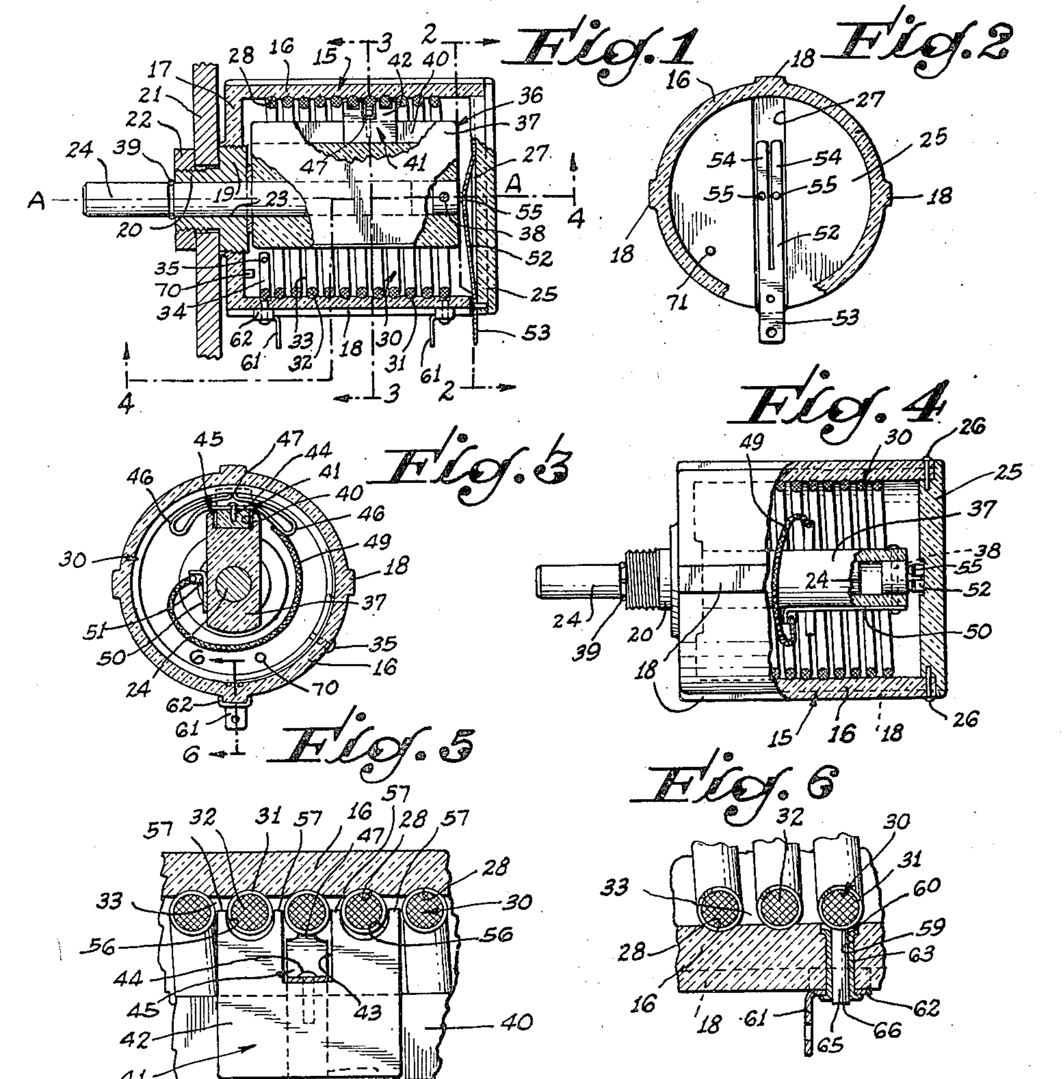
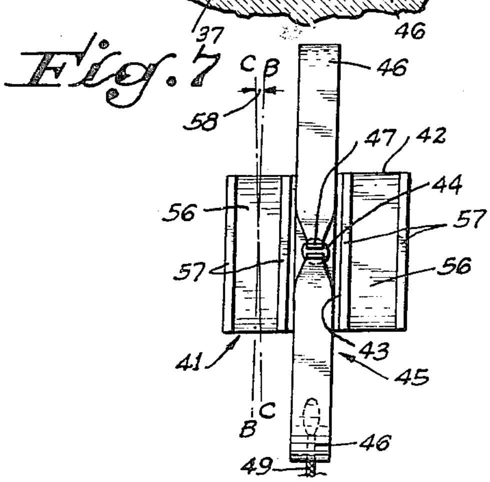
VARIABLE RESISTANCE DEVICE

Filed Oct. 22, 1945 2 Sheets-Sheet 1





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Filed Oct. 22, 1945 2 Sheets-Sheet 2

