

April 11, 1967

H. L. KRUSE

3,314,036

HELICAL-ELEMENT VARIABLE RESISTOR

Filed July 24, 1964

2 Sheets-Sheet 1

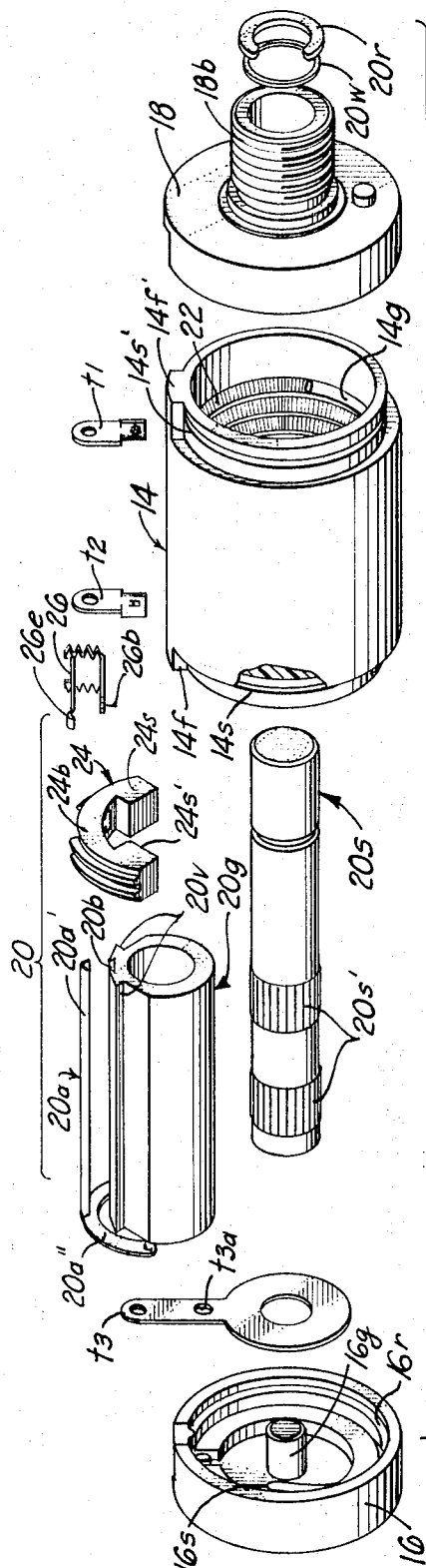


FIG. 2.

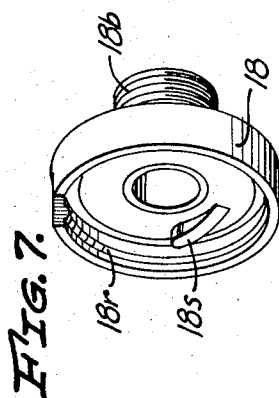


Fig. 7.

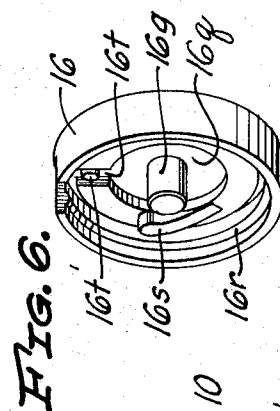


Fig. 6.

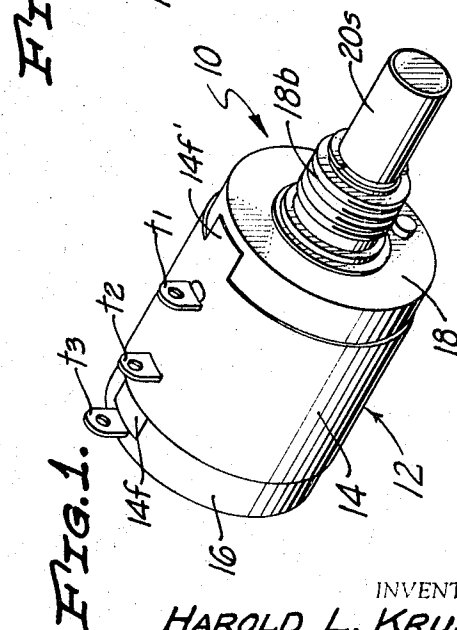


Fig. 1.

