June 1, 1965 J. E. ROLWES 3,187,289

SCREWSHAFT-ADJUSTED VARIABLE RESISTOR AND METHOD

Filed April 23, 1963 2 Sheets-Sheet 1

FIG. 1.

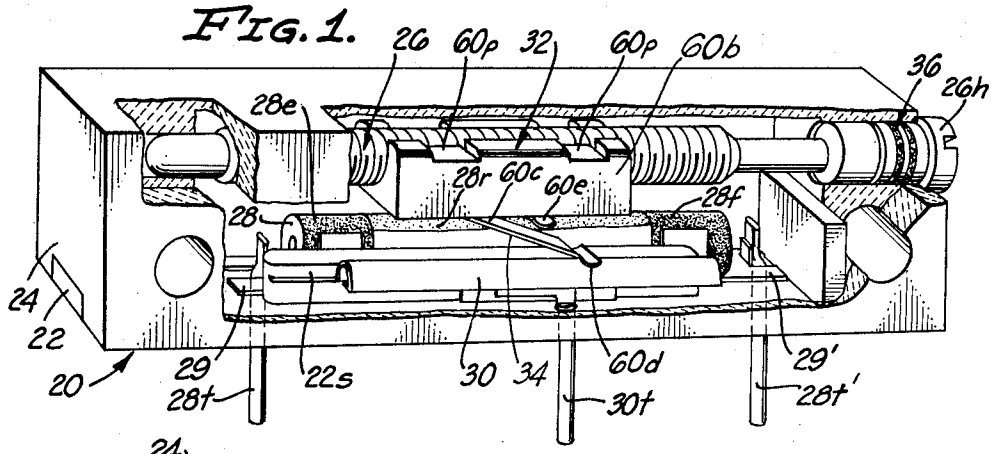


FIG. 2.

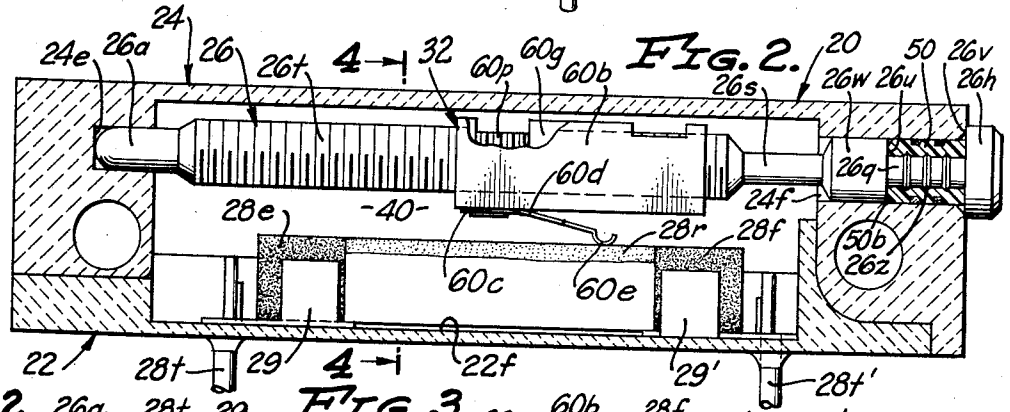


FIG. 3.

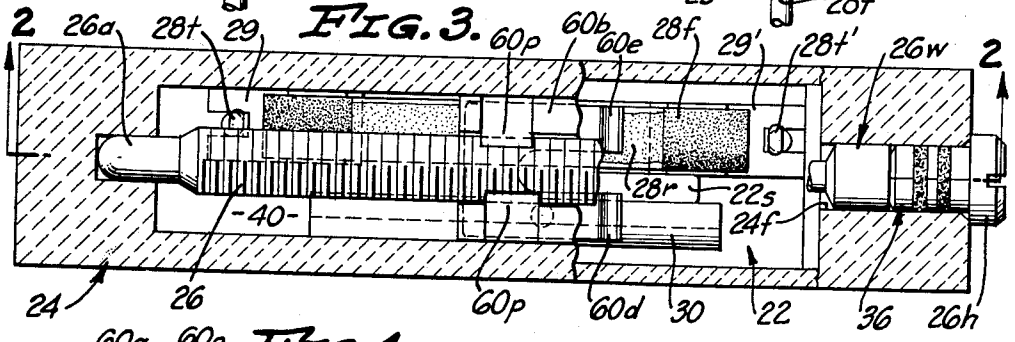


FIG. 4.

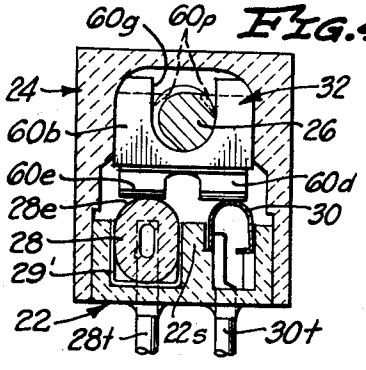
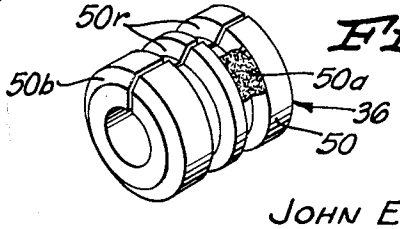


FIG. 10.



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Filed April 23, 1963 2 Sheets-Sheet 2

FIG. 5.

