June 26, 1951 W. D. VAN DYKE 2,558,326

POTENTIOMETER

Filed Oct. 19, 1949 2 Sheets-Sheet 1

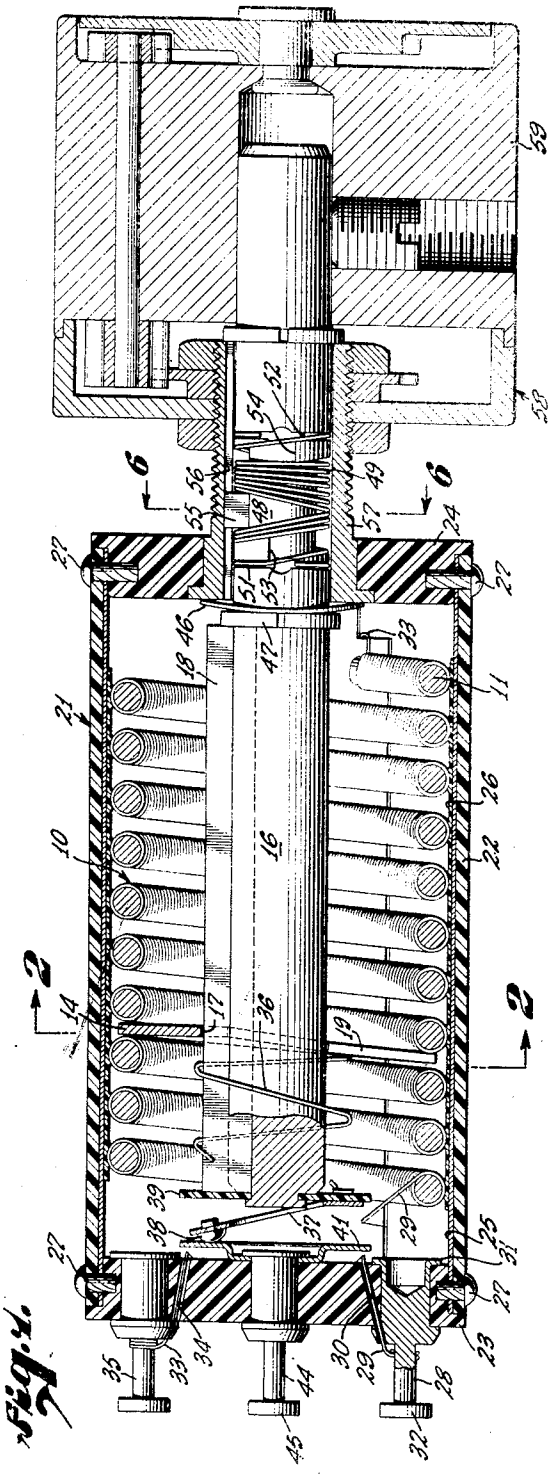


Fig. 4.

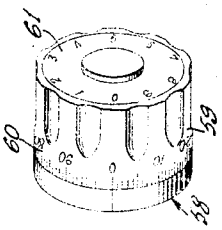
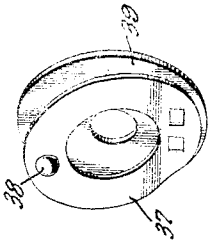


Fig. 3.



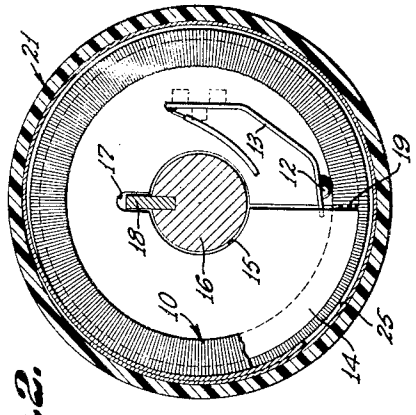


Fig. 2.

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Filed Oct. 19, 1949 2 Sheets-Sheet 2

Fig. 5.

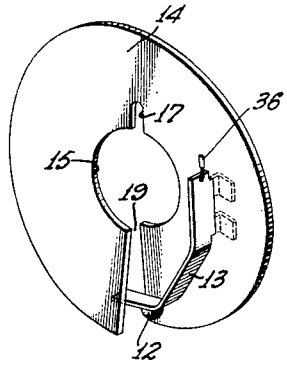


Fig. 6.

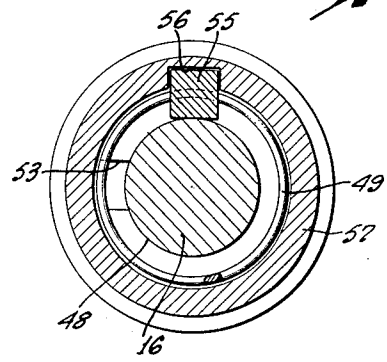


Fig. 8.

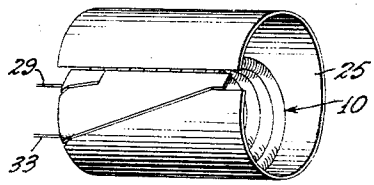


Fig. 7.