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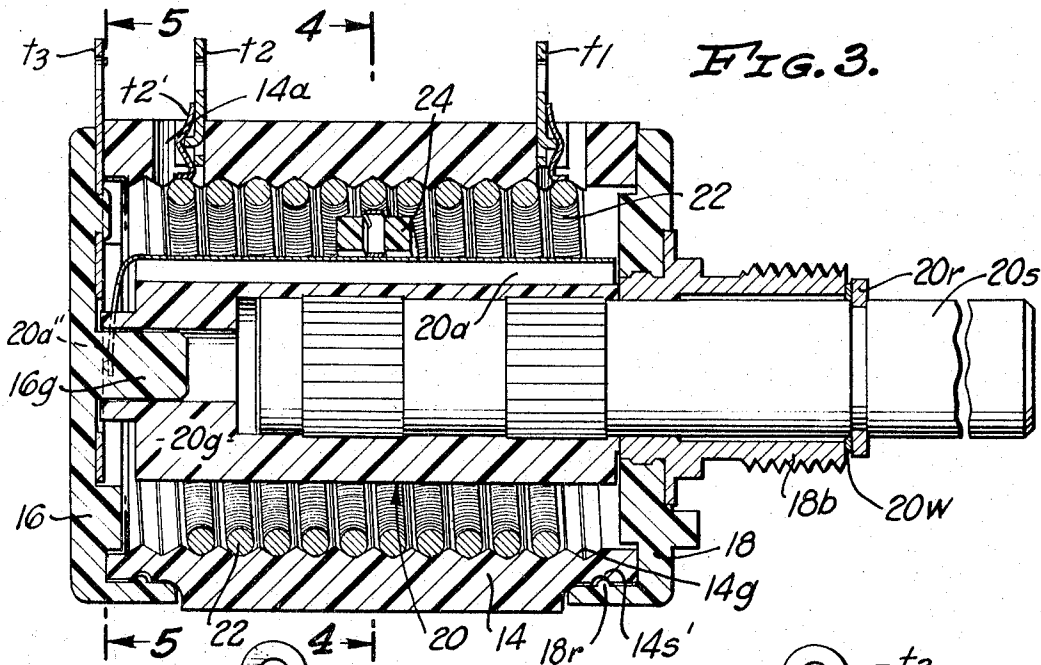
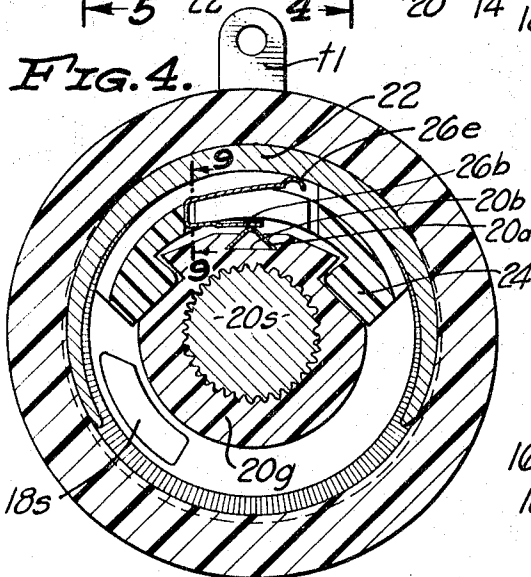
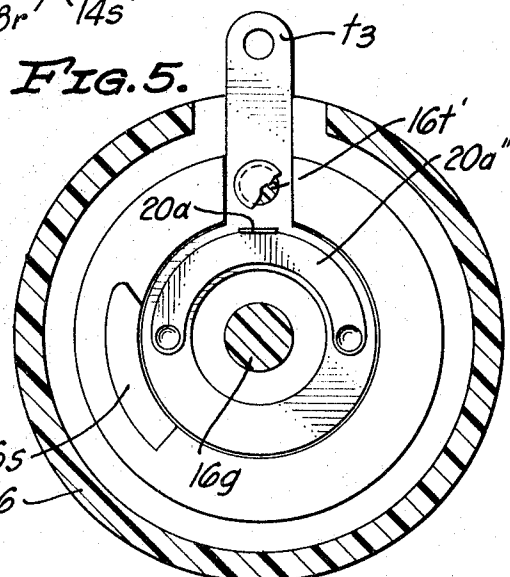
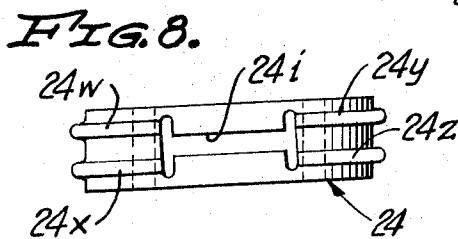
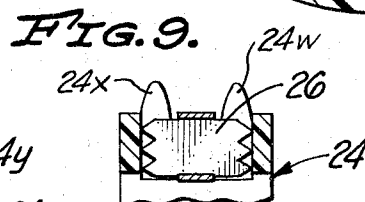
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HELICAL-ELEMENT VARIABLE RESISTOR