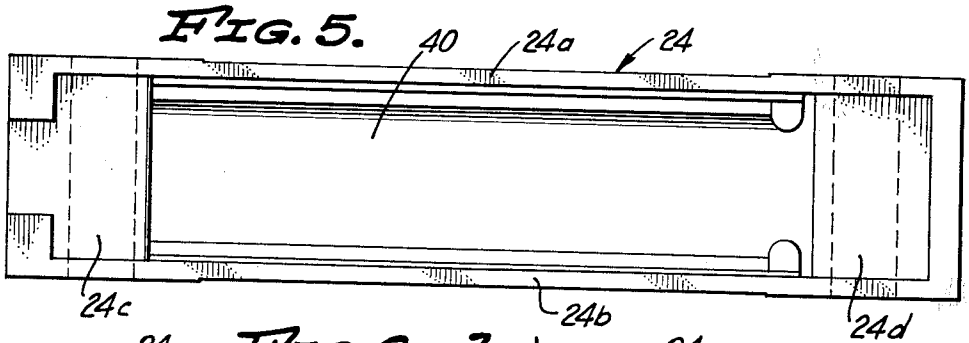


FIG. 6.

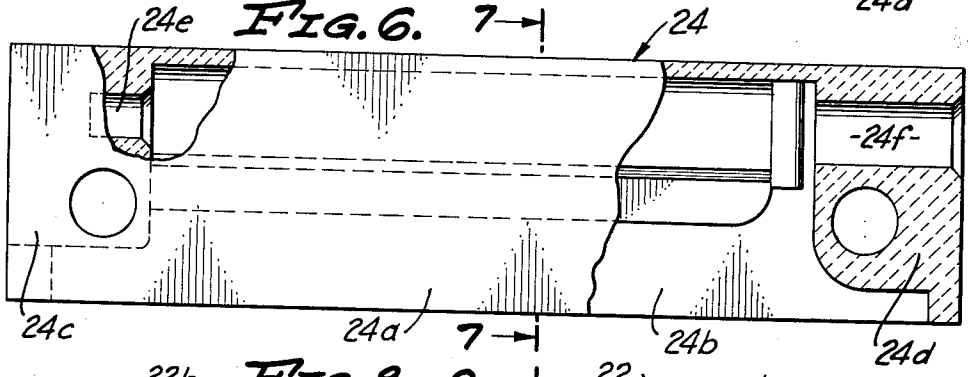


FIG. 8.

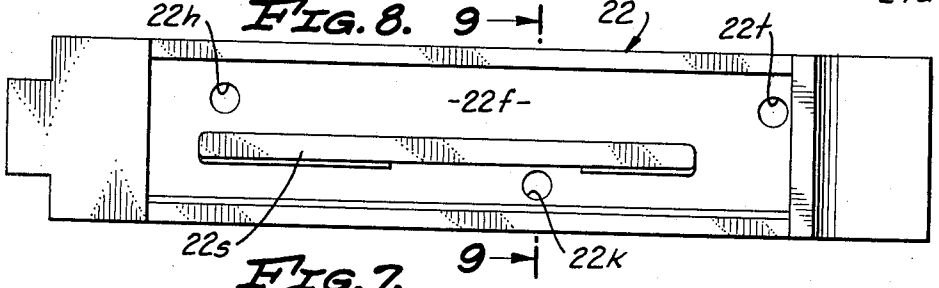


FIG. 7.

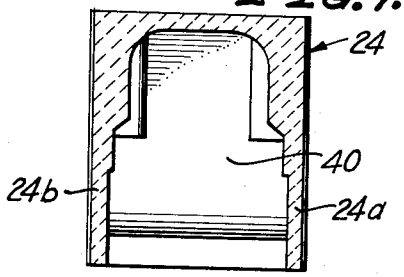


FIG. 11.

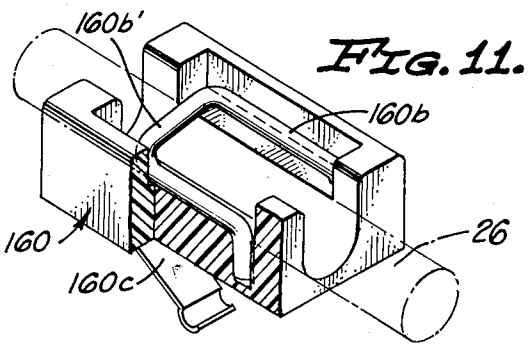
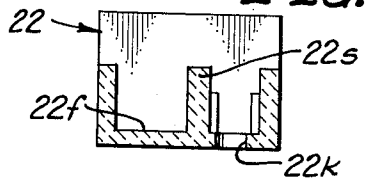


FIG. 9.



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United States Patent Office 3,187,289 Patented June 1, 1965

3,187,289

SCREWSHAFT-ADJUSTED VARIABLE RESISTOR AND METHOD

John E. Rolwes, Riverside, Calif., assignor to Bourns, Inc., a corporation of California

Filed Apr. 23, 1963, Ser. No. 275,165
26 Claims. (Cl. 338—180)

The invention herein disclosed pertains to variable resistors, and in certain aspects relates more particularly to such resistors of a class in which adjustments are effected by rotation of a shaft or leadscrew, and to improvements in modes of manufacturing variable resistors.

Variable resistors having small over-all dimensions and characterized by low total mass and high resistance to deterioration in humid-environments and further characterized by excellent precision and mechanical stability and long life at high temperatures and under severe vibration, are in demand for applications in airborne vehicles, missiles, and other places where severe environmental conditions or operational restrictions exist. Many types of variable resistors have been developed in attempts to provide a commercially practicable device of the class noted and meeting the noted qualifications. One difficulty encountered in producing a commercially practical variable resistor of the class noted is that of providing means for accurately maintaining the adjusting shaft against longitudinal movements, and of sealing the opening through which the shaft extends against ingress and egress of foreign matter. Many devices for restraining such shafts against longitudinal movement have been produced, but all apparently permit some such movement and all are expensive and time-consuming to install. The same is true of means for sealing the opening through which the shaft extends. In general, with the possible exception of commercially impractical, extremely expensive variable resistors that are not susceptible of being manufactured in quantity, the prior art variable resistors of the class noted have not attained more than a fraction of the desired attributes noted.