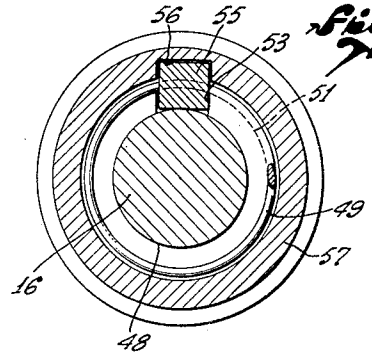
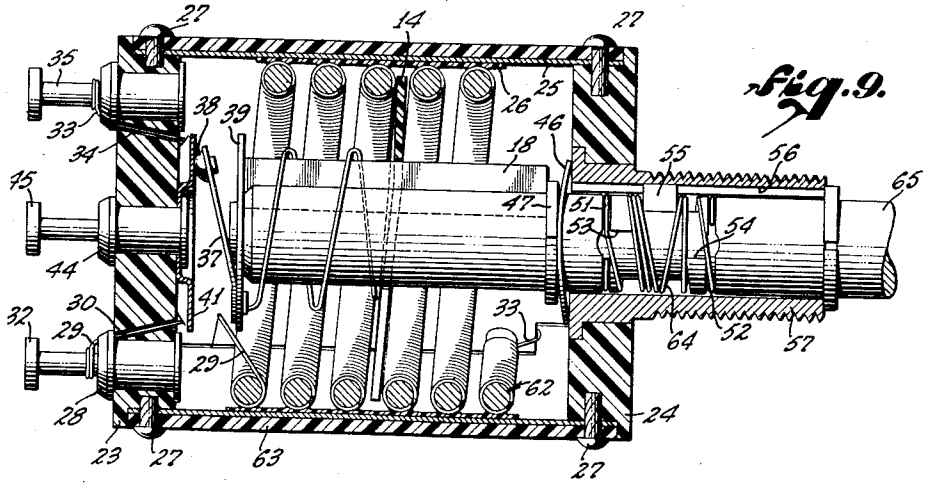


Fig. 9.



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2,558,326

UNITED STATES PATENT OFFICE

2,558,326

POTENTIOMETER

William D. Van Dyke, St. Petersburg, Fla.

Application October 19, 1949, Serial No. 122,205

17 Claims. (Cl. 201—56)

1

This invention relates to potentiometers, and more particularly to a potentiometer having the resistance element arranged as a helix and a sliding contact moving around the helical element.

Potentiometers of the type herein shown and described have been previously proposed and because of the helical arrangement of the resistance element these potentiometers are being used in many fields where extremely delicate measurements are required. They are especially adapted to fields in which low torque instruments are required, as the very high resolution permits the use of a contact member extremely light in weight. As very light contact members could be used, it was of course relatively easy to design actuators for moving the contact members which could be operated with relatively small forces. These prior low torque designs, however, created a problem in that it was difficult to accurately limit movement of the sliding contact between predetermined positions at opposite ends of the resistance element.

This was so as the very light sliding contacts were not rugged enough to take the forces exerted or acting thereon if the contact member itself formed a part of the mechanism for limiting or stopping movement of the contact member as it moved into a predetermined position at the one end or the other of the resistance element.

Although a number of proposals have been made to obviate this difficulty, none have successfully solved the problem created. These proposals have in most part failed because they have attempted to use the contact member itself as a part of the stop mechanism or as a means for actuating the stop mechanism. Where some success has been had by strengthening the contact member or its carrier, it has been gained at the expense of the low torque operational feature of the potentiometer. Other proposals involved the employment of mechanisms which not only produced hysteresis when the potentiometer was connected to a low torque actuator, but also introduced errors resulting from elements of the mechanism adversely affected by acceleration, deceleration and other conditions encountered in some fields in which such potentiometers are used today.

The potentiometer of the present invention is free of the objections found in these prior potentiometers, for the same can be used with any low torque actuator, is free of hysteresis, and the limit stops, positive in action, are of such construction that they do not introduce operational

2

defects or errors in the use of the potentiometer even in aircraft or other flight instrumentalities, such as rockets.

The resistance element of the potentiometer herein shown and described is helical in form and is engaged by a sliding contact carried by a relatively thin disc of insulation material. The disc is keyed to a shaft which is mounted for rotation about an axis coincident with the longitudinal axis of the resistance element. The disc also carries means extending between adjacent coils of the resistance element and cooperative therewith as the shaft is rotated, to move the disc longitudinally of the shaft as it rotates therewith to move the contact along the helical resistance element. The disc and contact member are extremely light in weight and thus do not produce inertia forces which would introduce hysteresis when low torque actuators are used to operate the potentiometer. It is possible to use very lightweight elements in the potentiometer of the present invention for the limit stops of the potentiometer are not a part of the contact mechanism, but are formed as separate means.

The means used to form the limit stops of the potentiometer of the present invention are located on the shaft to which the contact carrier is mounted and the restraining forces are taken not by the carrier or the contact member thereon but by the shaft itself. The stop means includes, in the one embodiment of the invention illustrated herein, a helical spring having the same number of turns as the resistance element. The spring sleeves the shaft and co-acts with a small lug to move the latter longitudinally of the shaft as the same is rotated. A pair of abutments, fixedly carried by the shaft and longitudinally spaced apart thereon, limit longitudinal movement of the lug in opposite directions for the helical spring extends between the abutments and the turns of the spring determine the number of rotations of the shaft necessary to move the lug from a position in which it is engaging one of the abutments to a position in which it is engaging the other of said abutments.

Movement of the lug in either direction along the shaft by rotation of the latter is stopped as soon as the lug is moved into engagement with one or the other of said abutments. As the lug is solidly mounted in a keyway or slot of a journal member supporting the shaft for rotation, the shaft is also held against rotation once the lug is moved into engagement with an abutment.

It will thus be seen that the stop mechanism of the potentiometer of the present invention

is positive in action and is actually formed in part by the shaft itself. As the shaft can be formed to take relatively high torsional forces without increasing the torque required to produce rotation of the shaft and consequently movement of the contact member, the stop mechanism is extremely rugged and yet does not impair the low torque operation of the potentiometer.

The stop mechanism does not complicate assembly of the potentiometer, for the resistance element is merely mounted in its housing in such a way that the element, when mounted, will remain fixed relative to the housing and the stop mechanism then assembled in such a manner that it will limit movement of the sliding contact member between predetermined positions at opposite ends of the element. This is so, for the helical spring is so formed that the coils thereof define a helical passageway of the identical number of turns as the helical resistance member and the position of the lug relative to the coils or turns of the spring can be set to always match the position of the contact relative to the coils or turns of the resistance element as the shaft is rotated.