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2 Sheets-Sheet 2



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3,314,036

HELICAL-ELEMENT VARIABLE RESISTOR

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10 Claims. (Cl. 338-143)

The invention herein disclosed pertains to variable resistors of the type that comprises a resistance element coiled into the form of a helix that is disposed around and coaxially with a rotatable adjusting shaft that is rotatable in bearing or bushing means and is effective to cause movement of a brush or wiper contact along a helical exposed contact zone of the resistance element. More particularly, the invention relates to improvements in the housing and adjusting means comprised in such variable resistors, whereby assembly of the several parts or components is made easy, simple, and inexpensive whereby the expense involved in manufacturing variable resistors of the noted type is grossly reduced.

Prior art variable resistors of the above-mentioned type are illustrated in the following-numbered patents: 2,361,010, 2,371,159, 2,454,986, 2,473,048, 2,495,321, 2,539,557, 2,813,182, 2,813,956, 2,883,501, 3,028,571. In general, and as illustrated by the cited patents, variable resistors of the type here pertinent and of interest comprise a means such as an internally helically grooved member supporting the helical resistance element internally, front and rear end members having bearing means and serving to close the ends of a cylindrical space inside the grooved member, the bearings supporting a rotor journaled in the bearing means, and a contact carrier movable along the rotor and carrying a brush or contact along the resistance element incident to rotation of the rotor. Also, electrical connections between respective ends of the resistance element and terminals, and a connection between the brush or contact and a third terminal, are variously constructed and arranged.

In the case of pertinent prior-art variable resistors numerous and relatively complicated operations are required in assembling the resistor, thus inordinately increasing the cost of manufacturing the instrument. For example, in those resistors in which the helical resistance element is inserted into a cup-like housing barrel, manufacture of the barrel is ordinarily complicated by necessity for machining a helical seat for the element, and by the operation of inserting the plurality of convolutions of the element into the helical seat with access limited to one end of the barrel. Also, in that type of construction, effecting a terminal connection to the inner end of the resistance element is complicated by inadequate or difficult access to the element at the closed end of the barrel. Such constructions are illustrated in the first six of the above-listed patents. In other prior art resistors comprising an element-supporting barrel open at both ends, relatively complicated means are used to secure end plates to the barrel; or application and curing of an adhesive is necessary, involving relatively lengthy operations such as careful application of adhesive to restricted areas of the surfaces to be joined. Further, the prior art resistors are characterized by rotor structures that are complicated and/or difficult to assemble, and that are expensive because they comprise many parts. Also, substantially all prior-art multi-turn helical element variable resistors comprise a surprisingly large number of parts; and in many instances some or many of the parts are of complex form or are otherwise expensive to produce.

The present invention obviates all of the aforementioned undesirable features characterizing the prior art resistors of the class here of interest, in part by providing a resistor comprised of only a very few parts, in part by utilizing only parts that are simple and inexpensive, and in

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part by an arrangement of parts that permits the parts to be assembled by very simple operations that do not involve more than a low level of manual dexterity and skill.

The invention provides a variable resistor having as a principal housing component a simple open-ended cylindrical member or barrel that is provided with an internal helical groove or element seat that is preferably formed in a simple molding operation. The ends of the barrel are provided with respective shelves that extend nearly all the way around the barrel, the shelves presenting respective snap-action formations, such as grooves, which are arranged and adapted for reception of complementary internal snap-action formations, such as ribs, that are provided on respective ones of end bells that are adapted to be pressed onto respective ends of the barrel to form a generally cylindrical housing or case. The barrel and the end bells are made of stiff resilient material, such as a cured synthetic resinous polymer, whereby by elastic deformation the end bells may be pressed onto ends of the barrel and are there retained by remanent stress induced during the pressing operation. Prior to application of end bells to the barrel, a plural-turns helical resistance element is permitted to expand from a winder mandrel into place in the internal groove in the barrel, terminal conductors are welded to the resistance element and to spring terminals, and the latter are then simply pressed into radial apertures produced in the barrel, to form a complete subassembly.