The present invention, by utilizing certain concepts and novel physical features of construction, provides a variable resistor of the class noted that is readily and inexpensively produced and duplicated in volume and which meets the noted need for a commercially practicable resistor having the noted characteristics with a precisely positioned shaft, effectively sealed, and at very low assembly cost. The novel features of construction and concepts including assembly procedures will hereinafter be made apparent.

Briefly, the invention comprehends provision of a substantially cylindrical opening extending into the body of the resistor, and a leadscrew having a portion dimensioned and disposed to be journaled in a portion of the cylindrical opening, the lead screw having a head spaced from the journaled portion by a circumferential or annular groove so that there are provided two oppositely-facing annular shoulders on the leadscrew within the opening. The annular shoulders are thus spaced apart by, and interconnected by, a portion of the leadscrew that is of smaller diameter than the opening in the resistor body. A series of circumferential ridges may be provided on the portion of reduced diameter. A somewhat elastic split-sleeve member is disposed in compression between the shoulders on the leadscrew and in compressive engagement with the reduced-diameter portion of the leadscrew. The sleeve is adhesively bonded to the interior wall of the opening in the resistor body by a suitable adhesive, and thus serves effectively to prevent axial movement of the leadscrew and concurrently acts to seal the opening against passage of foreign material.

It is, then, a prime object of the invention to provide improvements in easily manufactured high-grade shaft-adjusted variable resistors.

Another object of the invention is to provide an adjustable potentiometer having improved means for retaining an adjustment shaft in a precise longitudinal position relative to the body or housing of the resistor.

Another object of the invention is to provide improvements in means and methods of sealing a shaft-adjusted variable resistor housing against passage of foreign material.

Another object of the invention is to provide improvements in modes of manufacturing variable resistors.

Another object of the invention is to provide improvements in methods of assembling instruments of the class including shaft-adjusted variable resistors.

Another object of the invention is to provide an improved means for sealing the open shaft-bearing of a variable resistor and concurrently restraining the shaft against axial movement in the variable resistor.

Another object of the invention is to provide improvements in methods of sealing shaft-adjusted variable resistors against ingress of foreign material.

Another object of the invention is to provide a novel means for retaining an adjusting shaft in a fixed longitudinal position in an instrument housing.

Another object of the invention is to provide improvements in heat-resistance characteristics of sealed variable resistors.

Other objects and advantages of the presently disclosed invention are hereinafter set out in the appended claims or made evident in the following description of preferred methods of construction and a preferred physical embodiment of variable resistor exemplifying the principles of the invention, the preferred form of the said variable resistor being illustrated in the accompanying drawings forming a part of this specification.

In the drawings,

FIGURE 1 is a greatly enlarged pictorial representation of a preferred exemplary form of variable resistor, with portions broken away to reveal details of construction, the several components being only approximately to scale;

FIGURE 2 is a longitudinal sectional view of the resistor depicted in FIGURE 1 to a different scale, taken on a plane indicated by line 2—2 of FIGURE 3, but with certain parts shown in full rather than sectioned;

FIGURE 3 is a top view of the variable resistor depicted in FIGURE 1, with parts broken away or sectioned to reveal details of construction;

FIGURE 4 is a transverse sectional view of the resistor depicted in FIGURE 1, taken on a plane indicated by line 4—4 in FIGURE 2;

FIGURE 5 is a bottom view of the cover component or member of the resistor depicted in FIGURE 1;

FIGURE 6 is a view in elevation of the structure shown in FIGURE 5 with parts broken out;

FIGURE 7 is a transverse sectional view taken at a plane indicated by line 7—7 in FIGURE 6;

FIGURE 8 is a top view of the base or body member of the resistor housing depicted in FIGURE 1;

FIGURE 9 is a sectional view taken on a plane indicated by line 9—9 in FIGURE 8;

FIGURE 10 is a pictorial view of a preferred form of shaft-retaining and shaft-sealing sleeve utilized in the device depicted in FIGURE 1; and

FIGURE 11 is a fragmentary pictorial view of a modified form of contact carrier useful in extremely high temperature environments.

The invention is herein illustrated in connection with an exemplary screwshaft-adjusted variable resistor for purposes of convenience in illustration. As may be evi-

dent the scales to which the several drawings are made vary among the figures, solely in the interest of clarity of illustration and conciseness. Referring first to FIGURE 1, the variable resistor, indicated generally by numeral 20, is shown in the form of a potentiometer that comprises as principal components a housing comprising a body 22 and a cover 24, a screwshaft or leadscrew 26, variable resistance means including a resistance element 28, a return conductor or contact bar 30, and a slider or contact-carrier 32 carrying contact means 34, termination means including resistance element terminals 28*t* and 28*t'* and contact bar terminal 30*t*, and means indicated generally by numeral 36 for retaining the screwshaft in position and forming a seal therefor, those means being hereinafter described in more detail. The resistance element 28 comprises a resistance means 28*r* in the form of a film of resistive material, end portions of which are electrically connected to respective ones of the terminals 28*t* and 28*t'*; and variation of the resistance exhibited between either terminal 28*t* or terminal 28*t'* on the one hand and contact bar terminal 30*t* on the other hand is effected by movement or translation of the contact means 34 longitudinally along and in electrical contact with the upper exposed surfaces of the resistive means 28*r* and contact bar 30. Movement of the contact means 34 is accomplished by longitudinal movement of the contact carrier 32 to which the contact means is firmly secured by conventional means such as pins or by adhesive. The contact carrier is moved in the noted manner by the thread of of the shaft 26 as the latter is rotated, the thread of the shaft being yieldingly gripped by a portion of the contact-carrier or slider, 32, in a manner and by means hereinafter explained.

