March 22, 1966 M. E. BOURNS ET AL 3,242,450

POTENTIOMETER

Filed June 14, 1963 4 Sheets-Sheet 1

FIG. 2.

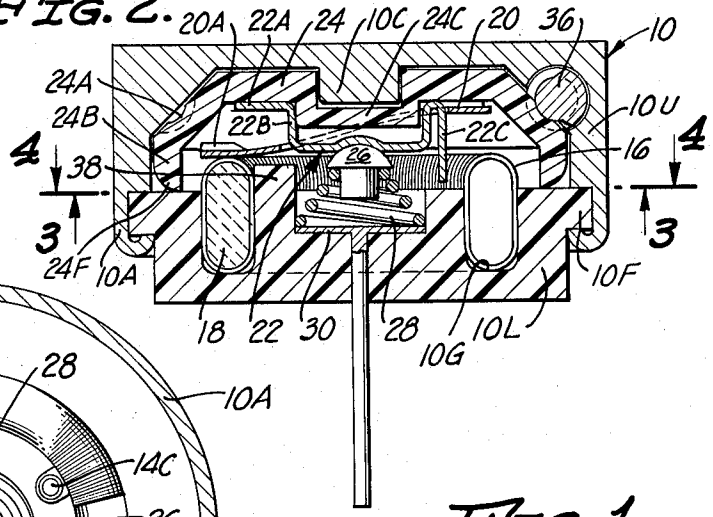


FIG. 4.

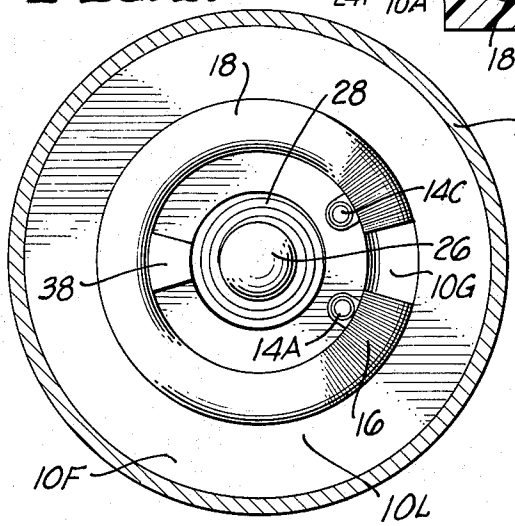
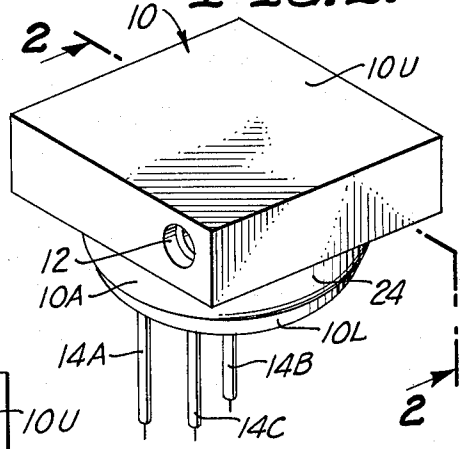


FIG. 1.



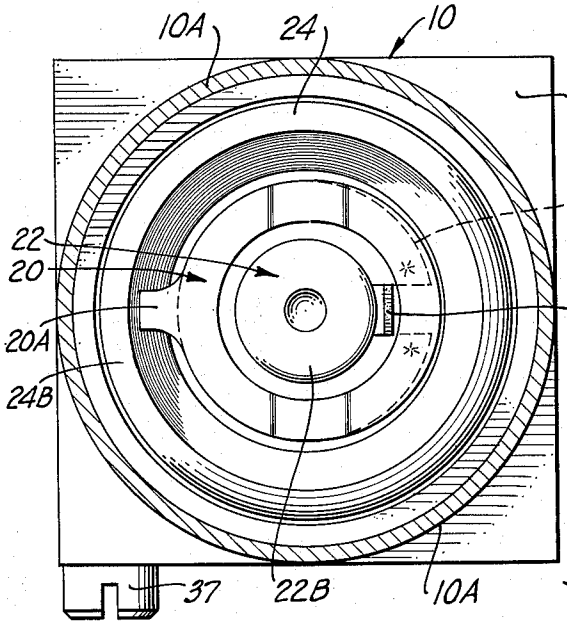


FIG. 3.

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POTENTIOMETER

Filed June 14, 1963 4 Sheets-Sheet 2

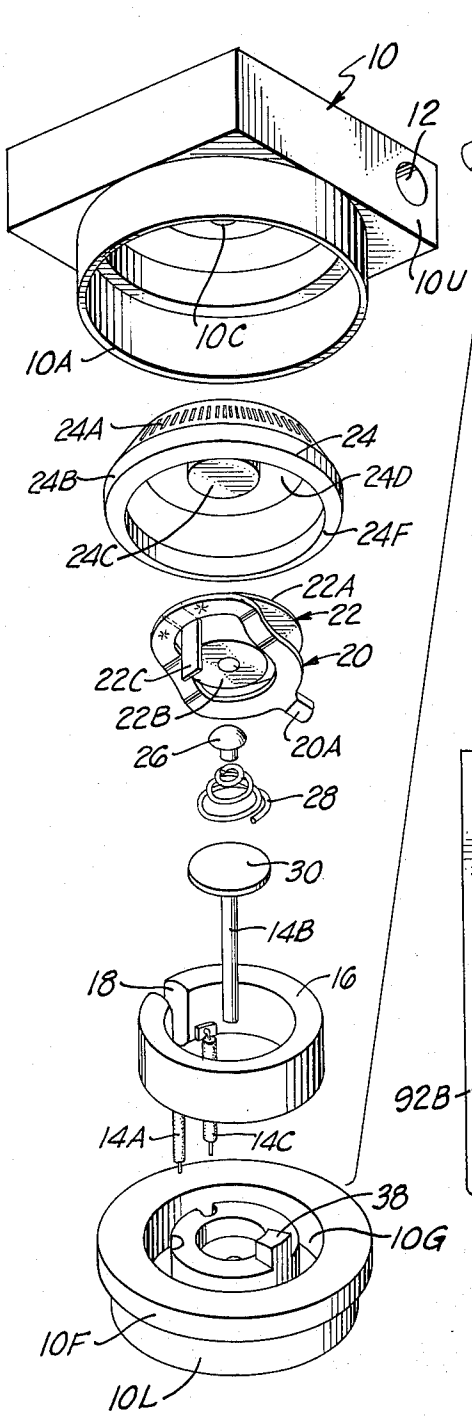


FIG. 5.