Fig. 8

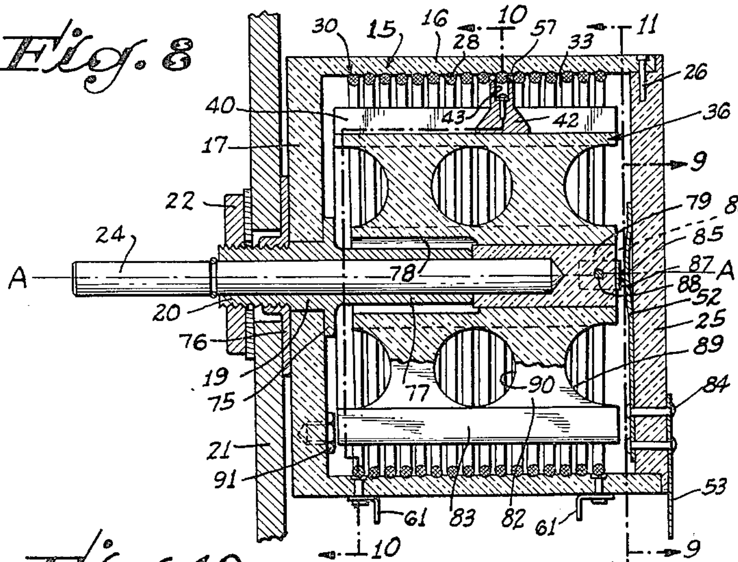


Fig. 9

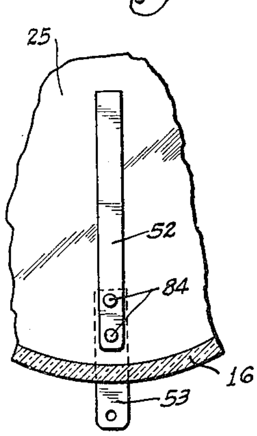


Fig. 10

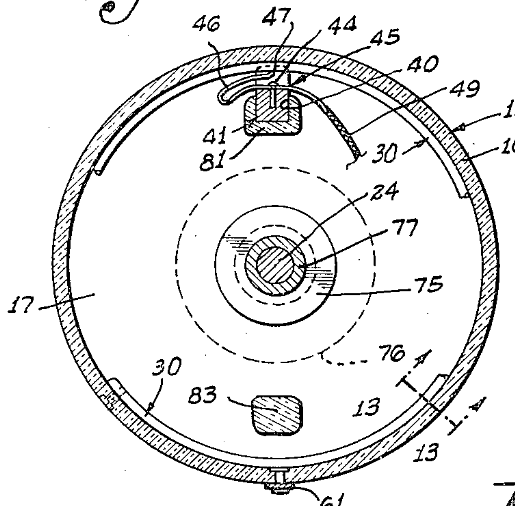


Fig. 11

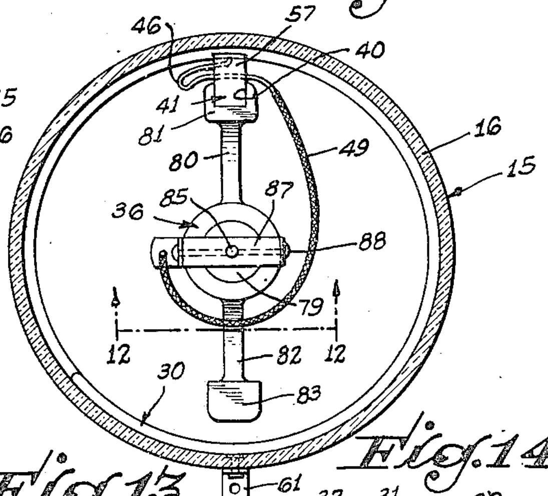


Fig. 12

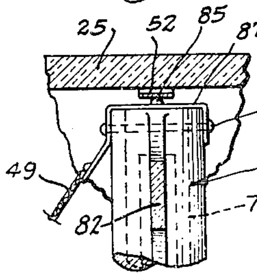


Fig. 13

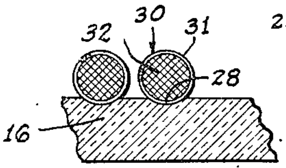
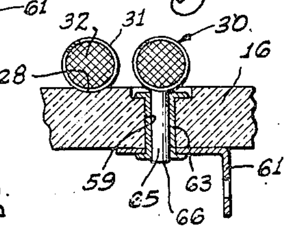


Fig. 14



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UNITED STATES PATENT OFFICE

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VARIABLE RESISTANCE DEVICE

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23 Claims. (Cl. 201—56)

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My invention relates in general to variable resistances for electrical circuits and, more particularly, to a low-torque precision device for adjustably varying the electrical resistance of a circuit. The invention will be illustrated as a variable resistor or potentiometer.

The invention is particularly applicable to variable resistors having a spirally wound resistance element, and is an improvement on the device shown in the patent to Henry H. Cary et al., No. 2,361,010. In the present specification and claims, as in the aforesaid patent, the words "spiral" or "spirally wound" conductor or resistance element are employed in the commonly used sense as including multi-turn configurations whether strictly helical or spiral in the true geometric sense, or whether of some other configuration in which progressive turns of the conductor or resistance element are disposed in a geometric pattern. The term "variable resistor" has reference to a variable resistance, potentiometer, or the like.

Variable resistors of the type herein disclosed usually include a control shaft which is turned through a plurality of revolutions to effect maximum adjustment. In many instances, precise installations require that the turning torque of the shaft be extremely low, e. g., in the neighborhood of 1–2 inch ounces, particularly when the device is remotely controlled by connection to small Selsyn motors or other drive means capable of producing only low torques. Also, such precise installations often require extreme accuracy in the sense that the change in resistance per degree of shaft rotation shall be linear throughout the complete range. Thus, if shaft rotation is plotted against change in resistance, it is often desirable that the resulting curve be linear within about .01–.05%.