The body 22 (FIGURE 8), while susceptible of being in any of many physical forms, is herein illustrated in the form of an elongate tray-like member formed by molding, and preferably is of insulative ceramic material. The body is formed with a floor portion 22*f* bounded by upright wall portions and from which floor extends an upright fin or separator 22*s*. The floor 22*f* is pierced by terminal pin passages 22*h*, 22*k* and 22*t* in which the electrical terminal pins 28*t*, 30*t* and 28*t'* are adapted to be sealed. As indicated in FIGURES 1 and 4, the sidewalls and separator 22*s* effectively provide longitudinal shaped slot-like recesses in which respective ones of element 28 and contact bar 30 are secured. Contact bar 30 has welded thereto the terminal pin 30*t* which extends through passage 22*k* formed in the floor of base 22. The resistance element, which may be of a variety of constructions, is depicted as a shaped ceramic rod having metal-coated ends 28*e*, 28*f*, between which extends the resistive film previously mentioned. Each of the metal-coated ends is gripped by opposed stiff resilient clamping flanges of respective ones of terminal clips 29 and 29' (FIGURE 2), the clips each comprising a flat base portion disposed on the floor 22*f* and further having an upturned lug that is welded to the flattened upper end of a terminal pin such as 28*t* or 28*t'*. The resistance element 28 and the contact bar 30 may be further held in fixed locations by potting compound or fused frit (not shown) disposed in the bottoms of the respective recesses and adherent to the body and to the lower portions of the element and bar. Also, as will be evident to those skilled in the art, the contact pins may similarly be united to the body by cement or fused ceramic material to provide a leak-proof seal at those localities.

As depicted in FIGURES 5 through 9, the body 22 and cover 24 are formed to interfit and form an elongate housing providing an elongate inner chamber indicated generally by numeral 40. It is in that chamber that the elongate resistance element and contact bar are disposed, and in which the elongate screwshaft 26 (FIGURES 2, 3 and 4) and other operating instrumentalities are disposed.

The cover member 24 of the housing (FIGURES 5, 6 and 7) comprises sidewalls 24*a*, 24*b* and endwalls 24*c*, 24*d*, the latter being of considerable thickness. A bearing recess 24*e* (FIGURE 6) is provided in the interior of endwall 24*c*, and in alignment therewith an opening 24*f* is provided in endwall 24*d*, all for accommodation of the screwshaft 26. As is indicated in FIGURE 2, the screwshaft is provided with an inner end 26*a* of reduced diameter to be journaled in recess 24*e*, and a threaded middle portion 26*t* exposed in chamber 40. The screwshaf has an outer end portion or shank 26*s* of special form, arranged to be journaled in the previously noted opening 24*f* in the cover 24, the shank portion terminating in means such as a head 26*h* that is accessible from outside the housing and which may be provided with a slot or the like for engagement by means used to effect rotation of the shaft. Other details of the screwshaft will be presently explained.

It is desired that the chamber 40 inside the housing be sealed against ingress or egress of material, and accordingly when the several active components have been installed in the base or body and the terminal pins have been sealed in their respective openings, the cover and body are brought together and sealed as by being clamped together during fusion or hardening of a sealant applied along contacting surfaces. Such sealing leaves only the opening 24*f* unsealed. It is known to those skilled in the instruments arts that much time and effort have been expended in attempts to provide satisfactory seal means for rotary adjusting shafts that must exend from the interior of a sealed chamber to the exterior ambient. Further, much time and effort have been expended in attempts to provide simple, inexpensive and yet precise means for preventing longitudinal displacements or shifting of such shafts. The usual solution of the sealing problem involves application of one or more O-rings in precision-formed recesses. The usual solution of the problem of retaining the shaft in a fixed position longitudinally involves use of clips or pins or the like that ride in one or more annular grooves formed in the shaft and which are affixed to stationary means such as part of the instrument housing. Most if not all of such shaft-retaining means are unsatisfactory because they permit some axial translation of the shaft; and most are undesirable from the standpoint of consuming valuable space and being troublesome and expensive to install. The latter objection also applies to the usual shaft-sealing means such as O-ring seals. As will presently be made evident, the present invention provides a very simple and easily applied means that performs both of the described functions of sealing and retaining in place the shaft, and which further does not permit any translation of the shaft and concurrently provides a much more effective and less troublesome seal that is effective at much higher temperatures than the maximum at which O-ring seals are effective. By use of the novel sealing and shaft retaining means, considerable valuable simplification of instrument assembly is attained and at the same time much improvement in operating characteristics is effected, all with reduction of material costs.

As indicated in FIGURE 2, the shank of the screwshaft 26 is provided with an elongate annular groove between oppositely facing shoulders 26*u*, 26*v* that are provided by a portion 26*w* of diameter slightly larger than the maximum diameter of the thread and by the head 25*h*, respectively. That portion 26*q* of reduced diameter disposed between the opposed shoulders is preferably but not necessarily provided with one or more annular ridges such as 26*z*, for a purpose presently explained. The shank portion 26*w* of the screwshaft can be of various lengths, depending upon instrument design considerations; and it serves, besides providing shoulder 26*u*, as a stabilizing means for the screwshaft in opening 24*f*.