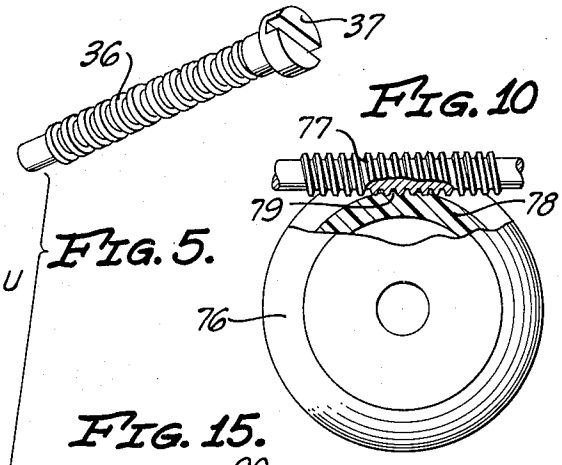


FIG. 10

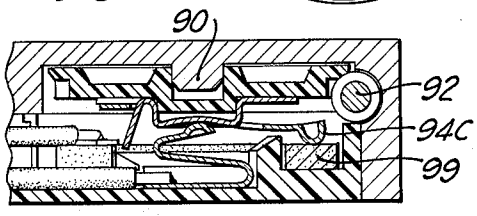


FIG. 15.

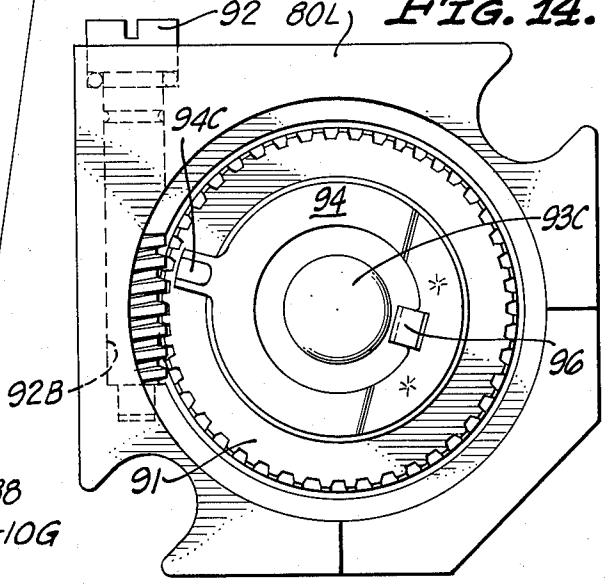


FIG. 14.

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March 22, 1966 M. E. BOURNS ET AL 3,242,450

POTENTIOMETER

Filed June 14, 1963 4 Sheets-Sheet 3

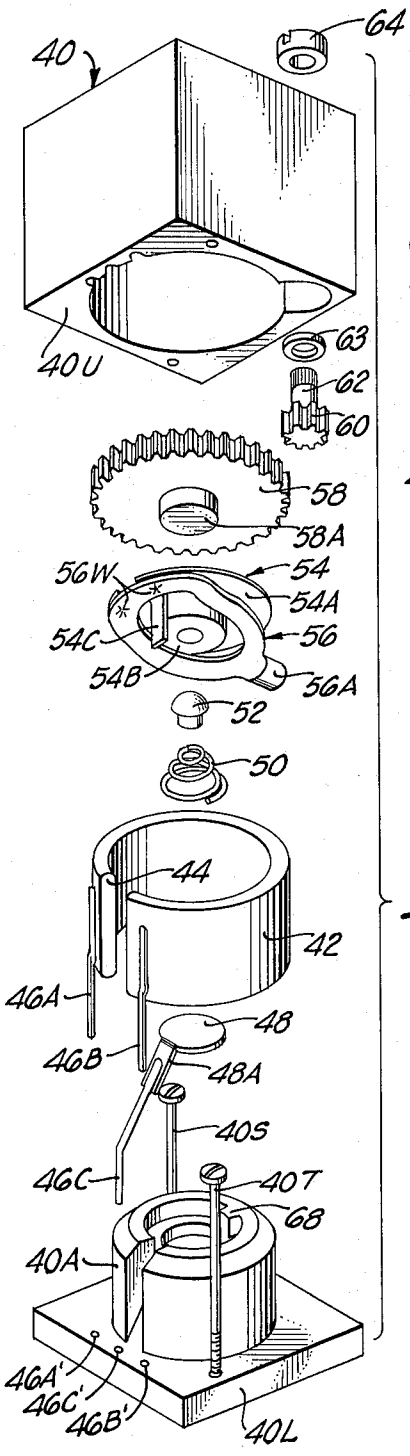


FIG. 6.

FIG. 7.

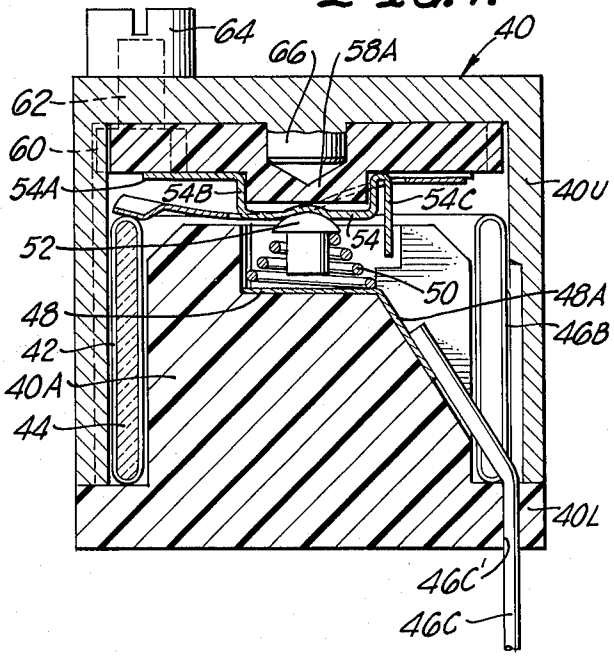
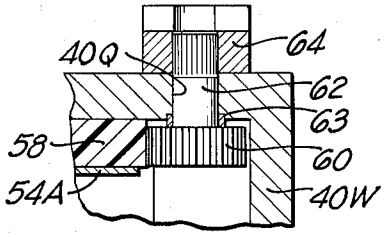


FIG. 8.