It is an object of the present invention to provide such a device which requires extremely low torque for operation; also, to provide a device of this character which is highly accurate in the sense that the resistance per unit length of the conductor or resistance element is very uniform and the change in resistance per degree of shaft rotation is substantially linear.

It is a further object of the invention to provide a novel movable contact which slides along a resistance element, and to provide a novel mounting for such movable contact, the mounting being associated with the resistance element to be guided thereby in a manner to advance the contact therealong in a precise manner. A further object is to provide novel guide means for such a mounting and, in the preferred embodiment, to

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dispose this guide means so that it extends substantially parallel to the turns of a spirally wound resistance element. A further object is to provide a mounting having at least one guide element extensible into a space provided between turns of a spirally disposed resistance element.

Further objects of the invention lie in the provision of a novel arrangement of a resistance element near its ends to permit the movable contact to move to a position near, at, or beyond the end of such resistance element, while still being guided in a path substantially conforming to the shape of the resistance element.

Still a further object of the invention is to provide a novel terminal means whereby electrical connections can be made to the ends of an electrically conductive element, such as the aforesaid resistance element, or to intermediate portions thereof to form taps therefor. Another object of the invention is to provide such a terminal means which acts as a support for the end or some other portion of an electrically conductive element.

A further object is to provide a novel method and apparatus for mounting a helical resistance element in a housing to be accurately concentric with an axis about which the control shaft turns. Any lack of such concentricity interferes with the linearity of the device. The present invention includes among its objects the use of a housing having a substantially cylindrical side wall, this housing being typically formed of phenol formaldehyde or other molded plastic, and a novel method of mounting a helical resistance element therein so that any deviation of the wall of the housing from cylindrical shape is not imparted to the resistance element.

Further objects lie in the provision of a variable resistance unit which is relatively simple and inexpensive to manufacture and which is structurally durable during operating conditions.

Further objects and advantages of the invention will be evident hereinafter from the description of two exemplary embodiments.

In the drawings, which are to be considered as illustrative only:

Fig. 1 is a longitudinal section through one embodiment of my invention;

Fig. 2 is a sectional view, taken as indicated by the line **2—2** of Fig. 1;

Fig. 3 is a sectional view of the device, taken as indicated by the line **3—3** of Fig. 1;

Fig. 4 is a view, partially in elevation and partially in section, taken as indicated by the line **4—4** of Fig. 1;

Fig. 5 is a fragmentary and enlarged view of the contact element and a portion of the winding shown in Figs. 1 and 3;

Fig. 6 is a fragmentary and enlarged view of a terminal contact, taken as indicated by the line 6—6 of Fig. 3;

Fig. 7 is a view of the contact assembly, taken in the direction of the arrow 7 of Fig. 5;

Fig. 8 is a longitudinal section through a second embodiment of my invention;

Fig. 9 is a fragmentary sectional view, taken as indicated by the line 9—9 of Fig. 8;

Fig. 10 is a transverse sectional view, taken as indicated by the broken line 10—10 of Fig. 8;

Fig. 11 is a transverse sectional view, taken as indicated by the line 11—11 of Fig. 8;

Fig. 12 is a fragmentary enlarged view of a portion of the end contact element of the device, taken along the line 12—12 of Fig. 11;

Fig. 13 is a fragmentary enlarged view of a portion of the conductor winding, taken as indicated by the line 13—13 of Fig. 10; and

Fig. 14 is a fragmentary enlarged view of a portion of the conductor winding as engaged by the terminal contact.

Referring particularly to Figs. 1 to 6, inclusive, the illustrated embodiment of the invention includes a housing 15, shown as including a cylindrical portion 16 closed by an end wall 17. These portions of the housing 15 are formed of insulating material, the housing being preferably molded of phenol formaldehyde or other plastic material. During the molding operation, longitudinal reinforcing ribs 18 are formed and, in this embodiment of the invention, the radial flange of a tubular member 19 is molded in place. This tubular member provides an externally-threaded neck 20 which may traverse an opening in a panel 21 to receive a nut 22 holding the device in position. The tubular member 19 provides an opening 23 journalling a control shaft 24 which rotates about an axis A—A substantially at the center of the cylindrical portion 16.

The housing 15 is closed by a removable cover 25 secured in place by any suitable means, such as pins 26, the inner face of this cover being provided with a transverse groove 27.

The inner surface of the cylindrical portion 16 provides a shallow spiral groove 28, best shown in Figs. 5 and 6, into which is expanded an electrically conductive element, exemplified as a resistance element and indicated generally by the numeral 30. This resistance element is preferably of the wound type. In the preferred construction, a small-diameter resistance wire 31 is wound helically around a larger-diameter core 32 to form what are hereinafter termed minor spiral turns. Thereafter, the core 32 with its minor spiral turns is bent into a spiral configuration, here illustrated as a helix, to form what are hereinafter termed major spiral turns adapted to extend into the shallow spiral groove 28. In the preferred construction, the turns of the spiral groove 28 are sufficiently spaced to separate the major spiral turns from each other to provide a spiral space 33 therebetween. Similarly, in the preferred construction, the minor turns of the resistance wire 31 are space-wound on the core 32. This resistance wire is preferably a bare or uncoated wire. If the core 32 is formed of non-conductive material, the resistance wire can be wound directly thereon. In the preferred construction, however, the core 32 is formed of a conducting material provided with a thin coating of insulating material separating the minor turns of the resistance wire 31 from the core. The resistance wire 31 is wound on the core in such manner that the electrical resistance of the resistance element 30 is substantially constant per unit of length of this resistance element.