According to the invention the means for retaining shaft 26 in a desired fixed position longitudinally of the resistor housing, and for concurrently sealing the opening 24*f* against passage of foreign material, comprises as means 36 a stiff resilient polymer insert or sleeve 50 (FIGURES 2 and 10), and means such as a self-harden-

ing adhesive 50*a* for securing the sleeve 50 in opening 24*f*. The sleeve is preferably, and as depicted, formed of a chemical polymer having resilience and good mechanical stability at high temperature and characterized by being self-lubricating or having a low coefficient of friction with stainless steel. An example of a suitable polymer is solid polymerized polytetrafluoroethylene. Preferably the sleeve is formed as a longitudinally slit member, as indicated in FIGURE 10, of outside dimensions (when closed) slightly greater than the complementary dimensions of opening 24*f*, and of length such as to require application of pressure in forcing the expanded sleeve into the annular groove between shoulders 26*u* and 26*v* of shaft 26. For example, if the opening 24*f* is a bore of diameter D, the normal free diameter of the sleeve when closed is $D+\Delta D$, where ΔD is a small fraction of D. Thus when applied onto shaft 26 between the shoulders, the outside diameter of the sleeve will be slightly larger than the bore diameter of opening 24*f*.

The sleeve 50 is further preferably beveled at the inner peripheral edge, as at 50*b*, and is provided with one or more external recesses that preferably but not necessarily are in the form of one or more annular grooves such as 50*r*. As a consequence of the noted construction, the sleeve 50, when applied as indicated onto the shaft, is under compressive strain and presses against shoulders 26*u* and 26*v* with some force. However, due to the presence of the external recesses and the beveled edge 50*b*, and the resilience of the polymer, the shaft and encircling sleeve may be forced into opening 24*f*, the material of the sleeve deforming slightly to accommodate itself to the necessary slight reduction in external cross-sectional dimensions. The sleeve, when thus forced into the opening 24*f* to the position depicted in FIGURE 2, is under considerable compressive stress and presses against shoulders 26*u* and 26*v*, and also tightly embraces the reduced-diameter portion of the shank of the shaft between the shoulders. Hence the sleeve forms an effective seal about the engaged peripheral surfaces of the shaft. That sealing action is enhanced by presence of the circumferentially extending annular ridges 26*z* in those instances or cases in which such ridges are provided.

To secure the sleeve 50 against displacement in opening 24*f*, and to effectively and permanently seal the juncture of the sleeve and the interior wall of the bore or opening 24*f* against passage of material, the external recesses provided on the sleeve are filled with a suitable adhesive 50*a*, and the exterior peripheral surface of the sleeve is very lightly coated with adhesive, prior to pressing the shaft and sleeve into the opening. The adhesive is chosen to be compatible with the material of the housing (cover 24) and such as will form a strong mechanical bond thereto and will produce an effective seal. Thermosetting epoxy resin is an example of adhesives that are found to be satisfactory for use with both ceramic materials and the more common synthetic resin or polymer housings. While not usually necessary, it may be found desirable in some constructions to secure good adhesion of the adhesive to sleeve 50, and in that case the surfaces of the recesses or grooves, 50*r*, may be first roughened or etched. In the case of a sleeve of fluorocarbon resin, the grooves or recesses may be rendered susceptible to adhesion by a known sodium-etch procedure. Following insertion and forcing of sleeve 50 and adhesive 50*a* into position (as with head 26*h* against cover 24), the adhesive is cured. The latter may require application of heat, or merely a period of time, depending upon the type of resin or adhesive used.

Disposed in operative engagement with the thread of the screwshaft 26 in the housing chamber 40 is a contact-carrier device 32 which as depicted in one preferred form in FIGURES 2 and 4 comprises a stiff resilient shaped block 60*b* of polymer, and metal means secured thereto for purposes presently explained. The block 60*b* is formed with a longitudinally-extending round-bottom groove 60*g*

(FIGURE 4), dimensioned to receive the threaded portion of the shaft 26 with a snug fit. Further the block has secured thereto on the bottom thereof by staples, keylock means, adhesive, or other suitable means a conductive contact plate 60*c* which comprises first and second resilient contact limbs or contacts 60*d*, 60*e*. The first of the contacts is arranged for brushing contact along contact bar 30 and the second for like contact with resistance element 28 as indicated in FIGURE 4. So that the block may be translated to move the contacts along the element and bar, end portions of the upstanding side portions of the block are deformed by hot-pressing whereby thread-engaging projections 60*p* are produced. The projections 60*p* thus are in effect portions of a threaded nut, and resiliently engage the thread of the shaft and serve to translate the block when the shaft is rotated. Preferably a polymer characterized by stability at high temperature is used for block 60, and the previously mentioned polyfluorocarbon is satisfactory for the purpose.

For use in very high-temperature environments in which contact-carrier blocks of polymer material are not suitable, a modified form of carrier block, depicted in FIGURE 11, may be used. Therein the block 160 is of ceramic material shaped as indicated and has attached thereto by embedment, adhesive, or other suitable means a contact plate 160*c*, and also a wire spring device 160*b* the two downturned ends of which are sealed into the block, as indicated. The ends may, for example, be secured to the block by being embedded in the ceramic material, or inserted into pre-formed holes and cemented therein by fused material such as frit. The spring device has two free reaches extending along respective upper side portions of the block and integral with an interconnecting bridge portion 160*b'* that is disposed transversely across the top of the screw shaft and presses downwardly on the thread thereof. Thus by engagement of the bridge 160*b'* with the thread of the shaft, the block 160 is translated along the shaft as the latter is rotated.