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POTENTIOMETER

Filed June 14, 1963 4 Sheets-Sheet 4

FIG. 11.

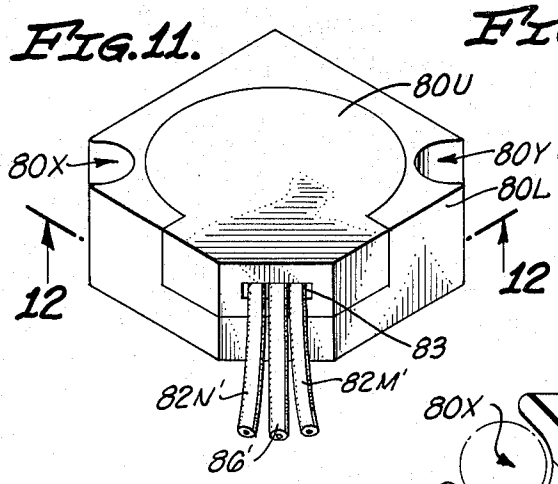


FIG. 9.

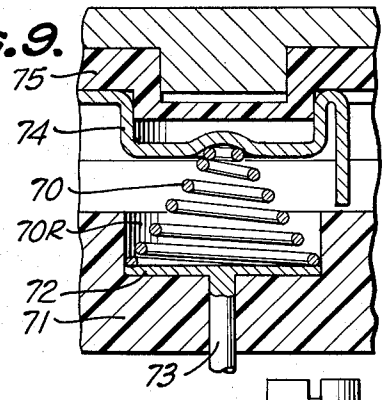


FIG. 12.

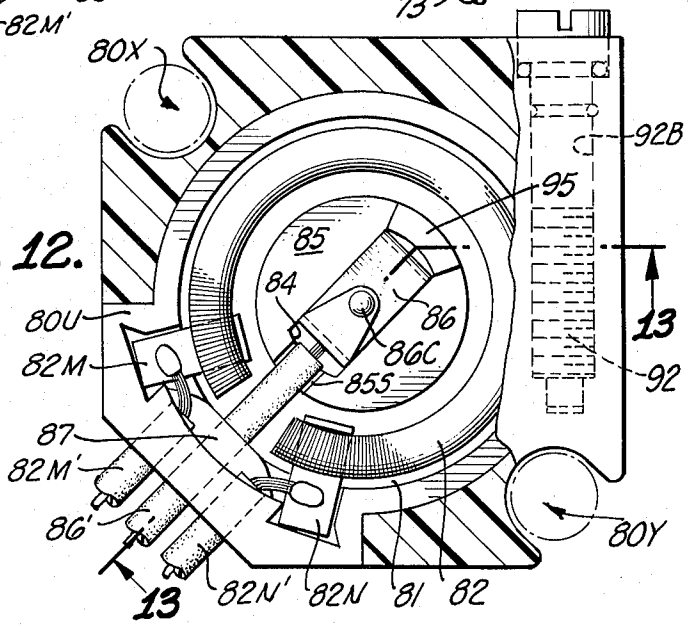
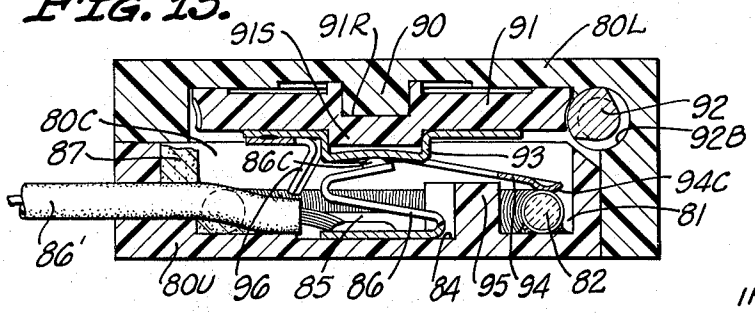


FIG. 13.



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3,242,450

POTENTIOMETER

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Filed June 14, 1963, Ser. No. 287,921
15 Claims. (Cl. 338—164)

The invention hereinafter disclosed pertains to variable resistors and more particularly to variable resistors of the potentiometer type utilizing a ring-shaped or "arcuate" resistance element and gearing means for adjusting the movable contact along the element to vary the resistance exhibited between terminals thereof.

This application is a continuation-in-part of our now abandoned application Serial No. 3,410, filed Jan. 19, 1960, entitled Potentiometer.

Potentiometers of the type to which the invention pertains have resistance elements of finite length over which the movable contact or wiper may be moved by the driving structure or mechanism. Due to the fact that the element and the contact are contained within a substantially closed housing and hence are hidden from view, a problem arises when the contact is driven to the end of the element and the technician or operator continues to attempt to move the contact past the end of the element. If some type of stop means is used to prevent movement of the contact off the end of the element, and the usual torque-multiplying apparatus is employed for moving the potentiometer contact, then damage can occur to the contact and/or other parts including the element when torque is applied after engagement of the stop means. It is quite possible to bridge the space between the ends of the potentiometer element or winding where a circular type of mandrel is used for such winding. However, this is undesirable electrically for many obvious reasons, amongst which is the abrupt change in signal level which occurs when the movable contact moves directly from the top to the bottom of a potentiometer element, that is, moves directly from one electrical end of the element to the other. It very often becomes necessary to use the full range of a potentiometer, and therefore one should be able to drive the contact to the electrical end of the potentiometer winding and not have to stop short of the end for fear that continued motion will cause damage to the potentiometer when the wiper is urged past the end of the winding or element.

An object of this invention is to provide a novel potentiometer construction wherein no damage occurs to a potentiometer when it is sought to move its contact past the end of the winding.

Yet another object of the present invention is to provide a novel arrangement for potentiometers wherein the contact is stopped at either end of the potentiometer winding or element, despite being urged past this stopping point by the mechanism which drives the contact.

Still another object of the present invention is the provision of a novel structure or apparatus for moving the contact of a potentiometer.

Yet another object of the present invention is the provision of a novel, useful and improved structural arrangement for a potentiometer.