It should be understood, however, that the invention is not limited to space-winding of the major and minor turns. In other instances, the type of winding suggested in the Cary et al. patent, supra, can be employed, in which event an insulation-coated resistance wire 31 can be wound around the core 32, the insulation separating the minor turns from each other and from the core and separating the major turns from each other. As pointed out in the patent, supra, the insulation can be removed from the resistance wire 31 in a zone to be engaged by a movable contact. If the major turns are electrically separated only by two engaging coatings of the insulating material surrounding the resistance wire 31, the space 33 will be somewhat smaller and will not extend completely to the midsectional plane of the core 32, the space 33 then being a V-like space bounded by surfaces of the coating of insulating material which converge into contact with each other.

In the preferred embodiment, the minor turns stop short of the ends of the core 32 to leave an exposed core portion 34 at each end, one of these core portions being shown in Fig. 1. The preferred method of inserting the resistance element 30 in the housing 15 is as follows. The innermost exposed core portion 34 is first secured in the shallow groove 28 as by passing a small pin or rivet 35 therethrough, as suggested in Figs. 1 and 3. The spiral resistance element 30 is then unwound or permitted to unwind to expand the diameter of the major turns to fit snugly in the shallow groove 28. This insures that the resistance element 30 will be retained in a configuration determined by the shallow groove 28. At this time the other exposed end portion 34 is secured in place, as by passing another of the pins or rivets 35 through the housing 15 or by other means.

If the change in electrical resistance is to be a linear function of shaft rotation, the resistance element 30, if of the disclosed helical configuration, must have all of its major turns concentric with the axis A—A about which the shaft 24 rotates. In using a molded housing 15, some difficulty has been experienced through inherent warping of the housing after it is molded. If this warpage makes the cylindrical portion 16 slightly elliptical in cross section or if the warpage displaces the cylindrical portion 16 from a truly concentric relationship with the axis A—A, the device will not be strictly linear and may not be within the small tolerances previously mentioned. For this reason I prefer to mold the housing 15 without the shallow groove 28 being formed during the molding operation. Instead, this shallow groove is later cut in the housing, as by mounting the neck 20 of the tubular member 19 in a collet or drill chuck in a lathe so that the collet or drill chuck axis coincides with the axis A—A. The shallow groove 28 is then machined so that its bottom wall is exactly concentric with the axis A—A which centrally traverses the opening 23 of the tubular member 19.

Disposed in the housing 15 to turn with the shaft 24 is a rotor, indicated generally by the numeral 36. This rotor includes a block of insulating material, hereinafter termed a carrier, 37, typically formed of a laminated phenolic resin and drilled off center in the embodiment illustrated, to receive the shaft 24 with a press fit. The shaft 24 extends only partially through the drilled opening of the carrier **37** and stops short of a metallic contact button or plug **38** which is pressed into the forward end of the opening for a purpose to be later described. A washer is usually disposed between the inner end of the rotor **36** and the tubular member **19**, and the rotor and shaft **24** are kept from large longitudinal movement by disposing a spring clip **39** in an annular groove of the shaft adjacent the end of the neck **30**.

The carrier **37** at its outer extremity provides a longitudinal channel **40** traversing the major turns of the resistance element **30**, this channel extending parallel to the axis A—A. Freely slidable along this channel is a contact assembly **41**, constructed as best shown in Figs. 1, 3, 5, and 7. This contact assembly includes a contact-guide member or sliding element **42** comprising a block of insulating material of a thickness to slide freely in the channel **40** and of sufficient length, measured longitudinally of the axis A—A, to prevent tipping.

The sliding element **42** provides a central transverse groove **43** of substantial depth but with its bottom wall terminating beyond the outermost edge of the carrier **37**, as best shown in Figs. 1 and 5. Secured to this bottom wall, as by a pin **44**, is the movable contact means of the invention, shown as comprising a resilient contact element, indicated generally by the numeral **45**, formed of a strip of spring bronze or the like bent into the configuration shown in Fig. 3. Each laterally-extending portion of this strip is bent to form a loop **46** of substantial length with its free end terminating radially beyond the pin **44** and being tipped with a suitable wear-resistant, low-resistance material such as a cobalt-tungsten or cobalt, chromium alloy, for example, "Stellite," or other hard, long-wearing material having relatively good electrical conductivity, to form a dual contact means comprising dual contacts **47** which simultaneously engage the same minor turn or closely adjacent minor turns and which move together and progressively across and in contact with the minor turns as the rotor **36** is turned. The resiliency in the loops **46** is sufficient to maintain good electrical contact between the contacts **47** and the resistance element **30**. However, should there be any momentary separation of either contact **47** from the resistance element, due to an intervening dirt or dust particle, the other contact **47** retains the circuit. This effectively eliminates those minor resistance variations known as "noise" and which are sometimes apparent in oscilloscope or radar uses of variable resistors. In addition, this dual-contact structure increases the life of the unit. In some instances, however, it is satisfactory to use a single loop **46** and a single contact **47**, as suggested in Fig. 10. In either construction the contact zone is opposite the groove **43** or the pin **44**, a very desirable feature, as it prevents any force applied to the contact assembly **41** in a direction tending to turn, twist, or rock it in the channel **40**, thus eliminating any binding tendency otherwise present. The sliding element **42** is quite small and of very small weight, and its inner surface is held lightly in resilient contact with the bottom of the channel **40** by the spring action of the loops **46**.