As will be evident, the resilient projections 60*p* of polymer block 60*b* are adapted to yield if and when the block is jammed or collides with an endwall of the chamber 40 during continued rotation of the shaft, the projections moving in and out as required to accommodate rotation of the shaft and its thread. Similarly, when free movement of ceramic block 160 is prevented during continued rotation of the shaft, the bridge portion 160*b'* of spring device 160 merely rises and falls as the land of the thread forces the bridge to move. In the case of both types of blocks, re-engagement of the contact-carrier drive means (projections 60*p* or spring bridge 160*b'*) with the screw thread is immediate and effective upon reversal of the direction of rotation of the shaft. Both contact carriers are prevented from rotating with the shaft by engagement of the block thereof with one or more interior wall surfaces of the chamber 40, as indicated, for example, in FIGURE 4.

From the preceding description of the several structures it is evident that with the resistance element, contact bar, and the associated terminal pins sealed in place in the body of the housing, and the contact-carrier block and appurtenances in place in chamber 40 and the cover member united with the body member, the screwshaft may be forced in through opening 24*f* until its inner end is driven through the slot of the contact-carrier block and into recess or bore 24*e*; and that during that single operation the block becomes effectively engaged with the thread of the shaft and the sleeve 50 and adhesive 50*a* are forced into position with the outer end face of the housing in contact with the shoulder 26*v* of the shaft. Alternatively, the shaft and the adhesive-coated sleeve-like body of polymer may be driven or pressed into place in the cover member 24 (the contact-carrier block being applied to the shaft during the pressing), prior to union of the cover and its components with body member 22 and the components carried by the latter. Thereafter adhesive is

applied to the two thus-produced subassemblies and they are brought into proper cooperative relationship and the adhesive is cured. Thus, as the adhesive 50*a* hardens it effectively secures and seals sleeve 50 to the wall of the opening 24*f*, and provides one or more rigid keys or locks that are effective to hold the sleeve against longitudinal movement in the opening. Further it is evident that all necessity for precise positioning of parts of the assembly and for very close dimensional tolerances in the parts, is obviated. Also by the single operation of pressing home the screwshaft and sleeve and adhesive into opening 24*f*, the accurate and inexpensive assembly of precise shaft-retaining means and of effective sealing means is easily accomplished and a device having the noted advantages is provided. The mentioned objects of the invention are thus attained.

In the light of the preceding disclosure of a preferred physical form of the invention and mode of assembly, variations thereof within the true spirit and scope of the invention will occur to those skilled in the art, and accordingly it is not desired that the invention be limited to exact details of the mode and structure except as required by the appended claims.

I claim:

1. A leadscrew-adjusted variable resistor comprising:
first means, comprising an elongate housing comprising wall-forming means providing an elongate chamber in the interior thereof and having an opening through an end wall thereof communicating with said cavity;
second means, comprising a leadscrew disposed longitudinally of said housing with a screw thread exposed in said chamber and a shank portion disposed in said opening, said shank portion comprising portions forming a circumferential groove bounded at its ends by shoulders;
third means, comprising a return conductor, a resistance element, contact means operable by said leadscrew and brushing on said element and conductor, and respective terminal means for said element and said conductor; and
fourth means, comprising a generally cylindric seal and retainer means tightly engaged in the said circumferential groove and adhesively secured to said housing means in said opening,
whereby said leadscrew is rotatably secured in a fixed longitudinal position relative to said housing.

2. A variable resistor according to claim 1, in which said housing comprises a ceramic body and a ceramic cover, and fire-resistant ceramic adhesive firmly securing said cover to said body and providing a hermetic seal therebebtween.

3. A variable resistor according to claim 1, in which said resistance element comprises a ceramic mandrel carrying a resistive metallic film, and in which said seal and retainer means is a longitudinal slit cylindrical sleeve composed essentially of a solid resinous fluorocarbon compound.

4. A variable resistor according to claim 1, said opening being a cylindrical bore of diameter D, and said leadscrew comprising in said shank portion a cylindrical portion bearing in said bore and having a head of minimum transverse dimension greater than said bore and comprising between said head and said cylindrical portion a portion of diameter less than D and having thereat at least one circumferential ridge, and said resistor comprising in said bore and compressively encircling said ridge a stiff elongate resilient polymer seal and means firmly securing said seal to said body in said bore, whereby said seal retains said leadscrew in a fixed longitudinal position and seals said opening against ingress of foreign material into said chamber.

5. A variable resistor comprising:
first means, comprising an elongate housing having means providing an elongate inner chamber bounded by walls including an endwall, said housing having an opening through said endwall into said chamber, said first means comprising operable variable resistance means in said chamber;
second means, including a rotatable shaft means operatively connected to said variable resistance means for operation thereof and extending into said chamber and having a shank disposed at least in part in said opening and said shank comprising a portion of reduced diameter bounded at both ends by portions of greater diameter to form an elongate circumferential groove;
third means, comprising a tightly-fitting resilient sleeve of stiff self-lubricating polymer disposed around said portion of reduced diameter of said shank and compressively pressing against said portions of greater diameter, said sleeve being under compression and firmly secured around its outer periphery to said housing at said opening and compressively engaging said portion of reduced diameter,
whereby said sleeve restrains said shank against axial translation relative to said housing and serves as a self-lubricating seal for said shank in said opening.

6. A variable resistor according to claim 5, in which said opening comprises a cylindrical bore and in which said sleeve has at least one circumferentially-extending groove in said bore, and adhesive means disposed in said groove and firmly securing said sleeve to said housing at said bore.