These and other objects of the present invention are hereinafter made evident or set out in the appended claims and are achieved in an arrangement wherein a frictional or slippable engagement is provided between a driving member and a driven member which moves the potentiometer contact over a potentiometer element. When the contact reaches the end of the potentiometer element, the driven member is stopped by structure provided for the purpose. By terms such as "end of the element" and the like as herein used is mean the electrical end of the element. Despite the continued rotation of the driving member or gear, the contact is stopped by action of stop means and will not move past the end of the element, and because of the frictional engagement of the driving and driven members a slippage occurs therebetween. However, thereafter as soon as the direction of rotation of the driving member is reversed, the driven member immediately rotates and moves the contact away from the end of the winding or element.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself, both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings, in which:

FIGURE 1 is an isometric view depicting a potentiometer embodying principles of this invention;

FIGURE 2 is a cross section of the structure shown in FIGURE 1, taken as indicated by the lines 2—2 of FIGURE 1;

FIGURE 3 is a view of the structure illustrated in FIGURE 1, taken in section and looking upward as indicated by lines 3—3 in FIGURE 2;

FIGURE 4 is another view in section of the structure illustrated in FIGURE 1, taken as indicated by the lines 4—4 in FIGURE 2;

FIGURE 5 is an exploded isometric view illustrating the arrangement of the components comprised in the embodiment of the invention depicted in FIGURE 1;

FIGURE 6 is an exploded isometric view of another embodiment of potentiometer according to this invention;

FIGURE 7 illustrates a cross section of an assembly of the embodiment of potentiometer shown in FIGURE 6;

FIGURE 8 illustrates a detail of the driving arrangement of the embodiment shown in FIGURE 7;

FIGURES 9 and 10 are framentary sectional views of alternative arrangements of components of potentiometers according to the invention;

FIGURE 11 is an isometric view of an embodiment of a potentiometer according to the invention and especially adapted for rapid and easy manufacture, of simple construction, and adapted for assembly in a stack of like units assembled on and supported by common supporting means;

FIGURE 12 is a partial-sectional view taken as indicated by broken line 12—12 of FIGURE 11;

FIGURE 13 is a distorted sectional view, the sectioning being as indicated by line 13—13 of FIGURE 12;

FIGURE 14 is an open face view of a lower housing member of the potentiometer illustrated in FIGURE 11, with driving and driven gear means installed and a contact device in operative position; and

FIGURE 15 is a partial sectional view illustrating a modified form of resistance element usable in the potentiometer of FIGURE 11.

Referring now to FIGURE 1, there is shown an isometric view of a potentiometer embodying principles of the invention. The potentiometer includes a housing 10, within which operating components are enclosed. The housing has an opening or passage 12 therein, for reception of a screw or worm gear by means of which the potentiometer is adjusted from the exterior of the housing may be made of any suitable material, such as "plastic," or metal if suitable insulation is provided as needed. Extending from the lower face of the housing are three insulated terminals or leads 14A, 14B, 14C. These leads provide external electrical connection to the two electrical ends of the potentiometer resistance element and to the movable contact of the potentiometer.

Referring now to FIGURE 2 and to the exploded isometric view shown in FIGURE 5, it may be seen that the housing **10** comprises an upper housing part or portion **10U** and a lower housing part or portion **10L**. The two portions are held together by the clamp section **10A** of the upper housing portion **10U**, which is turned or spun over the annular flange **10F** of the lower housing portion **10L**. The housing **10** provides a closed chamber and protective container for the movable parts of the potentiometer. The potentiometer resistance element or winding, **16**, is wound over a curved arcuate mandrel **18**, which with the winding fits within a groove **10G** provided therefor in the lower housing portion **10L**. The upper housing portion **10U** comprises an outstanding gudgeon or stud **10C** centrally located on the interior face thereof and preferably formed integrally therewith. The stud **10C** defines an axis of rotation and serves as a bearing for a somewhat cup-shaped driven gear device **24** which has a centrally located cylindrical bearing portion or device **24C** dimensioned for rotational fit upon the bearing provided by stud **10C** as indicated in FIGURE 2. The gear device **24B** is preferably made of molded synthetic resin and has an annular series of worm gear teeth **24A** disposed on a sloping exterior surface as indicated. The teeth are arranged for coaction with a driving screwshaft or worm gear **36** that is rotatably mounted in the bore-like passage **12** (FIGURE 5) formed in the upper portion **10U** of the housing. The screwshaft or worm gear **36** has means for application of driving torque, and in the illustrated form that means is a slotted head **37** adapted for reception of an end of a driver tool.

Gear device **24** has an annular rim of tapered cross section terminating in a relatively flexible resilient edge or lip **24F** (FIGURE 2) which is forced inwardly by the upper flat surface of lower portion **10L** of the housing when the housing is assembled. The rim or lip **24F** of the gear device thus serves as a secondary seal to exclude particles worn from the interacting gear surfaces and elsewhere, from the interior chamber of the potentiometer where such particles could seriously interfere with proper functioning of the electrical components of the instrument. Further the resilient lip of the gear device serves somewhat as a spring to effectively maintain the gear teeth engaged during normal operation, while permitting the gear device to yield away from the worm and thus permit relative slip between the teeth if rotation of the gear device is arrested while rotation of the worm gear **36** is continued. Thus in normal operation of the potentiometer, rotation of the worm gear **36** effects rotation of gear device **24**.

Rotatably disposed on the bearing portion **24C** of gear device **24** for rotation about the previously mentioned axis is a somewhat "hat-shaped" member forming part of a rotary device **22** (FIGURE 5) which has an annular flange or brim portion **22A** one flat surface of which is dimensioned and arranged for frictional coaction with a complementary annular flat "friction-clutch" surface **24D** provided on gear device **24**, whereby rotation of the gear device may be transmitted to the rotary device **22** when the latter is free to rotate and is pressed into frictional contact with the gear device. The crown porion **22B** of device **22** is dimensioned for close rotational fit on the bearing portion **24C** of the gear device. Rotary device **22** is provided with a protruding stop member **22C** (FIGURE 5) that may conveniently be formed as an integral portion by lancing of the brim **22A** and bending up a tab, as indicated. The stop member **22C** is disposed for arrestment by a stop **38** (FIGURE 5), provided as an abutment on lower housing portion **10L**, incident to continued rotation of device **22** in either direction. Thus as the worm gear **36** and gear device **24** are rotated the rotary device **22** is frictionally driven by the gear device until stop **22C** collides with stop **38**, after which continued rotation of the gear device in the same direction results in slippage between the two friction-clutch surfaces. Subsequent reverse rotation of the driving means

comprising the worm gear and gear device causes reverse rotation of device **22**.