The end bells are preferably formed as injection-molded parts. The closed end bell is produced with an inwardly projecting gudgeon providing a bearing, with a collector-ring retaining formation, and with a flange with an internal rib formation for cooperation with the groove on one end portion of the barrel as noted. Similarly the other (open) end bell is provided with a bushing providing a shaft-receiving bearing, and a similar flange and internal rib. Thus the end bells may be simply and easily pressed onto respective ends of the barrel, where they bring the bearings into coaxial alignment and where they are firmly retained by the snap-acting rib-in-groove formations.

A contact-driving rotor structure or device is produced by pressing a milled shaft into a somewhat cylindrical, shaped insulative member, one end of which member receives the aforementioned gudgeon of the closed end bell. The rotor structure has disposed and keyed thereon for longitudinal sliding motion therealong and rotary motion therewith, a preferably insulative slider which has a double-contact member one limb of which brushes on the resistance element and the other of which brushes on a return bus that is keyed in a longitudinal dovetail slot in the insulative rotor member and that has a brush in contact with the noted collector ring. The contact is so formed that it is easily pressed into permanent operative position in an aperture provided in the slider. By forming the return bus of resilient metal and as a long strip of V-section terminated at one end by a semicircular prong or limb, the bus is readily pushed into the dovetail slot in the rotor and serves to resiliently contact the return or collector terminal ring at the inner end of the cylindrical housing. Also, with the described rotary structure assembled as a subassembly, that structure may be inserted into the barrel and the exposed free shaft end pushed through the bushing of the open end bell. Thereafter a simple pressing operation suffices to affix in place the closed end bell and complete the main operations of the assembly.

It is, then, a principal object of this invention to provide a simple variable resistor of the noted type, that is comprised of but a very few parts all of which are of simple form and easily and inexpensively made, and which

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resistor may be quickly and easily assembled by an unskilled worker.

Another object of the invention is to provide a rotary variable resistor or potentiometer consisting of components that are easily assembled by unskilled personnel.

Another object of the invention is to provide a helical-element variable resistor composed of only a small number of components.

Another object of the invention is to provide a helical-element variable resistor of simple construction.

Another object of the invention is the provision of a helical-element variable resistor capable of rapid and easy assembly by unskilled personnel.

Other objects or advantages of the present invention are indicated or stated in the appended claims or in the following description of a preferred exemplary physical embodiment of the invention, the description containing references to the accompanying drawings that form a part of this specification. In the drawings:

FIGURE 1 is an enlarged pictorial representation of the aforementioned preferred exemplary variable resistor in assembled form;

FIGURE 2 is a pictorial representation of components of the variable resistor depicted in FIGURE 1, in disassembled array;

FIGURE 3 is a longitudinal sectional view of the variable resistor depicted in FIGURE 1, to a different scale;

FIGURES 4 and 5 are transverse sectional views of the variable resistor depicted in FIGURE 1, the views being taken at locations and in directions indicated by respective ones of broken lines 4—4 and 5—5 in FIGURE 3, with a member displaced to illustrate details;

FIGURES 6 and 7 are pictorial views of first and second end bells, respectively, of the noted variable resistor;

FIGURE 8 is a plan view of a contact-carrier or slider comprised in the resistor depicted in FIGURE 1; and

FIGURE 9 is a fragmentary view in section, illustrating details of the mechanical connection or fastening of a contact device to a contact-carrier or slider, the section being taken as indicated by the broken line 9—9 in FIGURE 4.

Referring now to FIGURES 1 and 2, the variable resistor, denoted generally by numeral 10, is of generally cylindrical configuration, and comprises a housing 12 consisting of a centrally-disposed internally threaded barrel 14, a closed end bell 16, and a bored end-bell 18 comprising a threaded bushing 18b. The housing components are preferably formed of an insulative synthetic resin, such as diallyl phthalate, by known injection-molding techniques. The resistor also comprises first and second resistance-element terminals *t1* and *t2*, and an electrical return terminal *t3* each of which extends through a respective opening or passage provided in or by the housing to provide externally-accessible termination connections; and operating means including a rotor device or structure 20 the shaft 20s of which extends through and is journaled in the bushing 18b of the housing.