To one of the loops **46** of the aforesaid strip is connected a flexible or pigtail lead **49** partially encircling the carrier **37** and joined to a contact strip **50** secured to one side of the carrier and held in place by a rivet **51** traversing and electrically connected to the contact button or plug **38**. This contact button or plug **38** rotates with the shaft **24** although electrically insulated therefrom by the carrier **37**. It is shown as engaged by a bowed spring contact **52** which extends in the groove **27** of the cover **25** and provides a terminal tab **53** extending from the housing **15**. This spring contact **52** is preferably bifurcated to provide bowed arms **54** on opposite sides of the axis A—A, the crest of each arm carrying a contact button **55** which is urged resiliently into engagement with the contact button **38**. As the shaft **24** turns, the contact buttons **55** engage the contact button **38** in an annular zone and insure good electrical contact.

While various means can be employed for conducting current to and from the movable contact means from a stationary position, usually outside the housing **15**, the aforesaid structure is preferred. The pigtail lead **49** offers substantially no impedance to the free movement of the sliding element **42** along the channel **40** throughout its length, nor does it tend to twist the sliding element in the channel and cause binding therein.

It is desirable that the spiral resistance element **30** serve as a track to guide the movement of the sliding element **42** along the channel **40** in such way that each dual contact **47** follows the major convolutions of the resistance element while sliding from one minor turn to the next during this advancement. The invention comprehends a means for accomplishing this result which requires a very low torque applied to the shaft **24**, yet which guides the sliding element in a positive manner to maintain the dual contacts **47** in proper relationship to the major turns of the resistance element **30**.

One structure for accomplishing this is best shown in Figs. 5 and 7 as including two grooves **56** on opposite sides of the central groove **43** to provide four guide elements **57**, respectively extending into four of the spiral spaces **33**. A lesser number of guide elements **57** can be employed, as later exemplified. If the major turns of the resistance element **30** are space-wound in a manner suggested in Fig. 5, the guide elements **57** may extend to or beyond the midsection of the core **32**, but, if the major turns are closer together, these guide elements will stop short of the midsection of the core. In either instance, the preferred structure contemplates that the guide element shall not wedge between the adjacent major turns of the resistance element, i. e., that there shall be some small amount of play longitudinally of the channel **40** between any of the guide elements **57** and the adjacent turns on opposite sides thereof. Preferably, the width of each guide element is made sufficiently small to accomplish this, thereby preventing any binding or undue friction by having any particular guide element **57** contact only one of the two adjacent turns at any particular time. Such a relationship aids very substantially in producing a low-torque device as it prevents any wedging action such as is present with the wheel of the aforesaid patent, which wheel is urged resiliently outward and tends to wedge between the adjacent turns to increase the torque required for turning the shaft **24**.

The preferred embodiment of the invention also contemplates that the guide elements **57** shall parallel the major turns of the spiral resistance element **30**. In the helical-type instrument shown, it is desirable that each groove **56** be cut in the sliding element **42** at an angle, other than a right angle, relative to the transverse axis of the channel 40, this angle being equal to the helix angle of the resistance element 30. As shown accentuated in Fig. 7, the axis B—B is the axis of one of the grooves 56, while a line C—C is transverse to the channel 40. The angle therebetween, indicated by the numeral 58, should be substantially equal to the helix angle of the resistance element, which typically is in the neighborhood of about 1°, more or less, thus disposing the guide element parallel to the major turns of the resistance element 30.

Means should be provided for electrically connecting some fixed portion of the resistance element 30 to an external circuit. The invention comprehends a novel terminal means in this connection, exemplified best in Figs. 1 and 6 as providing electrical connection with the resistance wire 31 near its ends, e. g., near the position where this resistance wire stops to leave the exposed core portion 34. Alternatively, the terminal means to be described can be employed for tapping the resistance element 30 at any position along its length or it can be employed to make electrical connection to an electrically conductive element, irrespective of its configuration.

