portion of said shaft, said contact member being capable of being disengaged from the threaded portion of said shaft when said shaft is turned so as to move said contact member beyond either end of said threaded portion, said contact member including resilient means engaging said resistance element so as to establish electrical contact therewith and so as to prevent rotation of said contact member when said shaft is rotated; and means projecting into said envelope for rotating said shaft.

24. An electrical instrument which comprises: a non-conductive member; a metal housing sealed to said non-conductive member so as to define an envelope; three electric wires passing through said non-conductive member, said wires being sealed to said non-conductive member and being insulated from one another, one of said wires extending through said envelope; a non-conductive member positioned within said envelope so as to support the end of said wire extending through said envelope remote from said first non-conductive member; a non-conductive coating positioned upon said wire extending through said envelope within said envelope; a resistance element positioned upon said non-conductive coating; means electrically connecting the ends of said resistance element with said wire extending through said envelope and another of said wires; an electrically conductive shaft positioned so as to extend through said envelope, said shaft including a threaded portion within said envelope; means establishing electrical connection between said threaded shaft and the third of said wires, said means being located within said envelope; a resilient metal contact member having a coiled center section and projecting ends, said contact member being positioned within said housing so that said coiled center section is normally engaged by the threads on said shaft, said ends engaging said resistance element in a plane transverse to the axis of said wire passing through said envelope on both sides of said resistance element so as to prevent rotation of said contact member when said shaft is rotated; and means projecting into said envelope for rotating said shaft.

25. An electrical instrument which comprises: a non-conductive member; a metal housing sealed to said non-conductive member so as to define an envelope; three electric wires passing through said non-conductive member, said wires being sealed to said non-conductive member and being insulated from one another; an electrical resistance element positioned within said envelope so as to be insulated from said housing; means connecting the ends of said resistance element with two of said wires; an

electrically conductive shaft positioned so as to extend through said envelope, said shaft being rotatably mounted and including a threaded portion and a cylindrical extension within said envelope; means positioned within said envelope and attached to the third of said wires resiliently engaging said cylindrical extension so as to establish electrical connection between said shaft and said third wire; a resilient metal contact member carried by the threaded portion of said shaft, said contact member being capable of being disengaged from the threaded portion of said shaft when said shaft is turned so as to move said contact member beyond either end of said threaded portion, said contact member including resilient means engaging said resistance element so as to establish electrical contact therewith and so as to prevent rotation of said contact member when said shaft is rotated; and means for rotating said shaft.

26. An electrical instrument which comprises: a non-conductive member; a metal housing sealed to said non-conductive member so as to define an envelope; three electric wires passing through said non-conductive member, said wires being sealed to said non-conductive member and being insulated from one another; an electrical resistance element positioned within said envelope so as to be insulated from said housing; means connecting the ends of said resistance element with two of said wires; an electrically conductive shaft positioned so as to extend into said envelope, said shaft including a threaded portion and a cylindrical extension within said envelope; bearing means resiliently holding said cylindrical extension positioned within said envelope and attached to the third of said wires so as to establish electrical connection between said shaft and said third wire; a resilient metal contact member carried by the threaded portion of said shaft, said contact member including resilient means engaging said resistance element so as to establish electrical communication therewith; and means for rotating said shaft.

27. An electrical instrument of the class described which includes: means defining a housing; an electrical resistance element positioned within said housing so as to be insulated therefrom; an electrically conductive shaft positioned so as to extend into said housing, said shaft being insulated from said housing and including a threaded portion and a cylindrical portion located within said housing; bearing means resiliently holding said cylindrical portion of said shaft, said bearing means being positioned within said housing and insulated therefrom; a resilient metal contact member carried by said threaded portion of said shaft, said contact member being capable of being disengaged from said threaded portion of said shaft when said shaft is turned so as to move said contact member beyond either end of said threaded portion, said contact member including resilient means engaging the sides of said resistance element so as to establish electrical contact therewith and so as to prevent rotation of said contact member when said shaft is rotated; and terminal means attached to the ends of said resistance element and to said bearing means, said terminal means being insulated from one another and from said housing and extending to the exterior of said housing.

28. An electrical instrument as defined in claim 27 wherein said resilient contact member includes a coiled section normally threaded on said threaded portion of said shaft and includes ends engaging sides of said resistance element.

29. An electrical instrument as defined in claim 26, wherein said means for rotating said shaft comprises a non-conductive member attached to one end of said shaft and resiliently engaging said metal housing to form a seal therewith; and a metal shell enclosing said non-conductive member, said metal shell being formed to receive an adjusting tool for rotating said shaft.

30. An electrical instrument as recited in claim 27 wherein said housing has an opening at one end defined by an extension in the walls of said housing, one end of said electrically conductive shaft extending into said opening, an elastomeric material ring filling said opening, extending beyond both sides of the extension of said housing walls defining said opening and having a diameter sufficiently large to be under compression by the extension of said housing walls and thereby hold said one end of said threaded shaft, a cap fitted over and engaging the portion of said elastomeric material ring extending on the outside of said housing walls, said cap being crimped over the extension of said housing walls and being formed to receive an adjusting tool for rotating said elastomeric material ring and thereby said shaft.

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