Another feature of the potentiometer of the present invention resides in the particular coaction between the resistance element and the stop mechanism. As the helical spring producing longitudinal movement of the lug between the abutment also determines the number of complete revolutions of the shaft necessary to move the contact about the entire series of turns of the resistance element, it is obvious that the same stop mechanism is easily converted for use with resistance elements of varying numbers of turns by merely using a spring defining a passageway of the same number of turns as the particular element with which the stop mechanism is used. For example, if the potentiometer is a "ten-turn" instrument, i. e., has a resistance element formed of ten turns, the spring must define a passageway of ten turns, and by merely substituting a spring which defines an eight-turn passageway the stop mechanism functions equally as well with an "eight-turn" resistance element.

In another embodiment of the present invention, the stop mechanism is substantially the same as above mentioned except that two lugs are used. In this form of the invention, the resistance element is formed of a relatively small number of turns and the helical spring controlling movement of the lug is formed with a larger number of turns than the element. In the assembly of this form of the stop mechanism, the one lug is so disposed as to be engaging one abutment while the other lug is mounted between the turn of the spring corresponding to the maximum number of turns of the element. Thus, when the shaft is rotated the first lug moves out of engagement with its abutment and the second lug will move into engagement with the other abutment after the shaft has been rotated a number of revolutions equal to the number of turns of the element.

Thus, the potentiometer of the present invention has all of the desirable features of the previously proposed helical potentiometers in that the elongate resistance element permits very accurate measurements to be made. Furthermore, the contact mechanism is such that low torque actuators can be used without the danger of hysteresis creating errors in the measurement affected. The stop mechanism, separate from the contact mechanism, is extremely rugged and, while positive in action, does not complicate either the assembly of the instrument or its operation.

Other features and advantages of the present invention will be apparent from the following detailed description, particularly when taken in connection with the accompanying drawing, in which:

Figure 1 is a sectional view of one embodiment of the potentiometer of the present invention including the registering actuator for rotating the shaft thereof;

Figure 2 is a section taken along line 2—2 of Figure 1;

Figure 3 is a perspective view of the contact member coaxially carried by the shaft and shown detached from the latter;

Figure 4 is a perspective view of the registering actuator for rotating the shaft;

Figure 5 is a perspective view of the contact carrier shown detached from the shaft;

Figure 6 is a section taken along line 6—6 of Figure 1;

Figure 7 is a sectional view of the potentiometer showing the lug in engagement with one of the abutments;

Figure 8 is a perspective view of the lining sheet which is bonded about the resistance element with the ends of the lining sheet separated to more clearly illustrate the leads of the resistance wire; and

Figure 9 is a view similar to Figure 1 showing a modified form of the potentiometer.

The potentiometer of the present invention, referring now to the drawing, and more particularly to Figure 1 thereof, comprises a resistance element 10, consisting of a core member 11, formed as a helix, having, in the embodiment of the invention illustrated, ten turns or coils. The core member 11 carries the resistance wire, which is helically wound thereon as in a conventional potentiometer with the opposite ends of the core exposed or free of resistance wire. The resistance wire is insulated from the core member preferably by coating the core member with a suitable insulating material prior to the step of winding the resistance wire thereon.

In the now preferred method of forming the resistance element, the same, after the resistance wire is wound about the core 11, is dipped into a liquid bath of some suitable insulating material, which when set and hardened not only insulates the turns of the resistance wire from each other, but also holds these turns against displacement. After the material in which the element is dipped has set and hardened, the core member is formed into a helix having the number of turns desired. The insulation material is now removed from at least the inner surfaces of the turns of the element to permit electrical engagement between the resistance wire and the movable contact 12 of the potentiometer.

In the illustrated embodiment of the present invention, the movable contact 12 is carried adjacent the one end of a spring arm 13 the opposite end of which is fixed to a disc 14 formed of some non-current conducting material. The disc 14, referring now to Figure 5, is formed with a centrally located aperture 15 to permit the disc to be coaxially mounted to a shaft 16 adapted to rotate about an axis coincident with the axis of the resistance element. The disc 14 is also formed with a narrow, radially extending slot 17 opening at one end into the aperture 15 for passing a key 18 longitudinally extending along the

shaft 16. It should now be seen that the disc 14 because of the key and slot connection to the shaft 16 will rotate therewith, but yet is movable longitudinally of the shaft 16.

To move the disc 14 longitudinally of the shaft 16, the disc, in the illustrated embodiment of the present invention, is split as indicated at 19 and the adjacent ends of the split portion of the disc are held apart by the free end of the spring arm 13 to which the contact member 12 is mounted. It will be seen now that the peripheral portion of the disc forms a helix and the helically arranged peripheral portion of the disc extends between adjacent turns of the resistance element 10. As will be shown, the resistance element 10 is fixed within the casing 21, and as the shaft 16 turns relative to the casing 21, the peripheral portion of the disc 14 extending between adjacent turns of the element acts as a follower which is cammed to the left or right as viewed in Figure 1, depending upon the direction or rotation of the shaft 16. It should be understood that the turns of the resistance element 10 will act as a cam, coacting with the peripheral portion of the disc 14 to move the latter longitudinally of the shaft 16 as the same is rotated. This movement of the disc 14 will of course cause the contact member 12 to move around the individual turns or coils of the resistance element to introduce varying degrees of the resistance into a circuit forming a part of the control apparatus.

The casing 21 in which the resistance element 10 is fixed includes a cylindrical element 22, the opposite open ends of which are closed by disc members 23 and 24 respectively. The cylindrical member 22 of the casing 21 is provided with a lining element 25 of non-current conducting material, which may comprise a sheet of some suitable paper, which preferably is coated or impregnated with a resinous material to strengthen the same, as well as to render the paper impervious to moisture. The sheet of paper is somewhat longer than the circumference of the inner cylindrical wall of the casing 21 so that the opposite ends thereof overlap after the lining sheet is coiled into a cylindrical form. This is clearly shown in Figure 2 of the drawing.

The resistance element, whose outer diameter is substantially the same as the inner diameter of the lining 25, is securely anchored or bonded to the latter by a bonding agent indicated at 26. The bonding agent may consist of the material used to impregnate the lining sheet, or may be a separate material applied between the impregnated lining and the turns of the resistance element. Whatever material is used, the same should be one which will securely bond the turns of the element to the lining sheet.

The lining sheet 25 is held against rotation relative to the casing 21 by the drive screws 27, or other fastening elements, used to mount the discs 23 and 24 within the opposite ends of the cylindrical member 22. As the lining 25 is held against rotation relative to the casing, the resistance element is, of course, also held against movement relative to the casing.

The disc 23 carries the terminals of the potentiometer and the rightward end of the resistance element 10, as viewed in Figure 1, is connected to a terminal 28 by a lead 29 electrically connected to the one end of the resistance element and, as best seen in Figure 8, passed between the overlapping end portion of the lining 25 somewhat longitudinally of the casing to a small aperture formed in the inner overlapping end portion adjacent to the terminal 28. The lead 29 is passed into the interior of the housing through this aperture and then lead outwardly of the housing through a passage 30 in the disc 23 formed adjacent the terminal 28 which is fixed in an opening in the disc 23 by peening over the inner end thereof as indicated at 31. The free end of the lead 29 is preferably secured to a pin 32, carried by the terminal 28, by a solder, although other means may be used to electrically interconnect the lead 29 and the pin 32.

A lead 33 electrically connected to the leftward end of the resistance element, as viewed in Figure 1, is passed through an opening formed in the inner overlapping end portion of the lining 25, referring again to Figure 8, and then passed longitudinally to the left, as viewed in Figure 1, to a second aperture through which the lead is passed into the interior of the casing 21. The free end of the lead is then passed through a passage 34 in the disc 23 contiguous to a terminal 35 similar to the terminal 28 which is fixed to the disc 23 in the same manner as is terminal 28 fixed to the disc 23. The lead 33 is electrically connected to the pin of terminal 35 in the same manner that lead 29 was fixed to the pin 32 of terminal 28.

A flexible lead 36 of a length substantially equal to the shaft 16 is wrapped about the latter and has one end electrically connected to the resilient arm 13 which carries the contact member 12. The opposite end of this lead is electrically connected, referring now to Figure 3, to an annular member 37 of a resilient current conducting material carrying a contact member 38. The member 37 is fixed to a disc 39 of some suitable insulation material, which is coaxially mounted to the one end of the shaft 16 and rotates therewith. As the conducting member 37 is fixed to the disc 39, the contact member 38 obviously will move in an annular path as the shaft 16 is rotated. The resilient current conducting member 37 holds the contact 38 carried thereby in good electrical engagement with an annular contact 41 fixed to the inner face of the disc 23 by a terminal member 44 similar to members 28 and 35, and which includes a pin 45 outwardly projecting from the disc 23.

It should now be seen that as the shaft 16 is rotated and the disc 14 is moved longitudinally thereof, the flexible lead 36 will follow the disc 14 to the end that the contact 12 is at all times electrically connected to the pin 45. Care should be taken to insure that the resilient member 37 to which the contact 38 is mounted will always urge the latter against the fixed contact 41 to maintain good electrical engagement between the contact 38 and the annular contact member 41.

The potentiometer just described has all of the desirable features of previously proposed potentiometers of this type, for the elongate resistance element 10 permits, as should be understood, extremely accurate measurements to be made. As the disc 14 to which the contact 12 is mounted is formed of a relatively light weight material, and as this disc itself is employed to move the contact 12 longitudinally of the resistance element 10, there is little resistance to movement of the contact 12, and the shaft 16 can be connected to measuring instruments of various types, which develop relatively low torque forces in operation.

The potentiometer of the present invention is

therefore not likely to produce errors in measurement due to hysteresis. In fact it has been found that in some fields of use, it is necessary to introduce some frictional resistance to rotational movement of the shaft 16, and this is most conveniently done by mounting a spring washer 46 between the inner face of the disc 24 and a collar 47 fixed to the shaft 16 adjacent to its passage through the disc 24.

It is of course desirable to provide some mechanism for limiting the movement of the contact 12 along the element 10 and between the exposed opposite ends of the same, as well as for preventing the disc 14 from being moved out of engagement with the outer turns of the resistance element 10 for it will be remembered that it is this engagement which produces the longitudinal movement of the disc 14 relative to the shaft 16. Although in some previously proposed potentiometers, this stop mechanism has coacted with the contact carrier itself to limit movement of the latter, in the present invention the stop mechanism is separate and forms no part of the contact carrier. This is done to relieve the disc 14 of the strain which would obviously be imposed thereon if the disc was moved into engagement with fixed abutments or the like, which would limit movement of the disc 14.

The stop mechanism of the potentiometer of the present invention is formed by reducing the shaft 16 as indicated at 48 to form an annular channel receiving a helical spring 49. The spring circumscribes or sleeves the bottom wall of the channel and the opposite ends of the spring are fixed to the shaft 16 by anchoring the ends in narrow grooves formed adjacent the side walls 51 and 52 of the channel. The side walls 51 and 52 of the channel are formed with abutments 53 and 54, respectively, each having a relatively wide face extending substantially parallel to the longitudinal axis of the shaft 16. The abutments are arranged in oppositely facing relation and, as will be hereinafter shown, cooperate with a small lug 55 to limit rotation of the shaft 16 and consequently movement of the contact 12.

The lug 55 is slidably mounted in a slot 56 formed in the wall of the bore of an elongate bearing member 57 in which the shaft 16 is journalled. The bearing member 57 is formed with an enlarged head-like extremity which is coaxially fixed in a centrally located opening in the disc 24 with the body or shank portion of the bearing member projecting outwardly from the exterior face of the disc. It will be seen that the slot 56 extends longitudinally of the shaft 16 and is of a depth less than the thickness of the lug 55 so that a portion of the lug projects into the channel 48. The outer face of the lug 55 actually engages the bottom wall of the channel 48 and is thus supported for sliding movement by the walls of the slot 56 as well as the bottom wall of the channel 48. The portion of the lug 55 projecting from the groove 56 is adapted to be mounted between adjacent turns of the spring 49 which, as the shaft is rotated, moves the lug 55 longitudinally of the slot 56 in one direction or the other depending upon the direction of rotation of the shaft 16. The coils of the spring 49 disposed between the side walls 51 and 52 are of such a number that the same define therebetween a helical passageway of the same number of turns as the resistance element. The helical passageway defined by the coils of the spring extends from one abutment to the other and the lug moves relatively through the passageway as the spring revolves with the shaft. Thus revolutions of the shaft equal in number to the turns of the resistance element will move the lug from one abutment to the other.

As long as the lug 55 is between any adjacent turns of the spring 49 other than the outer pairs of adjacent turns, the lug will be moved longitudinally of the shaft 16, for each rotation of the same, a distance equal to the diameter of the wire of which the spring is formed. The lug during its relative movement around and through the outer pairs of adjacent turns of the spring must move a relatively greater distance, however, to bring the lug into facewise engagement with one or the other of the abutments 53 and 54.

To bring about this movement the side walls 51 and 52 of the channel are formed as helical surfaces having a pitch substantially equal to the width of the faces of the abutments 53 and 54. With the side walls 51 and 52 thus formed, the lug during its relative movement through the outer pairs of adjacent turns of the spring will move a distance longitudinally of the shaft equal to the pitch of the helical surfaces presented by the walls 51 and 52 of the channel 48. This is so, for the lug, as it distends the turns of the spring 49, will be urged thereby against one or the other of the helical surfaces presented by the side walls 51 or 52 and consequently when disposed between either of the outer pairs of adjacent turns will move during a complete revolution of the shaft 16 a distance substantially equal to the pitch of the surfaces, which, as above explained, is substantially equal to the width of the faces of the abutments. Movement of the lug into engagement with either abutment will, of course, hold the shaft against rotation.

This construction results in a more positive and more rugged stop mechanism, for the lug can be formed of a relatively larger size than would be possible if the helical surfaces were not present. This should be obvious, for otherwise the abutment could be no wider than the diameter of the wire of which the spring is formed.

In the assembly of the potentiometer of the present invention the contact member 12 is positioned so that it is in engagement with a predetermined point or position at the one end of the resistance element 10. While the contact member is held in this position the stop mechanism is assembled with the lug in engagement with the abutment 54. With the potentiometer thus assembled, rotational movement of the shaft 16 will, as previously explained, move the disc 14 longitudinally of the shaft to bring about movement of the contact member 12 around the turns of the resistance element 10. With the potentiometer assembled as above described, that is, with the lug 55 engaging the abutment 54 and the contact 12 engaging a predetermined position at the rightward end of the resistance element as viewed in Figure 1, ten turns of the shaft 16 will move the lug into engagement with the abutment 54 as the contact 12 moves into engagement with a predetermined position at the opposite or leftward end of the resistance element as viewed in Figure 1.

Although any means may be used to turn or rotate the shaft 16, in the embodiment of the invention illustrated in Figure 1, a registering actuator 58 of the type shown and disclosed in my copending application, Serial No. 790,402, (now Patent No. 2,532,970, issued December 5,

1950) is shown. This actuator comprises a body member 59 directly fixed to the one end of the shaft 16 and consequently the shaft is rotated as the body member is rotated. The manner in which the elements of the actuator cooperate with each other to register turns of the shaft 16 is not required for a full understanding of the invention herein shown, but suffice it to say, the actuator comprises a pair of scales 60 and 61, referring now to Figure 4, which indicate, respectively, fractional and complete revolutions of the shaft 16.

Although the lug is subject to shear forces, if an attempt is made to rotate the shaft after the lug is engaged with one or the other of the abutments, by merely forming the lug of a material having a high shear strength, all danger of the lug failing in use is eliminated. The stop mechanism of the present invention furthermore is positive in action, for the retaining forces are exerted directly on the shaft and not indirectly as in some prior potentiometers. The shaft, however, is well able to take the torsional forces created therein as the lug is moved into engagement with one or the other of the abutments integrally formed on the shaft. Furthermore, the stop mechanism of the present invention in no way interferes with the operation of the potentiometer and does not increase the torque required to rotate the shaft 16.

As the turns of the helical spring control the relative movement of the lug about the shaft in substantially the same way as the turns of the resistance element control the relative movement of the contact relative to the shaft, a potentiometer having a five-turn resistance element, for example, can be provided with a stop mechanism of the present invention by merely using a five turn helical spring.

There is shown in Figure 9 a potentiometer of substantially the same construction as that of the potentiometer shown in Figure 1, and in which elements thereof identical to elements of the first described potentiometer are identified by the same reference characters. The potentiometer of Figure 9 differs from the potentiometer shown by Figure 1 only in the number of turns of the resistance element. The resistance element 62 of the potentiometer illustrated in Figure 9 is formed with but five turns and consequently can be housed in a casing 63 of a shorter length than the casing 21.

As the resistance element 62 has but five turns, the spring 64 controlling movement of the lug 55 is consequently formed of the number of turns or coils which will define a five turn passageway through which the lug relatively moves as the shaft is rotated. The mode of operation of the potentiometer of Figure 9, however, is the same as that of the potentiometer shown by Figure 1, with this exception: The contact 12 is moved from one extreme position at the one end of the resistance element to a second extreme position at the opposite end of the element by five complete revolutions of the shaft 65. The five complete revolutions of the shaft also, as should now be understood, move the lug 55 from a position in which it is engaging the one abutment to a second extreme position in which it is engaging the second abutment. Thus, here again the lug moves into engagement with an abutment and prevents further rotation of the shaft at the same time the contact moves into its limit or preselected position on the resistance element.

It should be seen now that by merely changing the helical spring, it is possible to adapt the stop mechanism of the present invention to potentiometers having a wide range of turns. Although some difficulty might be experienced with one-turn instruments if but one lug was used, the stop mechanism can be adapted to a one-turn instrument by using two slugs in the place of one. In such a construction, the potentiometer would be assembled with the one lug engaging the one abutment and the contact 12 at the one extreme position relative to the resistance element and the second lug would be mounted between the second and third turns of the helical spring adjacent to the opposite abutment. This second lug would obviously then move into engagement with the opposite abutment upon one complete revolution of the shaft. One complete revolution of the shaft would of course move the other lug out of engagement with its abutment, but one complete revolution of the shaft in the opposite direction would again move this lug back into engagement with its abutment. In this particular arrangement of the stop mechanism, the number of turns in the helical spring would, of course, be immaterial.

Although the now preferred embodiments of the present invention have been shown and described herein, it is to be understood that the same is not to be limited thereto, for it is susceptible to changes in form and detail within the scope of the appended claims.

I claim:

1. A potentiometer of the type described, comprising: 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 the 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 substantially equal to the helix angle of said resistance element; said guide element extending into said space and engageable with at least one of adjacent turns defining said space; a contact carried by said contact assembly and spaced from said guide element; 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 maintain said contact in engagement with said resistance element; and means, separate from said contact assembly, for engaging and positively holding said rotor against continued rotation after said contact assembly has moved said contact into engagement with either end of said element, thereby limiting movement of said contact to movement between predetermined positions at opposite ends of said element.

2. A potentiometer of the type described, comprising: a resistance element providing a plurality of turns extending around an axis, there being a space between adjacent turns of the same figuration as said resistance element; a contact assembly, including a guide element extending into said space between adjacent turns of the element; said contact assembly providing a contact spaced from said guide element and retained in contact with one of said turns by said assembly as the same moves along said axis; a rotor journalled to turn about said axis; means for mounting said contact assembly to move along

said rotor to retain said guide element between said adjacent turns while advancing said contact along said resistance element; a pair of spaced abutments formed on said rotor; shear-resisting means reciprocally movable longitudinally of said rotor between and into engagement with one or the other of the said abutments; and means for moving said shear-resisting means in opposite directions longitudinally of said rotor upon rotation thereof in opposite directions, the engagement of said shear-resisting means with either of said abutments holding said rotor against further rotation in the direction producing movement of said shear-resisting means into engagement with the engaged abutment.

3. A potentiometer of the type described, comprising: a resistance element disposed helically about an axis to provide a plurality of turns, said element including a core and a resistance wire wound substantially helically therearound to form minor turns, the minor turns formed by the opposite ends of said resistance wire being located inwardly of the opposite ends of said core to form exposed core portions at the opposite ends of said core; a shaft coaxially mounted for rotational movement relative to said resistance element; contact means engaging said element and keyed to said shaft for rotational movement therewith; means carried by said contact means extending intermediate adjacent turns of said element and reacting therewith to move said contact means longitudinally of said shaft as the same is rotated, whereby rotation of said shaft moves said contact means in a helical path along said element; a pair of abutments longitudinally spaced apart on said shaft; stop means movable between and into engagement with said abutments; said stop means holding said shaft against rotation when moved into engagement with one or the other of said abutments; and means for synchronizing movement of said stop means relative to said abutments with movement of said contact means whereby said stop means moves into engagement with one or the other of said abutments as said contact means moves into engagement with one or the other of the minor turns formed by the opposite ends of said resistance wire.

4. A potentiometer of the type described, comprising: a helical resistance element having a pre-selected number of turns; a shaft; means for mounting said shaft coaxially of said element for rotational movement relative thereto: a contact adapted to engage said element; a contact carrier mounted to said shaft for rotational movement therewith and longitudinal movement there along, said carrier extending between adjacent turns of said element and reacting therewith to move said contact along said resistance element as said shaft is rotated; a pair of abutments longitudinally spaced apart on said shaft; a lug; means carried by said mounting means for holding said lug against rotation with said shaft while permitting movement of said lug longitudinally of said shaft between and into engagement with one or the other of said abutments; a helical spring fixedly sleeving said shaft and disposed between said abutments, said spring defining a helical passageway having a number of turns equal to the number of turns of said resistance element; the turns of said spring moving said lug longitudinally of said shaft as the latter is rotated; the movement of said lug into engagement with one or the other of said abutments holding said shaft against further rotation in the direction producing movement of said lug into engagement with the engaged abutment.

5. A potentiometer of the type described, comprising: a helical resistance element having a preselected number of turns; a shaft coaxially mounted for rotational movement relative to said element; a contact adapted to engage said element; a contact carrier mounted to said shaft for rotational movement therewith and longitudinal movement therealong, said carrier extending between adjacent turns of said element and reacting therewith to move said contact along said resistance element as said shaft is rotated; a pair of abutments longitudinally spaced apart on said shaft; a lug; means for supporting said shaft for rotation, including means for mounting said lugs for reciprocal movement longitudinally of said shaft between and into engagement with one or the other of said abutments; and a helical spring sleeving said shaft and disposed between said abutments, said spring defining a helical passageway having a number of turns equal to the preselected number of turns of said resistance element; said lug being mounted for relative movement through the turns of said spring as the latter rotates with said shaft, whereby rotation of said shaft moves said lug longitudinally of said shaft, the engagement of said lug with one or the other of said abutments holding said shaft against further rotation in the direction producing movement of said lug into engagement with the engaged abutment.

6. A potentiometer of the type described, comprising: a helical resistance element having a preselected number of turns; a shaft coaxially mounted for rotational movement relative to said element; a contact adapted to engage said element; a contact carrier transversely mounted to said shaft for rotational movement therewith and longitudinal movement therealong, said carrier extending between adjacent turns of said element and reacting therewith to move said contact along said resistance element as said shaft is rotated; a pair of spaced abutments formed on said shaft; a lug retained against rotation and mounted for reciprocal movement longitudinally of said shaft between and into engagement with one or the other of said abutments; means carried by said shaft and disposed between said abutments defining a helical passageway having a number of turns equal to the number of turns of said resistance element; said lug being mounted for relative movement through the turns of said passageway as said last named means rotates with said shaft; the engagement of said lug with one or the other of said abutments holding said shaft against further rotation in the direction producing movement of said lug into engagement with the engaged abutment.

7. A potentiometer of the type described, comprising: a resistance element disposed helically about an axis to provide a plurality of space turns; a shaft mounted for rotation about an axis coincident with said first named axis; a relatively thin disc of insulating material keyed to said shaft for rotational movement therewith and longitudinal movement therealong; a flexible arm having one end fixed to said disc; and a contact carried adjacent to the free end of said arm and resiliently held thereby in engagement with said element; said disc being formed with a slit radially extending inwardly from the periphery thereof; the free end of said arm extending through said slit and holding the defining edges

of said slit spaced apart to form the periphery of said disc as a helix having a pitch substantially equal to the distance between adjacent turns of said resistance element; the periphery of said disc extending between adjacent turns of said resistance element and reacting therewith as said disc rotates with said shaft to move said disc longitudinally of said shaft and the contact around the turns of said element.

8. A potentiometer of the type described, comprising: an open ended housing providing an internal cylindrical wall surface; a sheet of insulating material coiled to extend around said wall surface with the opposite end portions thereof in overlapping arrangement; a resistance element disposed helically about an axis to provide a plurality of equally spaced turns; means bonding the outer surfaces of said turns to the inner surface of said coiled sheet engaging said cylindrical wall surface; means closing the open ends of said housing; means for holding said closing means against displacement from said housing, said holding means securing said coiled sheet to said housing thereby fixing said resistance element against the movement relative to said housing; an electrical conductor connected to opposite ends of said resistance element, the inner overlapping end portion of said sheet having an opening formed therein through which at least one of said conductors is passed to longitudinally extend between said overlapping end portions.

9. A potentiometer of the type described, comprising: a resistance element disposed helically about an axis to provide a number of turns; a shaft; means for mounting said shaft for rotation about an axis coincident with said first named axis, a contact assembly mounted to said shaft for rotation therewith and longitudinal movement therealong; means for moving said assembly longitudinally of said shaft as the same is rotated; a contact mounted to said assembly and engaged with and movable about the turns of said element as said assembly is moved along said shaft as it rotates therewith; means fixed to said shaft defining a passageway helically arranged about an axis coincident with the axis of rotation of said shaft, said passageway formed of the same number of turns as said element; a member slidably mounted in a groove formed in said shaft-mounting means longitudinally extending relative to said shaft; said member having a portion thereof disposed within said passageway and relatively movable therethrough as said shaft is rotated; an abutment fixed to said shaft and disposed at each end of said passageway, revolutions of said shaft equal in number to the turns of said element moving said member from a position in which the same is engaging one of said abutments to a position in which the same is engaging the other of said abutments while simultaneously moving said contact from a predetermined position adjacent one end of said element to a predetermined position adjacent the other end of said element.

10. A potentiometer of the type described, comprising: a resistance element disposed helically about an axis to provide a number of turns equally spaced apart; a shaft; means for mounting said shaft for rotation about an axis coincident with said first named axis; a contact assembly mounted to said shaft for rotation therewith and longitudinal movement therealong; means carried by said assembly extending between adjacent turns of said element and reacting therewith to move said assembly longitudinally of said shaft as the same is rotated; a contact mounted to said assembly and engaged with and movable about the turns of said element as said assembly is moved along said shaft; means on said shaft defining a helical passageway of the same number of turns as said element; a member held against rotation with said shaft and movable longitudinally of the same; said member having a portion thereof disposed within said passageway and relatively movable therethrough as said shaft is rotated; and an abutment fixed to said shaft and disposed at each end of said passageway; movement of said member into engagement with either one of said abutments by rotation of said shaft holding said shaft against a continued rotation in the direction producing movement of said member into engagement with an abutment.

11. A potentiometer of the type described, comprising: a resistance element disposed helically about an axis to provide a plurality of turns, said element including a core and a resistance wire wound substantially helically therearound to form minor turns, the minor turns formed by the opposite ends of said resistance wire being located inwardly of the opposite ends of said core to form exposed core portions at the opposite ends of said core; a shaft coaxially mounted for rotational movement relative to said resistance element; contact means engaging said element and keyed to said shaft for rotational movement therewith; means carried by said contact means extending intermediate adjacent turns of said element and reacting therewith to move said contact means longitudinally of said shaft as the same is rotated, whereby rotation of said shaft moves said contact means in a helical path coincident with the turns of said element; a pair of abutments longitudinally spaced apart on said shaft; a lug movable between and into engagement with one or the other of said abutments; said last named means holding said shaft against rotation when moved into engagement with one or the other of said abutments; and a helical spring surrounding said shaft between said abutments, said spring defining a helical passageway of the same number of turns as said resistance element and synchronizing movement of said lug relative to said abutments with movement of said contact means relative to said element whereby said lug moves into engagement with one or the other of said abutments as said contact means moves into engagement with one or the other of the minor turns formed by the opposite ends of said resistance wire.

12. A potentiometer of the type described, comprising: a resistance element disposed helically about an axis to provide a number of turns equally spaced apart; a shaft; means for mounting said shaft for rotation about an axis coincident with said first named axis; a contact assembly mounted to said shaft for rotation therewith and longitudinal movement therealong; means carried by said assembly extending between adjacent turns of said element and reacting therewith to move said assembly longitudinally of said shaft as the same is rotated; a contact mounted to said assembly and engaged with and movable about the turns of said element as said assembly is moved along said shaft by rotation thereof; a pair of abutments longitudinally spaced apart on said shaft; a helical spring coaxially fixed to said shaft intermediate said abutments; the coils of said spring defining a helical passageway of the same number of turns as said resistance element;

and a lug mounted for sliding movement longitudinally of said shaft, a portion of said lug extending into said passageway, whereby rotation of said shaft moves said lug relatively through said passageway coincident with movement of said contact about the turns of said element; engagement of said lug with one or the other of said abutments holding said shaft against rotation, thereby limiting movement of said contact relative to the turns of said element between predetermined positions at opposite ends of said element.

13. A potentiometer of the type described, comprising: a helical resistance element having a preselected number of turns; a shaft coaxially mounted for rotational movement relative to said element; a contact adapted to engage said element; a contact carrier transversely mounted to said shaft for rotational movement therewith and longitudinal movement therealong, said carrier extending between adjacent turns of said element and reacting therewith to move said contact along said resistance element as said shaft is rotated; a pair of spaced helical surfaces coaxially formed on said shaft; an abutment formed on each surface and presenting a face substantially parallel to the axis of said shaft and of a width substantially equal to the pitch of said helical surfaces; a multi-turn spring fixed to said shaft and defining a helical passageway of the same number of turns as said element extending between said surfaces; a lug slidably mounted relative to said shaft; a portion of said lug extending between adjacent turns of said spring; means for holding said lug against rotational movement with said spring as the shaft is rotated to move said contact along said element; the turns of said spring as the latter rotates with said shaft slidably moving said lug longitudinally of said shaft, movement of said lug relative to the turns of said spring coinciding with movement of said contact relative to the turns of said element so that said lug moves into engagement with one or the other of said abutments as said contact moves into a predetermined position at one end or the other of said element, the spaced helical surfaces cooperating with said spring to move said lug a distance substantially equal to the width of the faces of said abutment during the revolution of said shaft relatively moving said lug through either of the outer turns of said passageway.

14. A potentiometer of the type described, comprising: a helical resistance element having a preselected number of turns; a shaft coaxially mounted for rotational movement relative to said element; a contact carrier transversely mounted to said shaft for rotational movement therewith and longitudinal movement there along; a contact mounted to said carrier and adapated to engage said element; said carrier extending between adjacent turns of said element and reacting therewith to move said contact along said resistance element as said shaft is rotated; said shaft being reduced in diameter to form an annular groove therearound; an abutment formed on each of the opposite side walls of said groove; said side walls each defining a helical surface of a pitch substantially equal to the width of each abutment, each surface leading to the abutment formed thereon; a helical spring coaxially fixed to said shaft and disposed within said groove to extend between said abutments; said spring defining a helical passageway having the same number of turns as said resistance element; a lug slidably mounted relative to said shaft; a portion of said lug extending between adjacent turns of said spring; means for holding said lug against rotational movement with said spring as the shaft is rotated to move said contact along said element; the turns of said spring as the latter rotates with said shaft slidably moving said lug longitudinally of said shaft, movement of said lug relative to the turns of said passageway coinciding with movement of said contact relative to the turns of said element so that said lug moves into engagement with one or the other of said abutments as said contact moves into a predetermined position at one end or the other of said element, the helical surface formed on each side wall of said groove cooperating with said spring to move said lug a distance substantially equal to the width of the abutment during the revolution of the shaft relatively moving said lug through either of the outer turns of said passageway.

15. A potentiometer of the type described, comprising: a helical resistance element having a preselected number of turns; a shaft coaxially mounted for rotational movement relative to said element; a contact carrier transversely mounted to said shaft for rotational movement therewith and longitudinal movement therealong, said carrier extending between adjacent turns of said element and reacting therewith to move said contact along said resistance element as said shaft is rotated; said shaft being reduced in diameter to form an annular groove therearound; an abutment formed on each of the opposite side walls of said groove; a helical spring defining a helical passageway of the same number of turns as said element, said spring coaxially fixed to said shaft and disposed within said groove to extend between said abutments; a lug slidably mounted relative to said shaft; a portion of said lug extending between adjacent turns of said spring; means for holding said lug against rotational movement with said spring as the shaft is rotated to move said contact along said element; the turns of said spring as the latter rotates with said shaft slidably moving said lug longitudinally of said shaft, movement of said lug relative to the turns of said passageway coinciding with movement of said contact relative to the turns of said element so that said lug moves into engagement with one or the other of said abutments as said contact moves into a predetermined position at one end or the other of said element.

16. An instrument of the type described, comprising: a shaft; means for mounting said shaft for rotational movement about the longitudinal axis thereof; means operatively connected to said shaft and moved thereby as the same is rotated; and means for limiting rotational movement of said shaft to a predetermined number of revolutions thereby preselectively limiting movement of said last named means, said limiting means including means on said shaft defining a helical passageway having turns of the same number as said predetermined number, a member held against rotation with said shaft and movable longitudinally of the same, said member having a portion thereof disposed within said passageway and relatively movable through one complete turn thereof upon each complete revolution of said shaft, and an abutment fixed to said shaft and disposed at each end of said passageway, movement of said member into engagement with either one of said abutments by rotation of said shaft holding said shaft against continued rota-

tion in the direction producing movement of said member into engagement with an abutment.

17. An instrument of the type described, comprising: a shaft; means for mounting said shaft for rotational movement about the longitudinal axis thereof; means operatively connected to said shaft and moved thereby as the same is rotated; and means for limiting rotational movement of said shaft to a predetermined number of revolutions, thereby preselectively limiting movement of said last named means between alternate limit positions, said limiting means including a pair of abutments longitudinally spaced apart on said shaft, a helical spring surrounding said shaft between said abutments, said spring defining a helical passageway having turns of the same number as said predetermined number, a lug mounted between the coils of said spring and movable through the passageway defined thereby upon rotation of said shaft and into engagement with one or the other of said abutments depending upon the direction of rotation of said shaft, the helical passageway formed by said spring synchronizing movement of said lug relative to said abutments with movement of the means operatively connected to said shaft, whereby said lug moves into engagement with one or the other of said abutments as said means is moved into one or the other of its limit positions.

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