As exemplified in Fig. 6, an opening 59 is drilled or otherwise formed through the cylindrical portion 16, desirably, though not necessarily, through one of the ribs 18. This opening 59 is internally counterbored, as indicated at 60. A terminal 61 is preferably employed, having a U-shaped base section 62 straddling the adjacent rib 18 and providing an opening of substantially the same diameter as the opening 59. Through these openings is extended a tubular member formed of electrically conductive material and exemplified as a hollow rivet 63, this being done before the resistance element 30 is in place. One end of this hollow rivet flares outward in the counterbore 60 and the other end flares outward beyond the terminal 61 to hold this terminal in its straddling position. Actual electrical contact between the hollow rivet 63 or the terminal 61 and the wire 31 of the resistance element 30 is made by inserting a pin 65, preferably formed of copper, and tinned on all surfaces. The inner surface of the hollow rivet may be tinned or uncoated and, in the former instance, the periphery of the pin 65 need not be tinned. This pin provides an end 66 contactable by a heated soldering iron or other heating element which applies sufficient heat to solder the pin in the hollow rivet and to solder the inner end of the pin 65 to the immediately adjacent turns of the resistance wire 31. This insures good electrical contact between the resistance wire and the terminal 61. The soldered connection also retains the end turn of the resistance element 30 in definitely fixed position and prevents any unwinding or loosening of the minor turns of the resistance wire 31 from the core 32.

It is desirable to provide suitable stop means for limiting the movement of the contacts 47 along the resistance element 30 and to limit the rotation of the shaft 24. For this purpose a stop member 70 is molded or otherwise secured to the end wall 17 of the housing to be in the locus of movement of the sliding element 42 when the contact 47 nears the end of the last turn of the resistance element 30. Engagement will be effected only when the sliding element 42 advances along the channel 40 to contact the stop member 70. A similar stop member 71, shown in Fig. 2, is molded integral with or otherwise attached to the cover 25. The stop members may be positioned to stop the contacts 47 before or when they engage the resistance wire 31 immediately opposite the pin 65 of the terminal means. Alternatively, the contacts 47 or either of them can be stopped after movement beyond this position, either in or out of engagement with the resistance wire. The exposed core portion 34 continues the spiral space 33 to receive the guide elements 57, wherefore the contacts 47 are properly guided to or beyond the end of the resistance wire 31 or the terminal means.

The embodiment of the invention shown in Figs. 8 to 14 is particularly desirable when larger-diameter units are desired. Essentially, most of the elements of the device are similar to those illustrated in the embodiment of Figs. 1 to 7 and need not be particularly described. Variations from the previous structure are as follows.

In the embodiment of Fig. 8, the tubular member 19 is not molded in place but provides an inner flange 75 and an outer threaded flange 76 which clamp against the end wall 17 of the housing. The outer flange 76 is threaded on the externally-threaded neck 20 and may engage the inner surface of the panel 21, the device being held in place by tightening the nut 22, previously mentioned. In this embodiment of the invention, as before, the shallow groove 28 is preferably cut after the housing has been molded. This can be accomplished by appropriately mounting the housing in a lathe to cut the shallow groove 28 concentric with the central axis A—A of the housing, which is also the central axis of the shaft 24.

The rotor construction differs somewhat in Fig. 8. With the larger-sized units, it is desirable to extend the tubular member 19 a substantial distance into the interior of the housing to form a sleeve 77 providing an extended journal for the shaft 24. The rotor 36 provides a cavity 78 receiving this sleeve and carries a member 79 in which the end of the shaft 24 extends as a press fit. The rotor itself may be formed of metal and, and this embodiment, provides an arm 80 supporting a carrier 81 having the longitudinal channel 40 previously mentioned and along which the contact assembly 41 slides. A similar arm 82 carries a counterbalancing weight 83 to balance the rotor.

In the embodiment of Figs. 8 to 14, the arrangement for connecting the terminal tab 53 to the contact 47 differs slightly. Here, the terminal tab 53 is mounted on the exterior of the cover 25, and rivets 84 form a good electrical connection to the spring contact 52 which, in this embodiment, need not be disposed in a groove of the cover. This spring contact 52 is not bifurcated, but its crest resiliently engages a contact 85 carried by a U-shaped member 87 straddling the end of the rotor and held in place by a rivet 88. The previously-mentioned pigtail lead 49 is connected to this U-shaped member and extends through either a notch 89 or an opening 90 of the rotor 36 to connect with the contact assembly 41. Such a pigtail lead may be of the insulated type to prevent engagement with the main portion of the rotor if formed of metal, although such contact is not detrimental except in very sensitive circuits as the main portion of the rotor is not directly connected in any electric circuit. In this connection, it should be understood that the sliding element 42 is formed of insulating material, as previously described.

The contact assembly 41 is similar to that previously described except that it provides a diverging base for greater stability and the contact element 45 provides a single loop 46 and a single contact 47, the pigtail lead 49 being connected to an extension of the contact element 45. However, the sliding element 42 in this embodiment is cut away to provide only two of the guide elements 57, respectively positioned on opposite sides of the central transverse groove 43. As before, the guide elements 57 extend freely and without wedging into the spiral space 33 to guide the sliding element 42 and its contact 47 along the major turns of the resistance element 30.

The terminal connections in this embodiment are similar to those previously described. However, the stop means comprises a headed screw 91 threaded into the end wall 17 at a position to be engaged by the sliding element 42 during advancement of the contact 47 along the last turn of the resistance element 30. A similar headed screw, not shown, is threaded into the cover 25 to form the other stop means.