The rotary device **22** is arranged to be pressed against gear device **24** and held in place on the bearing portion **24C**, by suitable resilient means, and as shown, by a spring-pressed contact button **26** the rounded head of which is disposed for brushing reception in a centrally located dimple formed in the top of crown **22B** of device **22**, as is indicated in FIGURE 2. The contact button **26** includes a shank portion that is received in the open apical end of a compressed conductive conical spiral spring **28** whose base presses against the flat disc-like head **30** of an electric return terminal **14B** that is sealed in the center of lower housing portion **10L** as indicated in FIGURE 2.

Secured to the brim or flange of the hat-shaped part of rotary contact device **22** adjacent the stop **22C**, as by spot welding on opposite sides of the notch made by removal of material for stop **22C**, and as indicated in FIGURE 3, is a resilient contact member or means **20** of configuration indicated in FIGURE 5. The contact means comprises a contact proper **20A** that is dimensioned and disposed to brush along an arcuate path provided by an arcuate exposed surface of the resistance element winding **16**, as indicated in section in FIGURE 2. As is evident, the free contact-bearing portion of the contact means stands away from the brim of device **22** and resiliently presses the contact **20A** against the resistance element. The geometrical arrangement of the electrical ends of the resistance element, stop **38**, and stop **22C** is such that when stop **22C** is driven against stop **38**, contact **20A** is driven to a corresponding electrical end of the resistance element. Thus the contact is never driven off the resistance element, but may be driven to either electrical end thereof. The electrical connection or path is from a selected point along the resistance element, through contact **20A** and the spring part of the contact device to the brim of device **22** via the weld, through the crown portion of device **22** to button **26**, through the button to spring **28** and disc **30** and terminal **14B**. The resistance element preferably comprises a wire-wound mandrel of the configuration indicated in FIGURES 2 and 4, with the winding ends terminated by means of clips or welds as indicated in FIGURE 5 and connected thereby to respective ones of terminals **14A** and **14C**; however, as is evident to those skilled in the art, other types of resistance elements, such as that illustrated in FIGURE 15, may be used.

Preferably, and as indicated in FIGURE 2, the upper portion **10U** of housing **10** may be of metal, and the lower portion **10L** made of molded insulative synthetic resin, whereby the several terminal members may be sealed in situ during the formation of the latter portion of the housing. In that case the gear device **24** is preferably formed of insulation to avoid an electrical connection of upper portion **10U** to the contact.

In FIGURES 6, 7 and 8 there is illustrated a second construction of potentiometer embodying the present invention. In FIGURE 6 there is shown an exploded isometric view of the parts of the potentiometer. In FIGURE 7 there is shown a cross-sectional view of the assembled parts. A housing **40** consists essentially of an upper portion **40U** and a lower portion **40L**, which are shaped to fit together to form a chamber in which are enclosed all the moving parts of the potentiometer except the driving worm gear. The upper and lower housing portions may be fastened together by screws **40S**, **40T** as indicated in FIGURE 6. The upper housing portion **40U** consists of a block of a suitable insulative material which is hollowed out or molded to provide space for enclosing the operating parts of the potentiometer. The lower housing portion **40L** has formed therewith a winding-holding or element-receiving formation **40A** over which there fits a resistance element comprising a winding **42** which is wound on a curved mandrel **44**. Leads or terminals **46A**, **46B** (FIGURE 6) are brought from the ends of the potentiometer winding through suitable

holes 46A' and 46B' formed in the lower housing portion 40L.

As is indicated in FIGURE 7, lower housing portion 40L is provided with a centrally-disposed flat seat upon which rests a conductive member 48 comprising a disc-like body portion and a tab 48A. The tab is welded to a terminal 46C which with the tab resides in a slot in a side of formation 40A and which terminal extends downwardly and through an aperture 46C' provided in lower housing member 40L. Disposed on member 48 in a recess in formation 40A is a conical conductive spring 50 the apex of which supports a conductive button 52 as indicated. Button 52 is by spring 50 forced upwardly into electrical contact with a dimple centrally located in the crown 54B of a device 54 that is rotatably disposed on a cylindrical stub or bearing 58A provided on a spur gear 58. Device 54 is a combination device serving as a friction clutch member, part of a return conductor circuit or means, a contact support and a stop member. The device is like or similar to the previously described component 22 and is herein for convenience termed a "rotary contact device." Spur gear 58 is in turn journaled for rotation on a cylindrical stub shaft or stud 66 provided as a protuberance on the inner end wall of upper housing portion 40U. The spur gear has an annular friction face disposed for coaction with a complementary surface on device 54.

Also as indicated in FIGURES 6 and 7, there is affixed to the flange 54A of rotary contact device 54 a resilient deformed ring-shaped contact means 56 that comprises a contact 56A formed and disposed for brushing contact along an exposed arcuate face or zone of the resistive means of the aforementioned resistance element. The contact means may be conductively connected to and affixed to the brim or flange of the rotary contact device by spot welding the two components together at 56W as indicated in FIGURE 6. The rotary contact device 54 comprises a preferably integral stop 54C that is conveniently disposed diametrically opposite contact 56A and that is proportioned and arranged to collide with a stop 68 (FIGURE 6) provided as an abutment or projection on the formation 40A of the lower portion 40L of the housing. The arrangement and construction is such that as contact 56A reaches either electrical end of the resistance element the stop 54C collides with stop 68 whereby continued rotation of the device 54 and contact means 56 is arrested or prevented. Under the latter condition or circumstance the interengaging generally annular friction clutch faces of flange 54A of the rotary device and of spur gear 58 indulge in relative movement or slipping incident to continued rotation of the gear.

Gear 58 meshes with a driving pinion 60 (FIGURE 8) that is fixed upon or integral with a shaft 62 and is thus journaled in a bore or passage 40Q (FIGURE 8) formed in the wall of the upper portion 40U of the housing. A sealing ring 63 is preferably provided for shaft 62, as indicated; and the pinion is maintained in operative position in mesh with gear 58 by a slotted head 64 that is affixed to the outer end of the shaft by adhesive or other suitable conventional means.

With continued reference to FIGURES 6, 7 and 8, it is from the preceding description evident that with the components in positions indicated in FIGURE 7 and with the terminals sealed in place (as by adhesive) and with the housing portions secured together and similarly sealed, the value of resistance exhibited between terminal 46C and either of the other terminals may be varied from a minimum or zero value to a maximum value by application of driving torque to head 64 in the appropriate direction; the internal circuit being from terminal 46C to member 48 and on through spring 50, button 52, the clutch portion of device 54, contact means 56 and a portion of the resistance element to either of terminals 46A and 46B. The compression of spring 50 causes that component to exert a force that maintains the friction clutch surfaces of device 54 and spur gear 58 in proper frictional contact while permitting effective electric conduction and, when necessary, slippage of the frictional clutch surfaces. As is evident the structural arrangement and configurations of parts, and functional operations, are similar to those of the embodiment of FIGURE 1.

In FIGURE 9 there is depicted an alternative construction and mode for maintaining the principal gear and the clutch device in proper operating relationship and for effecting electrical circuit continuity within the potentiometer with a minimum of brushing contact connections. Therein a conical spring 70 having a suitably large number of turns or convolutions is disposed with its base in a cylindrical recess 70R provided in a formation 71 comprised in the lower housing member, and the base of the spring is welded (or fusion-united as by brazing or soldering) to a disc 72 forming a head end of a terminal 73. At its apical end the spring 70 is similarly fusion-united with the center portion of the crown of a clutch device 74. The latter is of form similar to devices 22 and 54 previously herein described, and operates in the same manner. As is evident, there may thus be eliminated two more or less variable-contact locations in the potentiometer, there being substituted two continuous electrical junctures. Thus the electrical "noise" incident to such variable contact junctures is obviated. Also as is evident, rotation of the contact is permitted by winding or unwinding of spring 70, without appreciable dimunition of the effectiveness of the friction clutch surfaces provided on member 74 and the mating gear 75.

In FIGURE 10 there is shown a fragmentary view of a modified type of screwshaft or worm gear driving arrangement, utilizing a flanged driven wheel rather than a true worm wheel or gear. Therein a wheel device 76 having a pulley-like configuration is engaged by the screw thread of a worm or screwshaft 77 and is rotated by rotation of the screwshaft. The wheel is provided with a rim portion 78 of resilient slippery material such as nylon or polymerized polytetrafluoroethylene. The composition and arrangement is such that a transitory thread 79 is impressed or created in the noted material at the location of contact with the screwshaft thread, as illustrated, whereby the wheel is rotated incident to screwshaft operation, and the interengagement is such that when an associated clutch or other driven device is arrested, slippage between the worm gear thread and the wheel may occur. Utilization of this type of driving structure in the potentiometer has the advantage of substantially eliminating the backlash normally existent in interengaging toothed gears.

In FIGURES 11, 12, 13 and 14 there is depicted a modified form of potentiometer embodying the principles of the invention and adapted for simple, easy mounting upon a supporting structure by means of pins or screws secured to such structure, also adapted and arranged for easy and rapid but accurate assembly, and, further, constructed and arranged as a relatively thin flat instrument permitting stacking of a plurality of like potentiometers in a small space. As indicated in FIGURES 11 and 13, the operating parts of the potentiometer are enclosed in a housing of generally square box-like configuration, the housing comprising an upper portion or lid 80U and a lower portion or base 80L. When fitted together the two portions provide a somewhat circular enclosed chamber 80C (FIGURE 13) in which operating components are disposed. The base 80L is of somewhat square plan form (FIGURE 14) and is provided with opposed notch-like recesses 80X, 80Y (FIGURE 11) dimensioned and arranged to receive parallel pins or screws that may be attached to a panel or other structure. The disposition of such pins or screws relative to the housing is indicated by dot-dash lines in FIGURE 12, the lines indicating cross-sections of the pins or screws. As is indicated in FIGURES 12 and 13, lid 80U is provided with an arcuate recess or slot 81 in which is disposed an arcuate resistance element 82. The resistance element is preferably

secured in place in the recess by adhesive, and is provided with terminal clips or strips 82M, 82N that are affixed to the element as by welding and to which respective flexible insulated terminal leads or conductors 82M' and 82N' are conductively united as by solder or the like. The terminal conductors or leads pass through an aperture 83 (FIGURE 11) formed in the lid, and in which aperture they are sealed and anchored by adhesive synthetic resin. Thus effective trouble-free terminal connections are provided for the resistance element. The lid 80U is also provided with a central generally rectangular recess 84 (FIGURES 12 and 13) nearly completely encircled by a wall 85. In the recess is disposed a resilient return conductor device 86 formed as a generally S-shaped spring strip the base of which is adhesively secured to the lid at the bottom of the recess 84. The return conductor device 86 comprises a contact point 86C at its free end (FIGURE 12). A flexible-lead insulated terminal conductor 86' is conductively connected to the base of device 86 (as by soldering) and extends radially outwardly in a slot 85S formed in wall 85 and through an insulative plug 87 and through the aforementioned aperture 83 in which it is sealed with small portions of the previously described wire terminals 82M' and 82N'. Thus an effective terminal connection is provided for the movable contact of the potentiometer. The resistance element and spring device 86, with the associated flexible terminal conductors, are seen to form, together with lid 80U, an integral subassembly of components that is readily and inexpensively assembled and easily combined with a second organization or subassembly of parts presently to be described. Further, the lid subassembly permits easy visual inspection and electrical and mechanical testing of the terminals and resistance element. As is evident, pin terminals can readily be substituted for those illustrated.

As is indicated in FIGURES 11 and 12, the lower housing portion or base 80L is formed with a flat outer face, and of configuration such as to be complementary to the outline shape of the lid 80U and to receive the latter in but one relative position and with a close fit therebetween. Thus the lid may be adhesively united to the base and the line of juncture therebetween easily sealed by an adhesive that also serves to firmly secure the two housing portions together. The base 80L is provided with a centrally disposed cylindrical stud 90 protruding from the inner floor of the base. The stud serves as a stub shaft or bearing and defines an axis. Upon the stud or bearing a gear device 91 in the form of a worm wheel is disposed for rotation about the axis. The worm wheel is held in mesh with the thread of a driving worm gear or wormscrew 92 that is journaled for rotation in a stepped passage or bore 92B (FIGURE 13) provided in the base and tangentially communicating with the interior chamber 80C. Worm gear 92 is constructed and arranged to have an end thereof accessible from the exterior of the housing for application thereto of driving torque in an evident manner. The driven gear (worm wheel 91) is provided with a central bearing portion formed to provide a cylindrical recess 91R complementary to stud 90 as indicated in FIGURE 13; and the bearing portion also provides a cylindrical protuberance or stub 91S that in turn serves as a shaft or bearing upon which a rotary contact device 93 is rotatably mounted. The worm wheel 91 and the rotary contact device have complementary annular friction clutch surfaces that are maintained in frictional contact and thus permit transmission of torque from the worm wheel to the rotary device while allowing slippage or relative movement therebetween as may be necessary. As is evident, the worm wheel is similar to previously described gear 58 and gear device 24 in form and function.