7. A variable resistor according to claim 5, in which there are provided on said portion of reduced diameter of said shank a plurality of spaced-apart circumferentially-extending ridges, and wherein said sleeve in the free state has a cylindrical interior, whereby said sleeve under compression in said opening conforms to the shape of said ridges and provides an improved self-lubricating seal for said shank.

8. A variable resistor according to claim 7, in which said opening comprises a cylindrical bore and in which said sleeve has at least one circumferentially-extending groove in said bore, and adhesive means disposed in said groove and firmly securing said sleeve to said housing at said bore.

9. A variable resistor comprising:
first means, comprising an elongate housing composed essentially of a body member and a cover member and formed to provide an elongate internal chamber bounded by walls including a thick end wall, said end wall having a generally cylindrical bore-like opening therethrough;
second means, comprising a resistance element including an elongate mandrel, secured in said housing, said mandrel supporting exposed resistive means thereon between the ends thereof, and respective terminal means for end portions of the resistive means;
third means, comprising an elongate conductive bar secured in said housing with an exposed portion thereof disposed generally parallel to said exposed resistive means, and terminal means for said bar;
fourth means, comprising an elongate screwshaft having a screw thread exposed in said chamber and a shank portion in said opening of said end wall, said shank portion having shoulders spaced apart by a circumferentially extending annular groove;
fifth means, comprising contact means including a device yieldingly engaging said screw thread for translation thereby incident to rotation of the screwshaft, and including interconnected conductive contacts each arranged for brushing engagement with a respective one of said conductor bar and said element incident ot such translation;
sixth means, comprising a generally cylindrical elongate resilient sleeve disposed in said groove and com-

pressively engaging said shank between said shoulders and bearing against said shoulders; and

seventh means, comprising adhesive means securing said sleeve to said housing in said opening;

whereby said screwshaft is rotatably held in position in a fixed position longtitudinally of said housing.

10. A variable resistor according to claim **9**, said shaft between said shoulders comprising at least one circumferentially-extending annular ridge; and adhesive means sealing said cover member to said body member;

whereby said chamber is effectively sealed against passage thereinto of foreign matter.

11. A variable resistor according to claim **10**, said cover member and said body member being of ceramic material and said adhesive means sealing said cover member to said body member being ceramic material.

12. A variable resistor according to claim **11**, said sleeve being composed of a solid self-lubricating polyfluorocarbon resistant to deterioration in hot environments.

13. A variable resistor according to claim **11**, said contact means comprising a contact carrier formed of a substantially solid block of stiff resilient heat-resistant polymer said block having an open elongate slot in which a portion of said screw thread is disposed and gripped around a major portion of the thread periphery by said block.

14. A variable resistor according to claim **11**, said contact means comprising a contact carrier formed as a block of ceramic material having means for yielding engaging said thread, whereby incident to extreme rotation of said screwshaft and jamming of said contact carrier, the connection between said thread and said contact means yields and avoids breakage of components.

15. A variable resistor comprising:

first means, including an elongate hollow housing providing an elongate chamber having an endwall pierced by a longitudinally-extending bore;

second means, including a screwshaft journaled in said housing and having a screw thread exposed in said chamber and a shank extending through said bore and having spaced apart shoulders separated by an elongate annular groove, said shank being disposed with said groove in said bore;

third means, comprising a stiff resilient polymer sleeve means compressively disposed between said shoulders and encircling and compressively engaging said shaft thereat;

fourth means, disposed in said bore between said sleeve means and said housing, serving to secure said sleeve means to said housing at said bore whereby to restrict said screwshaft against longitudinal translation relative to said housing and to seal said bore against passage of matter;

and fifth means, including variable resistor means and at least two terminal means, disposed in said chamber and connected to said screwshaft for operation thereby to vary the resistance exhibited between the two terminal means.

16. A variable resistor according to claim **15**, said variable resistor means comprising a ceramic contact carrier and contact means carried thereby, and said housing being composed of a ceramic body member and a ceramic cover member secured thereto by a ceramic bond.

17. A variable resistor comprising:

first means, comprising a housing formed to provide an interior chamber bounded by walls including an end wall, said end wall being pierced by an opening providing a bore;

second means, comprising a resistance element disposed in said chamber, and terminals for said element connected to respective end portions of said element and extending to the exterior of said housing;

third means, comprising a shaft rotatably journaled in said housing and having a shank extending through said opening, said shank including opposed shoulders separated by an elongate annular groove;

fourth means, comprising a contact carrier and a contact carried thereby, connected to said shaft for movement thereby incident to rotation of the shaft; said contact being arranged to brush along and in contact with said element;

fifth means, including a terminal accessible from outside said housing and means electrically connecting said contact to said terminals; and

sixth means, comprising a resilient solid self-lubricating polymer sleeve having at least one circumferentially-extending groove recess around the exterior thereof and said sleeve compressively pressing against said shoulders and compressively engaging said shank between said shoulders and pressing against said housing within said bore, and said sixth means comprising an annular ring of hardened resin filling said groove recess and firmly bonded to said housing therearound, whereby said sleeve seals said bore and said hardened resin effectively resists longitudinal translation of said shank.

18. A leadscrew retainer and seal for an elongate leadscrew-adjusted variable resistor having an elongate housing forming an elongate interior chamber defined by walls including an end wall and having a longitudinally-extending bore through an end thereof and which resistor includes an elongate leadscrew comprising a threaded portion adapted for exposure in the said chamber and a shank portion adapted for repose in the said bore, the said shank comprising a portion of reduced diameter bounded by oppositely facing annular shoulders forming an annular groove, said retainer and seal comprising: a resilient elongate self-lubricating stiff resilient polymer sleeve dimensioned to be received under compressive strain within said annular groove between said annular shoulders, said sleeve having external recesses formed therein, and

impervious adhesive means filling said recesses and adapted to adhere to the said housing circumferentially around said sleeve and firmly sealing said sleeve to said housing.