Within the barrel of the housing 12 there preferably is formed a helical groove or thread 14g (FIGURES 2 and 3), into which a helical resistance element 22 is formed or is expanded from a mandrel and seated by spring action. The resistance element, here shown in exemplary form and for convenience as being of the conventional helical wire-wound type comprising an insulated resilient wire core bearing a winding of resistance wire, is turned or wound on a temporary mandrel (not shown), and is inserted into the barrel while still captive on the mandrel. When released from the mandrel the element expands in the manner of a stressed coil spring, the turns or convolutions of the element coming to rest in groove 14g while still attempting to continue expansion due to stress remaining in the core of the element. That mode of inserting a helical element in a barrel is known in the art and accordingly is here not further described.

Terminal-receiving apertures, such as aperture 14a

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(FIGURE 3), are provided through the barrel 14; and, with the resistance element in place as described, a wire connection (such as *t2'*) to the resistance element is made by welding one end of a lead wire or ribbon to a selected turn of the resistance element at the bottom of an aperture, and the other end is welded to a respective terminal member such as *t2* or *t1*. Thereafter the terminal members are pressed into the respective apertures preferably with adhesive applied as a sealant. As is indicated in FIGURES 2 and 3, each of the terminal members is formed with a lower end portion struck out or shaped to arcuate form, and punched to provide a lateral weldment projection to which the ribbon is welded. The arcuate lower end of the terminal member is compressed prior to insertion into an aperture, and tightly engages the wall of the aperture when permitted to expand. With an application of self-curing adhesive (not shown in the interest of clarity) the terminals close and seal the apertures and provide an externally-accessible connection to respective electrical ends of the resistance element.

The closed end-bell 16 (FIGURES 2, 4 and 6) is constructed or formed with an inwardly-extending gudgeon 16g that provides one axis-defining bearing member, about which axis rotatable means presently to be described rotate. End bell 16 further is formed with an annular recess 16q with a radial extension 16i, shaped to receive the ring-like inner portion of the aforementioned electrical return terminal *t3* (FIGURE 2). To facilitate retention of the terminal *t3* in the end bell 16, the terminal is provided with a small aperture *t3a* for reception of a small fit 16i' (FIGURE 6) which, following placement of the terminal in place in recess 16q, is heat-swaged over the edge of aperture *t3a* as indicated in FIGURE 5. By the latter procedure the terminal is, in effect, riveted to the interior face of end bell 16. The end bell further is provided with a shaped stop-abutment 16s (FIGURE 6) the function of which is to arrest or limit movement of a contact-carrier that is comprised in the rotary operating means of the resistor. Also, on the interior face of the flange portion of end bell 16 there is formed one of a cooperating set of male and female snap-action retainer means. As illustrated, an arcuate ridge 16r (FIGURE 6) is provided in the end bell as the male member of the set; and the cooperating member will presently be described.

The second, or bored end bell, 18, of the resistor, is similarly provided with a stop abutment 18s (FIGURE 7) and an annular ridge 18r that is dimensioned and spatially positioned for snap-action cooperation with a complementary groove 14s' formed on the respective flange at the end of housing barrel 14 (FIGURE 2). By such means, including the slightly elastic nature of the material of which the housing components are made, the end bells may be forced onto respective ends of the barrel and are there held in place. As is made evident, particularly in FIGURES 1 and 2, the end bells are provided with notches or indentations arranged to receive with a close dimensional fit respective formations 14f and 14f' provided on barrel 14; whereby the end bells are properly positioned relative to each other and whereby stop abutments 16s and 18s are properly positionally related. As is also evident, adhesive sealant may if desired be applied to mating surfaces of the end bells and barrel 14, for more effectively sealing the housing. Self-curing epoxy resin is cited as a satisfactory sealant.