In practice, variable resistors of the type herein disclosed have been made which deviate from strict linearity only 0.01%, the torque requirements on a unit 1½" diameter being about 1 inch-ounce and on a unit of 3" diameter only about 2.5 inch-ounces. One of the features of the invention is that slight variations in the rotor construction do not affect the linearity of the device. In addition, the device provides a relatively rigid rotor and controls the radial position of the guide elements 57 so that they do not wedge between the major turns. At the same time, the contact assembly 41 is guided to move in a spiral path corresponding to the configuration of the resistance elements 30, and there is no danger of the guide elements 57 slipping over any one of the major turns. In addition, the contact pressure between one or more contacts 47 and the resistance element 30 is maintained sufficient to insure good electrical conductivity.

Various changes and modifications can be made without departing from the spirit of the invention as defined in the appended claims.

I claim as my invention:

1. In a variable resistor, the combination of: a resistance element providing a plurality of turns extending around an axis, there being a space between adjacent turns of the same configuration as said resistance element; a contact assembly including a guide element of a size to extend loosely into said space when said contact assembly is at a given distance from said turns, said contact assembly providing a contact spaced from said guide element and retained in contact with one of said turns by said guide element as said contact assembly moves along said resistance element; a rotor journalled to turn about said axis; and means for mounting said contact assembly to move along said rotor at said given distance from said turns to retain said guide element loosely in said space while advancing said contact along said resistance element.

2. In a variable resistor, the combination of: a resistance element providing a plurality of turns extending around an axis, there being an open-sided space between and bounded by adjacent turns of the same configuration as said resistance element; a contact assembly including a sliding element, a contact means carried thereby, and a guide element projecting therefrom into the open side of said space to retain said contact means in engagement with one of said turns, the thickness of said guide element being less than the width of said space to permit slight movement of said guide element along said guide member in moving from engagement with one of said adjacent turns into engagement with the other of said adjacent turns; a rotor journalled to turn about said axis; and means for mounting said contact assembly to move along said rotor at a fixed distance from said turns to retain said guide element in said space while advancing said contact means along said resistance element.

3. In a variable resistor, the combination of: a resistance element providing a plurality of turns extending around an axis, there being a space between adjacent turns of the same configuration as said resistance element; a contact assembly including a sliding element, a contact means carried thereby, and a guide element projecting therefrom into said space to retain said contact means in engagement with one of said turns, said contact means including two contacts simultaneously engaging said resistance element at closely adjacent positions spaced slightly from each other in the direction of said resistance element to engage the resistance element at closely adjacent positions; a rotor journalled to turn about said axis; and means for mounting said contact assembly to move along said rotor with said guide element extending into said space to advance said contact means along said resistance element.

4. A resistor as defined in claim 3, in which said contact means includes two looped resilient members respectively carrying said two contacts which simultaneously engage the resistance element at said closely adjacent positions.

5. In a variable resistor, the combination of: a resistance element providing a plurality of turns extending around an axis, there being a space between adjacent turns of the same configuration as said resistance element; a contact assembly including a sliding element, a contact carried thereby, and a guide element projecting therefrom into said space to retain said contact in engagement with one of said turns, the length of said guide element measured along said turns being substantially greater than the thickness of this guide element, said guide element being angled with respect to said axis to dispose the longitudinal plane of said guide element substantially parallel to said turns of said resistance element; a rotor journalled to turn about said axis; and means for mounting said contact assembly to move along said rotor at a fixed distance from said turns to retain said guide element in said space while advancing said contact along said resistance element.

6. In a variable resistor, the combination of: a resistance element providing a plurality of turns extending around an exis, there being a space between adjacent turns of the same configuration as said resistance element; a rotor journalled to turn about said axis providing a channel traversing said turns; a sliding element slidable along said channel; a contact carried by said sliding element and engaging a turn of said resistance element; and means for advancing said sliding element along said channel to advance said contact along said resistance element, said means including a guide element extending into said space to follow the convolutions of said resistance element.

7. A combination as defined in claim 6, in which said sliding element comprises a block of insulating material providing an extension forming said guide element.

8. A combination as defined in claim 6, in which

said guide element is disposed at an angle with respect to said channel, said angle being other than a right angle and being such as to dispose said guide element substantially parallel to said turns.

9. In a variable resistor, the combination of: a resistance element disposed helically about an axis to provide a plurality of turns, there being a helical space between and bounded by the sides of adjacent turns; a rotor journalled to turn about said axis of said helix; a contact assembly including a guide element disposed in a plane which is angled with respect to a plane perpendicular to said axis, the angle between said planes being equal to the helix angle of said resistance element, said guide element extending into said space; a contact carried by said contact assembly and spaced from said guide element; and means for mounting said contact assembly to move along said rotor in a direction substantially parallel to said axis, said guide element following said helical space as said rotor is turned about said axis to advance said contact assembly along said rotor and maintaining said contact in engagement with said resistance element.

10. In a variable resistor, the combination of: a resistance element disposed helically about an axis to provide a plurality of turns, there being a helical space provided by adjacent turns and bounded by the sides thereof; a rotor journalled to turn about said axis; a contact assembly including a contact and including a guide element extending into said space; and means for mounting said contact assembly to move along said rotor at a substantially fixed distance from said turns to maintain said guide element in said helical space and advance said contact assembly along said rotor as said rotor is turned while guiding said contact to move along said resistance element, said guide element being of such size and extending into said helical space to such limited extent as to permit slight movement of said contact assembly along said rotor to engage said guide means with the sides of the adjacent turns.