Rotary contact device 93 is of similar configuration and operates in manner similar to the previously described devices 22 and 54, and has a brim portion to which is conductively secured a resilient contact means 94 that comprises a contact 94C disposed to be brushed along an exposed surface of resistance element 82. The brim portion of device 93 is of generally annular form, with a portion removed to form a stop. In essence it provides an annular friction clutch surface is herein for convenience termed annular. The resilient ring-like contact means 94 is secured to the brim portion of the rotary device by spot welding as indicated and in a manner exemplified and explained in connection with FIGURE 5. Thus it is evident that with the flat bottom of base 80L reposing open face up on a support, the rotary components of the potentiometer may readily be placed in position, the worm gear, worm wheel, rotary clutch and contact means each in that order, to form a readily-assembled organization of parts. Further it is evident that thereafter the aforedescribed integrated subassembly including lid 80U may be easily and accurately brought into coacting relationship with the base and rotary parts, the spring 86 being compressed somewhat in the process, and the housing portions adhesively sealed to form a completed potentiometer. As is evident to those skilled in the art, O ring means, and/or retainer means, may be used if desired, to retain the worm screw or gear 92 in position and seal the passage 92B against entry or exit of material. As the lid 80U is brought into position in and on the base 80L, the contact point 86C conductively engages the center of the crown of the rotary device as spring 86 is compressed, and thus the friction clutch surfaces are engaged and the gear devices are held in place and in meshed condition. Further, contact 94C engages the resistance element 82 and the contact means is stressed to maintain a firm engagement of the contact 94C with the resistance element. Thus the now evident electric circuit through the electrical components is completed.

Means are provided to restrict movement of contact 94C beyond either electrical end of the resistance element. Such means may conveniently comprise a stop 95 preferably formed as an integral upstanding abutment portion of arcuate wall 85 of lid 80U (FIGURE 12), and a lanced and bent portion of the brim of the rotary contact device and herein denoted by numeral 96 (FIGURE 13). The stop means function in a manner identical with other similar means previously herein described. As may be evident, the housing portion 80U and 80L, and gear device 91 are conveniently formed as molded parts, of synthetic resin or the like insulative material. If made of conductive material, insulation of certain components may be effected in ways well known in the art.

A fragmentary sectional view of a modified form of potentiometer similar to that depicted in FIGURES 11–14 is shown in FIGURE 15. Therein an arcuate resistance element 99 having a flat exposed face is used in place of the wirewound resistance element 82 of the previously described potentiometer. The resistance element 99 may comprise an arcuate block of insulative material bearing a surficial deposit of resistive material, or, alternatively, a similar arcuate block of molded resistive material. In either case, terminal clips and connections are utilized. In other respects the potentiometer structure may be the same as that depicted in FIGURES 11–14.

In the preceding descriptions of a preferred exemplary physical embodiment of the invention and modified forms of portions thereof it has been made evident that several substitutions of components of one form for those of another form may be made within the several variations of housing structures, by slight changes of shape. It should also be noted that the drawings are not throughout to the same scale, the scale having been varied to facilitate illustration of details; and the drawings are in the interest of clarity of illustration grossly enlarged. Further, having disclosed in detail herein exemplary potentiometer constructions embodying the principles of the invention, it is evident that in the light of that disclosure various modifications falling within the spirit and scope of the invention will occur to others and especially to those skilled in the potentiometer art. Accordingly it is desired that the invention be not restricted to exact details of the chosen exemplary embodiments herein disclosed, and that the

invention be restricted only as defined in the appended claims.

We claim:

1. An adjustable potentiometer comprising:

housing means providing an enclosed chamber of generally circular plan form and providing an inwardly-extending stud providing a bearing structure defining an axis;

gearing journaled in said housing and including a gear wheel having an axis of rotation coincident with said axis and having an axial recess arranged to receive said bearing structure so that said gear wheel is rotatable on said bearing structure about said axis, and said gearing including driving gear means engaged with said gear wheel to drive the latter and having a portion accessible from the exterior of said housing for receiving driving torque, said gear wheel being provided with a stub protuberant opposite said axial recess and coaxial therewith;

a rotary clutch member in said chamber, said clutch member having a central portion complementary to said stub and rotatable thereon and further having an outer surface engaging said gear wheel to be frictionally driven thereby, and a contact means supported by said clutch member and rotatable therewith, said contact means comprising a contact rotatable in an arc about said axis of rotation, and terminal means for said contact; and

a resistance element in said chamber having an arcuate contact zone exposed for brushing engagement by said contact and engaged by the latter, and teminal means for said resistance element.

2. A gear adjusted potentiometer comprising:

first means, including housing means comprising first and second principal portions formed to interfit and form an enclosed chamber, one of said portions having a cylindrical projection extending into said chamber and providing a bearing;

second means, including a driving gear journaled in said housing and a driven gear rotatably mounted on said cylindrical projection and in mesh with said driving gear, said driven gear having a cylindrical projection coaxial with said first named cylindrical projection and forming a bearing;

third means, comprising a rotary contact device rotatably mounted on the cylindrical projection of said driven gear and having a portion having frictional engagement with said driven gear to be frictionally driven thereby incident to rotation of said driven gear, said contact drive including an electrical contact movable in an arcuate path in said chamber;

fourth means, including an arcuate resistance element affixed in said housing and having an exposed contact surface extending along said arcuate path to be brushed by said electrical contact; and

fifth means, comprising insulated electrical terminal connections to said resistance element and said contact device.

3. A gear adjusted potentiometer according to claim 2, including

sixth means, comprising first and second stop means the first of which is stationary relative to said housing and the second of which is connected to said rotary contact device and rotatable therewith along an arcuate path terminating at the said stationary stop means,

whereby incident to continued rotation of said driving gear said driven gear rotates and by frictional transmission of torque rotates said rotary contact device until the said first stop means engages said second stop means and is arrested thereby and thus causes slipping of one of said friction clutch surfaces relative to the other friction clutch surface, to obviate damage to any of said means.

4. A potentiometer according to claim 2, including

sixth means, said sixth means including first and second stop means the first of which is held stationary relative to said housing and the second of which is carried by said rotary contact device and disposed to move in an arcuate path intersected by said first stop means,

whereby incident to continued application of driving torque to said worm gear rotation is imparted to said worm wheel and to said contact through said friction clutch surfaces to effect variation of electrical resistance exhibited between said electrical termination and one of said terminal means until said second stop means is moved into engagement with and arrested by said first stop means and thereafter slipping occurs between said friction clutch surfaces and damage to components in said housing is obviated.

5. A worm-gear adjusted potentiometer according to claim 2, including in said fifth means resilient spring means disposed in said chamber between said first and second principal portions of said housing means and pressing against said rotary contact device to urge the latter into frictional engagement with said driven gear and to provide an electric terminal connection to said rotary contact device.

6. A worm-gear adjusted potentiometer comprising:

first means, including a housing comprising essentially first and second portions, said first portion comprising a somewhat square open box-like structure having first and second substantially parallel exterior surfaces providing respectively a flat bottom surface and a top surface said top surface being interrupted by a generally circular cavity formed in said first portion and said first portion provided with an inner cylindrical projection upstanding in said recess and defining an axis and said first portion further having a lateral recess leading into the said cavity, and further having a bore-like passage extending from the exterior thereof and disposed substantially tangentially of said recess and opening into the latter, said second portion of said housing having a generally arcuate portion complementary to and adapted to cover said cavity and further having a laterally extending lip portion integral therewith complementary to said lateral recess of said first portion and adapted to close the latter, said arcuate portion having a generally circular trough therein;

a second means, including an arcuate resistance element secured to said second portion of said housing in said circular trough, and terminal connections for said element extending therefrom to the exterior of said housing;

third means, comprising a driving worm gear rotatably journaled in said bore-like passage and a worm wheel meshed therewith and rotatably mounted on said cylindrical projection; and

fourth means, comprising rotary means including a rotary contact device, said rotary means engaging and driven by said worm wheel and said contact device comprising a conductive contact arranged in brushing contact with said arcuate resistance element, and terminal connection means for said contact extending to the exterior of said housing.

7. A potentiometer according to claim 6, in which said worm wheel comprises a friction-clutch surface and in which said rotary means is journaled on said worm wheel and comprises means having a friction-clutch surface complementary with said first-named friction-clutch surface and in engagement with the latter to provide a friction clutch drive for said contact device.

8. A potentiometer according to claim 7, in which said terminal connection means for said contact includes a conductive spring device secured to said second portion of said housing and arranged to press against a conductive part of said contact device and also includes a terminal wire connected to said spring device and extending

through said housing to the exterior thereof, said spring device serving to resiliently urge said friction-clutch surface of said rotary means into frictional engagement with said friction-clutch surface of said worm wheel.

9. A potentiometer according to claim **8**, in which said second portion of said housing comprises a stop abutment and said rotary contact device comprises a complementary stop device disposed to be driven into engagement with said stop abutment and thereby arrest rotation of said contact device to prevent movement of said conductive contact off either end of said resistance element.

10. A potentiometer according to claim **9**, in which said worm wheel comprises a cylindrical projection coaxial with said axis, and said rotary means comprises a cylindrical portion journaled on said cylindrical projection and further comprises a flange portion having said second-named friction-clutch surface, and said contact device further comprising a resilient member welded to said conductive flange and bearing said contact.

11. A gear-adjusted potentiometer comprising:

first means, including a housing providing an interior chamber and a passage leading into the chamber from the exterior of the housing;

second means, comprising a driving gear journaled in said housing with a portion accessible from outside the housing for application thereto of driving torque, said driving gear having a portion exposed in said chamber;

third means, comprising a driven gear having an exterior surface presenting an annular array of teeth in mesh with said driving gear and disposed in said chamber, said driven gear having a flexible resilient annular portion cooperating with a portion of said housing to form a seal isolating said exterior surface from a second surface of said driven gear, said second surface cooperating with a portion of said housing to provide a sealed portion of said chamber for enclosing potentiometer components;

fourth means disposed in said sealed portion of said chamber and including a resistance element having an arcuate contact surface, said fourth means comprising rotary means driven by said driven gear and including rotary contact means including a contact disposed to brush said arcuate contact surface; and

fifth means, including respective terminal connection means connected to end portions of said resistance element and said contact, said terminal connection means providing electrical connections extending to the exterior of said housing;

whereby particles such as may be produced by wearing of interengaging teeth of said gears are prevented from coming into contact with said arcuate contact surface of said resistance element.

12. A potentiometer according to claim **11**, in which said housing includes a bearing for said driven gear and in which said resilient annular portion of said driven gear serves the additional function of maintaining said driven gear on said bearing and in mesh with said driving gear.

13. A potentiometer according to claim **2**, said rotary contact device having a portion of hat-shaped form having a flat brim portion presenting a friction-clutch surface frictionally engaging a complementary surface on said driven gear and having a cylindrical portion extending from said flat brim portion and journaled on said projection on said driven gear.

14. A gear adjusted potentiometer comprising:

first means, including housing means providing a chamber;

second means including a driving gear and a driven gear supported by said housing means, said driving gear being in mesh with the driven gear;

third means, including a rotary contact device engaged by said driven gear and driven by the latter, said rotary contact device including a contact rotatable therewith along an arcuate path in said chamber;

fourth means, including a resistance element having an arcuate exposed contact surface disposed along said arcuate path, said contact surface being engaged by said contact;

fifth means, including terminal connections to respective ends of said resistance element; and

sixth means, comprising a terminal member, a partially compressed conical conductive spring having one end portion thereof conductively affixed to said terminal member and the other end portion thereof conductively affixed to said rotary contact device to provide an unbroken electrical conduction path from said terminal member to said contact,

said spring also serving to hold said rotary contact device in engagement with said driven gear and yielding to permit rotation of said rotary contact device by said driven gear.

15. A potentiometer comprising, in combination:

first means, including a resistive element and terminals therefor;

second means, including a contact constructed and arranged to brush along said resistive element in a space between first and second points thereon to cause variation of electrical resistance between one of said points and said contact, and terminal connections for said contact;

third means, including friction-clutch means, constructed and arranged to drive said contact to move the contact along said resistive element between said first and second points, said friction-clutch means comprising a plate-like element having a generally flat circular friction surface and a cylindrical center section, and including positive stop means effective to prevent movement of said contact by said friction clutch means beyond said space between said first and second points;

fourth means, comprising driving means including a gear, for effecting movement of said friction clutch means, said gear having a friction surface cooperating with said generally flat circular friction surface to frictionally drive said plate-like element, said gear having a boss fitting in said cylindrical center section and effective as a journal on which said plate-like element may rotate; and

fifth means, comprising means for rotationally supporting said gear and for rotating said gear.

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