The rotary operating components of the variable resistor comprise the rotor structure 20 (FIGURE 2). The rotor structure comprises the aforementioned shaft 20s which is journaled in bushing 18b, and the bored guide 20g into which the inner milled end of shaft 20s is pressed and the inner end of which guide is rotatably borne by gudgeon 16g as indicated in FIGURE 3. As becomes evident from consideration of the structure as portrayed in FIGURE 3, the guide 20g is assembled with shaft 20s by a simple pressing operation. The shaft 20 is

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firmly held in proper relationship with guide 20g by one or more series of knurling or milling 20s' that is produced on the shaft and the raised portions of which bite into the bore-wall of the guide.

Guide 20g is provided with a pair of opposed longitudinally extending V-ways 20v (FIGURE 2), and a longitudinally extending groove 20b which as indicated is of dovetail form. The groove is dimensioned to receive the elongate shank 20a' of a conductive return bus 20a, the guide being of insulation or being insulated so as to electrically isolate the return bus from shaft 20s. As is evident from FIGURES 2 and 4, the shank of the return bus is readily installed in the dovetail groove by being pressed into the groove from the inner end of the latter. The opposed V-ways 20v provide a track on which an arcuate contact-carrier or slider 24 is slidably supported in a manner indicated in FIGURE 4. Thus the slider has opposed shoulders or formations 24s, 24s' that are suitably dimensioned and disposed with inner edges received and slidable in respective ones of the V-ways; and hence as the rotor structure 20 is rotated the slider is moved around the longitudinal axis of the rotor and is concurrently allowed to partake of longitudinal translation along the V-ways.

The slider 24 functions to adjustably position a contact device at any desired location along the helical contact-surface or zone of the resistance element 22. The contact device serves to provide an electrical connecting link between the selected point or location on the resistance element, and the return bus 20a. As is indicated in FIGURES 4, 8 and 9, slider 24 is provided with an I-shaped aperture 24i through the arch or bridge interconnecting shoulders 24s and 24s'. The aperture is shaped and dimensioned to receive, with a tight press fit, a folded and toothed contact device 26 which has an outwardly-directed resilient limb terminated by a contact 26e disposed to resiliently brush on the resistance element, and an inwardly-directed second resilient limb terminated by a second contact 26b that is disposed to similarly brush on the return bus 20a which is always disposed radially inwardly of the bridge of the slider. The contact device is easily assembled into position in aperture 24i by a simple pressing operation, and the teeth or serrations provided on the base of the contact device between the two limbs engage the wall of the recess 24i and hold the device in position (FIGURE 9). As is evident from FIGURE 4, the contact 26e will brush along a helical path on element 22 as the rotor rotates, and the contact 26b will slide longitudinally along bus shank 20a', since the bus rotates with the rotor.

To cause the slider 24 to progress in either axial direction along the track provided by the V-ways, during rotation of rotor structure 20, the slider is formed with at least one, and preferably four, outwardly extending arcuate thread-like projections or ribs such as 24w, 24x, 24y and 24z (FIGURE 8), which ribs are dimensioned and disposed to slide between and be guided by, next-adjacent convolutions of the helical resistance element. Thus, preferably but not necessarily, the arcuate ribs and the body of the slider are formed to incline somewhat axially relative to the housing, that is, to conform to the helix formed by the resistance element. As is evident, the slider is either formed of insulative material or is insulated so that the ribs 24w, etc. and other portions thereof will not electrically contact the resistance element.

The preceding description of certain parts and details of construction make it evident that, following pressing of shaft 20s into rotor member 20g, the shank of return bus 20a' may be pressed lengthwise into the dovetail slot 20b, the contact device 26 pressed into I-shaped aperture 24i, and the slider 24 moved onto the V-ways of member 20g. Open end bell 18 may be pressed onto the end of the barrel which has previously been fitted with the resistance element 22 and terminals t1 and t2, and the outer