11. A combination as defined in claim 10, in which the adjacent turns of said resistance element are separated from each other whereby said helical space extends outwardly to the midsection of adjacent turns, said guide element extending substantially to said midsection.

12. A combination as defined in claim 10, in which each of said turns is substantially circular in cross section, adjacent turns being close to each other whereby said helical space is substantially V-shaped in cross section, said guide means extending into said space an insufficient distance to contact the sides of each of the adjacent turns at the same time.

13. In a variable resistor, the combination of: a housing providing a cylindrical portion; a helical resistance element mounted within said cylindrical portion and disposed helically about the central axis of said cylindrical portion to provide a plurality of turns substantially equally spaced from said axis, there being a helical space between and bounded by the sides of adjacent turns; a shaft journalled to rotate about said axis; a carrier mounted on said shaft and providing a guide means extending across said turns substantially parallel to said axis; a contact assembly movable along said guide means and providing a guide element extending into said helical space and a contact spaced from said guide element and retained in contact with one of said turns by said guide element as said contact assembly moves along said resistance element; a rotary contact member mounted on said carrier to turn therewith; a stationary contact member resiliently engaging said rotary contact member; and means for connecting said contact to said rotary contact member, said means including a flexible conductor partially surrounding said carrier and providing one end connected to said contact to move therewith.

14. A combination as defined in claim 13, in which said contact assembly comprises a block of insulating material having a projection forming said guide element, said contact being connected to said block of insulating material.

15. In a variable resistor, the combination of: a resistance element providing a plurality of turns disposed around an axis, there being a space between adjacent turns of the same configuration as said resistance element; a rotor journalled to turn about said axis; a sliding element movable along said rotor in a direction traversing said turns, said sliding element including a groove and two guide elements respectively on opposite sides of said groove and extending into said space a sufficient distance to advance said sliding element relative to said rotor as said rotor is turned about said axis; and a resilient contact element disposed in said groove and providing a contact slidable along said resistance element in contact with a turn thereof as guided by said guide elements.

16. A combination as defined in claim 15, in which said resilient contact element includes a looped portion, at least a portion of said looped portion being disposed outside said groove, one end of said looped portion being secured to said sliding element and the other end carrying said contact and urging same resiliently into engagement with said resistance element.

17. A combination as defined in claim 15, in which said rotor provides a groove traversing said turns and slidably receiving said sliding element, and in which said resilient contact element includes a looped portion, at least a portion of said looped portion being disposed outside said groove, one end of said looped portion being secured to said sliding element and the other end carrying said contact and urging same resiliently into engagement with said resistance element, the tension in said resilient contact element being sufficient to retain said sliding element in said groove of said rotor.

18. In combination: a housing providing a wall; an electrically conductive element within said housing adjacent said wall, said wall providing an opening opposite said electrically conductive element; a tubular member formed of electrically conductive material and disposed in said opening; and a pin formed of electrically conductive material disposed in said tubular member in electrical engagement therewith, said pin providing an inner end in electrical engagement with said electrically conductive element.

19. In combination: a housing providing a wall formed of electrical insulating material, said wall providing an opening; an electrically conductive element adjacent one end of said opening; a tubular member formed of electrically conductive material and disposed in said opening; a terminal at the other end of said opening and electrically connected to said tubular member; and a pin formed of electrically conductive material disposed in said tubular member in electrical engagement therewith, said pin providing an inner

end in electrical engagement with said electrically conductive element.

20. A combination as defined in claim 18, in which said tubular member comprises an inner end spaced from said electrically conductive element, and in which said pin projects beyond said inner end of said tubular member to engage said electrically conductive element.

21. In combination: a housing providing a wall formed of electrical insulating material, said wall providing an opening; an electrically conductive element adjacent one end of said opening; a tubular member formed of electrically conductive material and disposed in said opening; and a pin slidable into said opening and providing a peripheral surface closely adjacent the internal surface of said tubular member and providing an inner end engageable with said electrically conductive element and an outer end terminating adjacent the outer end of said tubular member to be contactable by a heating element, one of said surfaces being tinned and said inner end of said pin being tinned whereby contacting said heating element with said outer end of said pin will supply heat to said pin sufficient to solder same in said tubular member and to said electrically conductive element.

22. In a variable resistor, the combination of: a resistance element providing at least one turn disposed around an axis and comprising a core and a resistance wire wound substantially helically therearound to form minor turns, said core having an end and the last minor turn of said resistance wire terminating short of said end to form an exposed core portion; a rotor journalled to turn about said axis; and a contact assembly providing guide means engageable with said resistance element and also with said core portion when said rotor is turned to an extreme position, said contact assembly including a contact mounted thereon and engaging said resistance element and being guided to move therealong by said guide means, at least a portion of said guide means being movable opposite said exposed core portion to guide said contact substantially to the last minor turn of said resistance wire.

23. A method for mounting a multi-turn helical resistance element within a cylindrical portion of a housing to mount all turns of said resistance element equi-distant from a longitudinal axis of said housing even when all portions of the inner surface of said cylindrical portion are not equidistant from said axis, which method includes the steps of: rotating said housing about said axis; cutting a helical groove in said inner surface during such rotation; and expanding said helical resistance element within said housing to dispose its turns in said helical groove.

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