19. A leadscrew retainer and seal according to claim **18**, said sleeve being longitudinally slit to facilitate assembly onto the shank of the said leadscrew, and the said sleeve having an inner annular beveled edge to facilitate entry into said bore.

20. The method of assembling a shaft-adjusted instrument having a hollow housing and an adjusting shaft to be journaled in the housing and accessible from outside the housing by way of a bore-like opening in the housing in which a portion of the shaft is disposed, said opening to be sealed against passage of foreign material, said method comprising:

providing on the shaft a pair of opposed shoulders separated by an intervening elongate annular groove;

disposing on said shaft between said shoulders an externally circumferentially grooved resilient self-lubricating split sleeve of length at least equal to that of said groove and of external diameter when closed greater than the diameter of said bore-like opening;

filling the external circumferential groove in the said sleeve with a hardenable resinous fluid adhesive capable of forming a firm bond with said housing within said bore-like opening;

forcing said shaft and sleeve and adhesive into said opening and thereby compressing the ends of said sleeve against said shoulders and forcing the interior of said sleeve into compressive engagement with said shaft between said shoulders;

and permitting said adhesive to become hard, whereby said adhesive bonds to said housing and forms an annular ring locking said shaft against axial displacement in said bore-like opening and whereby said

sleeve seals the said opening against passage of foreign matter.

21. The method of sealing and retaining in place a rotary shaft of an adjustable instrument having a hollow housing through a thick wall of which the rotary shaft is arranged to extend, said method comprising, in any logical order, the steps of:

forming on the shaft an elongate annular groove bounded by oppositely facing shoulders;

providing a longitudinally split circumferentially externally grooved resilient deformable sleeve of length such as to provide a tight compressive fit on the said shaft between the shoulders thereof;

providing through the said wall an opening of cross-sectional dimensions slightly smaller than the comparable dimensions of the said sleeve when closed;

applying said sleeve on the said shaft between the said shoulders;

applying adhesive to said sleeve sufficient to substantially fill the external groove thereof;

forcing the rotary shaft and sleeve together into said opening and thus placing said sleeve under compressive stress; and

curing said adhesive, whereby to provide between the shoulders of the said shaft a sleeve that is securely affixed to the said housing in said opening to prevent longitudinal movement of said shaft in said opening, and whereby to provide an effective seal about said shaft in said opening.

22. The method of installing and retaining in place in a variable resistor housing a rotary adjusting shaft, said method comprising:

providing in a wall of said housing an opening of prescribed cross-sectional dimensions;

providing on said shaft an annular groove having opposed end faces and dimensioned to be received in said opening;

providing an externally recessed resilient non-metallic homogeneous split sleeve dimensioned to make a compressive fit in said annular groove and of slightly larger external cross-sectional dimensions than those of said opening;

mounting said sleeve in said annular groove and applying adhesive to the exterior of the sleeve sufficient to fill the external recesses thereof;

forcing said shaft and sleeve into said opening to compress said sleeve into compressive engagement with said shaft against the faces of said annular groove to adhesively join the wall of said opening to the adhesive in said recesses;

and curing said adhesive, whereby said sleeve is firmly secured in situ in said opening and said shaft is restrained against longitudinal displacement in said housing.

23. The method of assembling a leadscrew and leadscrew retainer in the apertured housing of a leadscrew-adjusted variable resistor, said method comprising:

providing an elongate bore in a wall of the housing;

providing an elongate annular groove bounded by end walls, in the shank of the leadscrew;

providing an elongate exteriorly recessed split sleeve of resilient self-lubricating material dimensioned to compressively engage said end walls and said shank of said leadscrew, and assembling said sleeve in said groove;

filling the recesses on the outside of said sleeve with an adhesive adherent to the said housing;

forcing the leadscrew and sleeve and adhesive into said elongate bore to place said sleeve under compression between the end walls of said groove and cause said adhesive to contact the wall of said bore;

and curing said adhesive whereby to adhesively secure said sleeve to said housing and thereby retain said leadscrew in position in said housing.

24. In a variable resistor of the type having operating instrumentalities housed in a sealed housing through an opening in which housing extends a rotatable shaft by means of which the operating instrumentalities are operated to effect variations in electrical resistance exhibited by the variable resistor: means for preventing axial translation of the shaft and sealing the shaft and opening against ingress and egress of foreign material, said means being disposed in said opening and comprising a stiff resilient substantially solid body of polymer compressively engaging the rotatable shaft around the periphery of the shaft and compressively pressing in opposite axial directions against surfaces of said shaft whereby to prevent axial movement of the shaft relative to the body of polymer and whereby to seal the interface between the body of polymer and the shaft, and said means further including adhesive means adherent to the housing and to the body of polymer around the periphery of at least a portion of the opening whereby said body of polymer is held in fixed position relative to the housing to prevent translation of the body of polymer relative to the housing and whereby a complete peripheral sealing of the interface between the body of polymer and the housing in said opening is attained.

25. Structure according to claim 24 in which the body of polymer exerts compressive forces on the housing in said opening to aid said adhesive in restraining the body of polymer against displacement relative to said housing.

26. Structure according to claim 24 in which said body of polymer is shaped to provide exterior recesses and in which said adhesive fills said recesses and serves as an anchor to retain said body in fixed position relative to said housing.

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