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end of shaft 20s run through the barrel and into and through the bushing 18b; care being taken when the slider initially makes contact with the inner end convolution of the resistance element, that the shaft and slider are rotated in the proper direction so that the guiding ribs or fins 24w, etc. of the slider are in effect screwed into the end of the screw-thread formation provided by the helical resistance element, and so that contact 26e rides onto the end of the resistance element without damage. The ring of terminal t3 is dropped into the complementary recess 16g in end bell 16, and tit 16' is swaged over the blade of the terminal as indicated in FIGURE 5, using a hot iron. With the shaft or rotor structure fully turned into the barrel, the gudgeon 16g of end bell 16 is started into the bore at the inner end of guide 20g, and the end bell is pressed into place on the end of the barrel. During the latter movement the ring of terminal t3 moves into electrical contact with the dual contacts provided at the ends of the limbs or tines of the portion 20'' of the return bus. As was previously indicated, an adhesive sealant, such as a self-curing synthetic resin, may if desired be used at the mating surfaces of the housing components, and is used at terminals t1 and t2, to seal the housing against passage of foreign material and to firmly anchor the terminals in place. Obviously such adhesive may alternatively be applied to a desired extent either during assembly, or thereafter. With the housing closed, a washer 20w and a retainer ring 20r are applied on shaft 20s as indicated in FIGURE 3, to complete assembly of the variable resistor. As is evident, no complicated operations are involved in assembly of the resistor, and with the possible exception of insertion of the resistance element into the barrel, the operations may easily be performed manually by an unskilled operator. Thereby the cost of producing the resistor is considerably reduced in comparison with that of prior art helical-element variable resistors.

The preceding description of a preferred exemplary physical embodiment of the invention and of a mode of assembling the components thereof demonstrates attainment of the aforestated objects of the invention. It also is evident that with the present disclosure of such exemplary embodiment in view, changes and modifications will occur to others, and accordingly I do not desire that the definition of the invention be restricted to the particular details illustrated and described, except as is required by the appended claims.

I claim:

1. A helical-element variable resistor comprising:

first means, including means providing a housing having an open-ended barrel-like central housing portion, and first and second end bells each providing a respective one of first and second ends of said housing, said barrel-like central housing portion and said end bells each having integral therewith a respective one of pairs of complementary interengaging snapping formations provided thereon one of which at each end of said housing comprises a groove and the other of which comprises a ridge mating with the grooves permitting direct endwise pressing of said end bells onto said housing portion and said formations serving to resiliently retain said end bells on said housing portion, and said housing portion and said end bells having at each end of said housing a set of complementary mating longitudinally-extending notch and key formations mutually effective to position the end bells and said body portion each relative to the others thereof and to prevent relative rotation therebetween, and said end bells comprising respective bearing means;

second means, including a plural-convolution helical resistance element disposed on the interior of said central housing portion about an axis extending longitudinally of said housing, and terminal means for respective ends of said resistance element;

third means, including rotary means journaled for rotation about said axis and supported by said bearing means, and a conductive electrical return bus included in said rotary means;

fourth means, including contact-carrier means and a contact device thereon, disposed between said rotary means and said resistance element and engaging said rotary means for rotation therewith about said axis and guided along a helical path adjacent said element, said contact device brushing on and electrically interconnecting said resistance element and said return bus; and

fifth means providing a terminal connection for said return bus;

whereby assembly of said variable resistor is facilitated.

2. A variable resistor according to claim 1, said rotary means comprising a shaft portion extending through one of said bearing means and out of one end of said housing, and said rotary means comprising an insulative rotor portion having a bore at one end thereof into which an inner deformed portion of said shaft is pressed to form a rigid integral rotary device, and said rotor portion being rotatably received at the other end thereof by the other of said bearing means.

3. A variable resistor according to claim 2, said rotor portion having a longitudinally-extending dovetail groove, and said return bus having a longitudinally extending shank of inverted-V cross section slidable into said dovetail groove to facilitate assembly of said bus with said rotor portion.

4. A variable resistor according to claim 3, said rotor portion having opposed V-ways and said contact-carrier having opposed shoulders complementary to and fitting said V-ways for longitudinal sliding motion therealong, said shoulders being separated by an arch portion of said rotor portion, and said arch portion being disposed to straddle said dovetail groove.

5. A variable resistor according to claim 4, said rotor portion having a longitudinally-extending dovetail groove, and said return bus having an elongate shank of V-shaped cross section longitudinally slidable in said dovetail groove, and said contact-carrier having an aperture in said arch portion and said contact device being press-fitted in said aperture and having first and second contacts in brushing contact with respective ones of said resistance element and said return bus.

6. In a helical-element variable resistor, in combination:

first means, including housing means including first and second bearing means the first of which is a gudgeon;

second means, including rotary means supported for rotation on said bearing means, said rotary means comprising an elongate insulative rotor portion having an elongate axial bore therein and rotatably supported at a first end of said bore by said gudgeon and said rotary means comprising a metal shaft portion having a deformed inner end portion press-fitted into the said bore for a substantial portion of the length thereof to unite said insulative rotor portion and said shaft portion into a rigid unitary rotor with the shaft portion in rigid driving relation to the insulative rotor portion and said shaft portion being rotationally supported by the second of said bearing means;

third means, comprising resistance element means including terminals, supported by said housing means; and

fourth means, including operating means driven by said rotary means and including a slider supported on said rotor portion and having a contact in brushing contact with said resistance element, and including terminal connections to said contact, whereby the cost of said rotary means is considerably less than a shaft of equal length, without sacrifice of precision

in the relationship of said second means relative to said first means.

7. In a helical-element variable resistor, the combination comprising:

first means, including housing means and a helical resistance element and terminals therefor supported by the housing means, said housing means comprising a cylindrical open-ended barrel and housing end-bells with cooperative snap-action formations thereon permitting simple press assembly, and electrical return terminal means mounted on a said housing end-bell and presenting an arcuate contact area at one end of the interior of said housing means; and second means, including a rotor structure supported for rotation by said housing means, said second means including means including a contact device driven along and in electrical contact with said resistance element incident to rotation of the rotor structure, said rotor structure comprising a longitudinal slot having an interior width greater than the width at the mouth thereof, and said second means including an elongate electrical return bus of inverted-V cross-section and of conductive material disposed in said slot and with the longitudinal edge portions pressing laterally against the walls of the slot and constrained by said walls against lateral movement relative to said rotor structure, said return bus having brushing electrical connection with said return terminal means at said one end of the interior of the housing means, said contact device having respective portions in electrical brushing contact with said resistance element and said electrical return bus;

whereby assembly of said bus on said rotor structure and assembly of said variable resistor are facilitated.

8. A variable resistor comprising: a resistance element arranged with a plurality of convolutions in the form of a helix about an axis; a housing comprising a barrel to the interior of which barrel the resistance element is secured, and the housing further comprising first and second ends providing respective bearing means defining said axis, said resistor further comprising rotary operating means including a rotor structure journaled for rotational support on the said bearings and the rotor structure slidably supporting a contact-device-carrying slider the contact device of which brushes on the said resistance element incident to rotation of the rotor structure, the rotor structure having an elongate dovetail slot therein and an elongate electrical return bus of V-shaped cross-section held captive in said slot in electrical contact with the slider contact device, and the said resistor further comprising terminal connections to the said resistance element and a terminal connection to the electrical return bus, said resistor being characterized by the said barrel and at least said first end of the housing being resilient and each thereof having integral therewith one of complementary male and female snap-action formations thereon permitting simple pressing of the end onto the barrel and providing secure attachment of the end to the barrel, whereby assembly of the variable resistor is greatly facilitated and the cost thereof reduced.

9. A variable resistor according to claim 8, characterized by said both ends of said housing and both ends of said barrel having respective complementary snap-action formations whereby said ends may be assembled to said barrel by simple oppositely-directed pressing operations.

10. A variable resistor comprising: a helical resistance element, a generally cylindrical housing with first and second ends providing axially aligned bearings and having said helical resistance element disposed therein in co-axial relationship with said bearings;

rotary means including a rotor structure rotationally supported by said bearings, and an electrical return

bus on said rotor structure parallel to said axis, said rotary means including a slider device including an insulative slider longitudinally slidable on said rotor structure and engaged therewith for rotation thereby and engaged with said resistant element to be turned therealong, said slider having a shaped radial aperture of I-shaped cross-section therethrough, and a conductive contact device having a central portion thereof press-fitted in one end of said aperture and thereby secured to said slider and said contact device having an outer flexible limb in brushing contact with said resistance element and an inner flexible limb in sliding contact with said return bus, and respective terminal connections to said electrical return bus and to electrical ends of said resistance element.

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RICHARD M. WOOD, *Primary Examiner.*

J. G. SMITH, *Assistant Examiner.*

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,314,036

April 11, 1967

Harold L. Kruse

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

Column 1, lines 23 and 24, for "2,539,557" read --
2,539,575 --; column 3, line 21, for "vairable" read --
variable --; column 6, line 19, for "portion 20'" read --
portion 20a'" --; column 9, line 5, for "resistant" read --
resistance --.

Signed and sealed this 14th day of November 1967.

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents