Nov. 8, 1960 F. H. KARG 2,959,729

ROTARY POTENTIOMETER

Filed Nov. 6, 1959

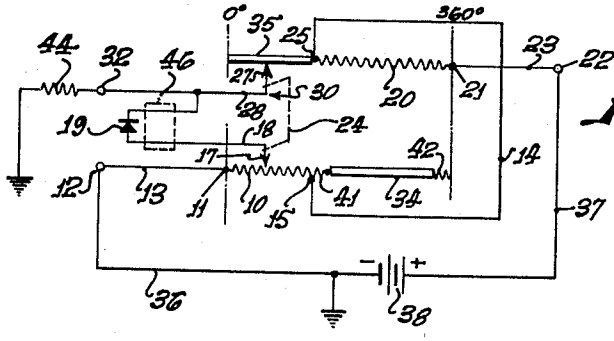


FIG. 1.

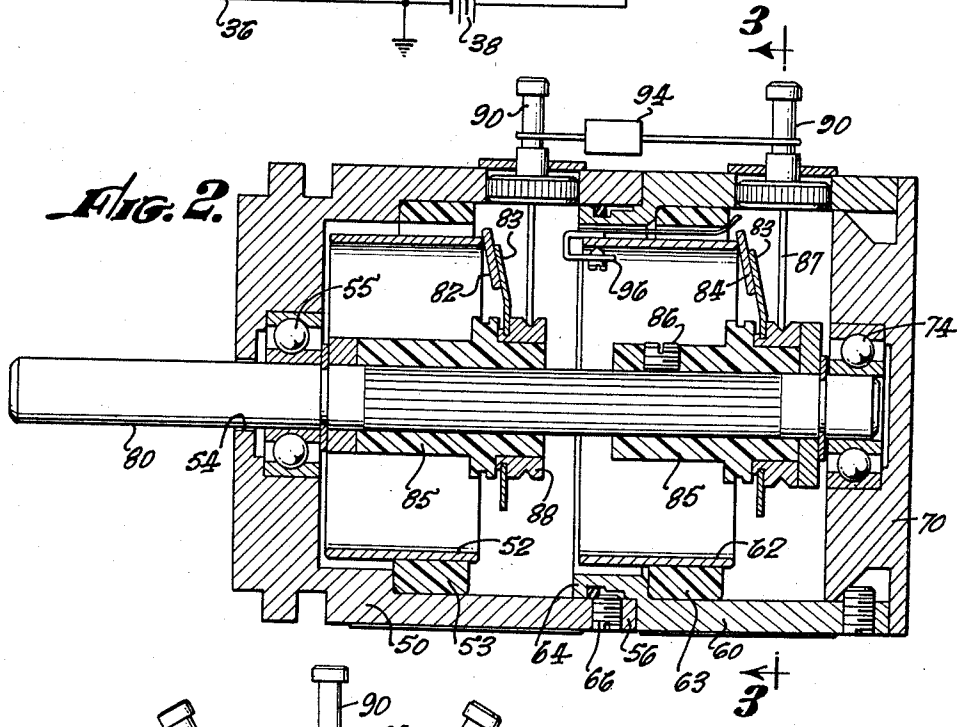


FIG. 2.

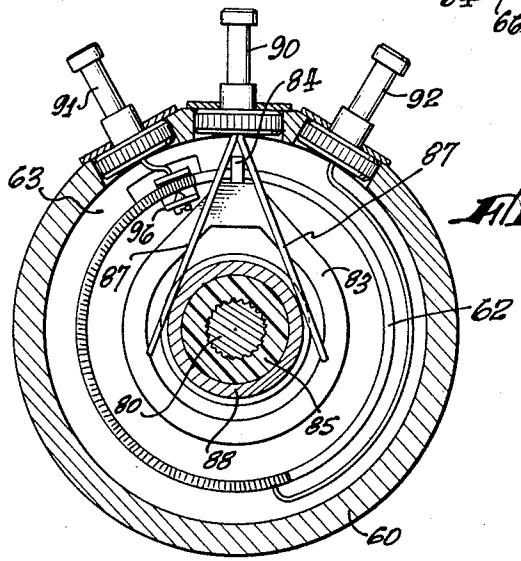


FIG. 3.

FRED H. KARG,
INVENTOR.

BY Barlow & Lewis

United States Patent Office 2,959,729 Patented Nov. 8, 1960

2,959,729

ROTARY POTENTIOMETER

Fred H. Karg, Burbank, Calif., assignor to Giannini Controls Corporation, Pasadena, Calif., a corporation of New York

Filed Nov. 6, 1959, Ser. No. 851,379

7 Claims. (Cl. 323—79)

This invention has to do generally with rotary potentiometers, comprising a resistance element that is curved, typically in a circular arc, and is engaged by an angularly movable brush, typically rotatable about the axis of curvature of the resistance element.

The invention relates more particularly to rotary potentiometers that are operable through an angle of substantially 360° or more.

The invention is particularly useful in connection with potentiometers wherein the brush is continuously rotatable, producing an output that is a periodic function of the brush angle, with a period of 360°.

A primary difficulty in constructing such potentiometers in the past has been the tendency of the brush to make contact with one end of the resistive element before it breaks contact with the other end. The brush thus tends to contact both ends of the element simultaneously, short circuiting the input terminals to the element. Alternatively, if the ends of the element are spaced apart circumferentially by a sufficient amount to prevent such short circuiting action, the brush tends to be momentarily out of contact with the element, interrupting the desired signal output.

The present invention avoids those and other difficulties in a particularly effective and convenient manner. That is typically accomplished by providing two distinct resistive elements or winding segments, which are connected in series. The potentiometer is typically provided with two input terminals which are connected to the respective winding segments adjacent opposite ends thereof, the other end portions of the winding segments being connected together. Those connections to the winding segments may be angularly adjustable, if desired. Separate brushes are provided for the respective winding segments. Each winding segment is made less than 360° in extent, the sum of the effective working portions of the winding segments being substantially equal to 360°. The winding segments are preferably arranged coaxially, but are spaced from each other transversely of their length, such spacing being typically either axial or radial in direction. Thus each brush can swing beyond the angular limits of its winding segment without contacting the other winding segment.

In accordance with the invention, the two brushes are connected in parallel to the effective output terminal of the potentiometer, means being provided in such connection to prevent current flow from one of the brushes to the other.

In preferred form of the invention, the two winding segments are carried on respective supports which are mounted coaxially in a manner permitting mutual angular adjustment. The two brushes are typically mounted on a common shaft, on which they may also be angularly adjustable. One or both of the winding supports may comprise portions of a housing structure that encloses the windings and brushes and provides bearing supports for the brush shaft.

A full understanding of the invention, and of its further objects and advantages, will be had from the following description of certain illustrative manners in which it may be carried out. The particulars of that description, and of the drawings which form a part of it, are intended only for illustration, and not as a limitation upon the scope of the invention, which is defined in the appended claims.

In the drawings:

Fig. 1 is a schematic drawing representing an illustrative embodiment of the invention;

Fig. 2 is an axial section representing an illustrative manner of constructing a potentiometer in accordance with the invention; and

Fig. 3 is a transverse section, taken on the line 3—3 of Fig. 2.

Fig. 1 represents the invention illustratively in the form of a schematic diagram, wherein the characteristically cylindrical form of the device has been developed onto a plane for clarity of illustration. Thus, the vertical lines denoted 0° and 360° represent a common axial plane of the actual device. The potentiometer winding comprises the two winding segments 10 and 20. Opposite end points 11 and 21 of the two winding segments are connected to the respective terminals 12 and 22 by the lines 13 and 23. Those terminals will be referred to for convenience as power or input terminals, since they are ordinarily, although not necessarily, connected to a suitable source of electrical power to produce a voltage drop in the potentiometer winding. Adjacent end points 15 and 25 of the two winding segments are connected together by the line 14, so that current can flow between power terminals 12 and 22 through the two winding segments in series. The angular relationship between end points 15 and 25 is determined, in a manner to be described, with relation to the respective brush actions; but those end points may be varied together as may be desired. One winding segment may, for example, extend only a few degrees, the length of the other being correspondingly increased so that their sum is substantially 360°.

The described opposite end points 11 and 21 and the adjacent end points 15 and 25 of the winding segments are not all necessarily at the extreme physical termination points of the actual winding structures. However, it is convenient to refer to those points as end points of the winding segments, since, as connection points of the described lines 13, 14 and 23, they define the effective ends of the actual working portions of the winding segments, as will appear more fully below. In the present illustrative instance, winding 10 extends to the right in Fig. 1 beyond end point 15, as shown at 41; and extends to the left beyond end point 11, as shown at 42. The portion 42 appears at the right edge of the developed diagram, but its right hand extremity is physically connected to left end point 11 of the winding proper.

The brush assembly 30, as represented in Fig. 1, comprises the two brushes 17 and 27, which are adapted to slidingly engage the respective winding segments 10 and 20. Brushes 17 and 27 are mechanically linked together with respect to their movement, as indicated schematically by the dashed line 24. As shown, the brushes are electrically connected in parallel to the terminal 32 via the respective lines 18 and 28. Terminal 32 will be referred to as an output terminal, but without implying any limitation upon the function or manner of connection of the potentiometer in any actual electrical system.

A unidirectional conduction device is provided in at least one of the lines 18 and 28. Such devices may be of any suitable type, such as vacuum tube or semiconductor diodes, for example. In the present embodiment, a single unidirectional device is represented schematically at 19 in line 18, oriented to permit current flow only in the direction from brush 17 toward terminal 32.

Suitable guide surfaces for the brushes are typically provided in those portions of the brush movement beyond the physical boundaries of the respective winding segments. Such surfaces, represented as the guide bars **34** and **35**, may be formed of dielectric material; or may comprise portions of initially continuous windings which have been severed to insulate them from other electrical components of the assembly.

In operation of the potentiometer, power terminals **12** and **22** are typically connected via the lines **36** and **37** to suitable sources of low and high potential, respectively, such, for example, as the grounded negative terminal and the positive terminal of a battery, as represented schematically at **38**. Output terminal **32** is typically connected to a negative reference potential or ground via a load resistance, indicated at **44**, which is high compared to the total resistance of the potentiometer winding. Resistance **44** may, for example, comprise the grid leak of a vacuum tube input circuit.

In discussing the brush action it will be convenient to distinguish the winding segments and their respective brushes by the terms "upper" and "lower," referring to their position as shown in Fig. 1, but not implying any necessary orientation of an actual potentiometer. With brush assembly **30** in the typical position shown in Fig. 1, lower brush **17** engages winding segment **10**, while upper brush **27** is isolated from segment **20**, riding on insulated bar **35**. The potential of output terminal **32** is therefore lifted above ground to the potential of that point of lower winding segment **10** at which it is engaged by brush **17**. That potential rises gradually as the brush moves to the right toward end point **15**.

The apparatus is preferably so dimensioned and adjusted that rightward brush movement causes upper brush **27** to first engage winding **20** at its end point **25** just as lower brush **17** reaches end point **15**. Such engagement causes no appreciable change in the potential at output terminal **32**, since the points **15** and **25** are at a common potential, due to connection **14**. Further brush movement to the right as seen in Fig. 1 causes the output potential at terminal **32** to increase smoothly in accordance with the potential tapped by upper brush **27**. Lower brush **17** typically continues for a short time to engage its winding **10**, due to the finite width of the brush; and may move for an appreciable angular distance over the portion **41** of the winding to the right of **15**, if such portion is present. But neither of those actions significantly affects the output signal at **32**, since the blocking action of diode **19** prevents brush **17** from lowering the output potential below that set by brush **27**. The exact length of winding portion **41** is therefore immaterial, so far as operation is concerned, and may have any convenient value. Winding portion **41** may be omitted altogether, if desired, though its presence generally facilitates smooth and continuous action of the potentiometer, as well as its construction and adjustment. After lower brush reaches insulated bar **34**, the output continues to be controlled by upper brush **27** and winding segment **20**.

As the brush movement approaches the lines 0° and 360° of Fig. 1, lower brush **17** again engages winding segment **10**, this time at the portion **42** which extends leftward beyond end point **11**. However, the output potential continues to be controlled by upper brush **27**, since the relatively low potential of portion **42**, corresponding to ground potential in the present instance, cannot be immediately communicated to output terminal **32**, due to the blocking action of diode **19**. The length of portion **42** may have any convenient value, including zero.

When upper brush **27** leaves winding **20**, that controlling circuit is opened, and the potential of output terminal **32** is free to drop, due to current through resistance **44** and reverse current through diode **19**, to the value set by lower brush **17**. The apparatus is preferably so arranged, with due regard for the finite brush widths, that brush **17** has then just reached end point **11** of winding **10**. Further brush movement then causes smooth increase of output potential from the minimum level of input terminal **12**. It is therefore evident that right hand brush movement produces a continuous output at terminal **32** that correctly represents the brush position at all times.

Movement of brush assembly **30** to the left as seen in Fig. 1 also causes smooth changes of output potential without any possibility of shorting the power terminals and without gaps or irregularities in the control action. As the brushes move leftward from the position illustrated, upper brush **27** engages end point **21** of winding **20** taking over effective control of the output potential regardless of the fact that lower brush **17** may continue to engage winding portion **42**, since the lower voltage of that portion is blocked by diode **19**. And upper brush **27** gives up control of the output potential only after breaking contact with winding **20** at end point **25**, regardless of the fact that lower brush **17** may previously have reached winding portion **41**.

The extensions **41** and **42** may be shorted, as with solder, for example, so that their effective voltage is independent of current drawn by the brush.

If it should be desired for any reason to reverse the connection of the potentiometer winding in the external circuit, so that power terminal **12** is positive with respect to terminal **22**, it is only necessary to reverse the polarity of unidirectional device **19**, so that it permits current flow from output terminal **32** toward brush **17**. Then, as in the arrangement illustrated, upper brush **27** controls the output potential whenever it is engaging its winding segment **20**. That arrangement, with both the supply voltage and diode **19** reversed from their illustrated directions, is useful, for example, when the output terminal **32** is to be connected to a circuit which tends to raise the potential of the terminal, rather than to lower it, as was assumed in the preceding description of Fig. 1. Thus, for example, when the output load, represented at **44**, is returned to a relatively negative reference potential, the arrangement of Fig. 1 is appropriate; when that reference potential is relatively positive, the inverted arrangement is appropriate. To facilitate reversal of the polarity of unidirectional device **19**, a reversing switch, which may be of conventional type, may be provided, as indicated schematically at **46**.

For many purposes it is unnecessary to provide extensions of one winding in both directions beyond the end points of its working portion, as illustratively shown at **41** and **42** in Fig. 1. For example, both of those portions can be omitted, and accurate construction and adjustment can be relied upon to give smooth and accurate transition from one brush to the other. It is usually helpful, however, to provide a winding extension at least at **41**, which controls the brush transition that occurs at a potential intermediate the supply potentials at power terminals **12** and **22**. And it is ordinarily preferred to provide extensions of one winding segment in both directions.

Figs. 2 and 3 represent an illustrative structure for carrying out the invention. Two mounting members **50** and **60** carry the respective winding segments **52** and **62**, which typically correspond to segments **10** and **20** of Fig. 1. Those winding segments may comprise resistive elements of any suitable type, including, for example, carbon resistors as well as wire-wound assemblies. When wire-wound resistance elements are employed, they may typically be toroidally wound on annular forms of conventional type, or may be wound on initially straight forms which are then bent to circular shape. Each of the winding segments may be made from a complete winding, substantially 360° in angular extent, which is then severed at one or more selected angular positions

to electrically isolate a portion corresponding to the insulative guide rail 34 or 35 of Fig. 1. The winding segments are typically mounted in their supports 50 and 60 by means of insulative mounting rings 53 and 63, respectively.

As shown, support 50 is of cup form, with a coaxial bore at 54 adapted to receive a bearing 55. Support 60 is of sleeve form with a flange 64 at one end adapted to coaxially engage the circular edge 56 of support 50, thus providing an angularly adjustable connection between the two supports. That adjustment can be locked, as by the set screws 66.

A circular end plate or cap 70 is mounted on support 60 at its end opposite to flange 64, as by the set screws 72. Cap 70 and the two support members form a closed housing enclosing the two resistance elements 52 and 53 and the brush structure to be described. A bearing seat for a second ball bearing 74 is typically provided coaxially on the inner face of cap 70.

A potentiometer shaft 80 is rotatably mounted in the bearings 55 and 74, with one end accessible outside the housing. Two brushes 82 and 84, which may be of conventional type, are mounted on shaft 80, as by the spring arms 83 and the collars 85 of insulative material, in position to engage edges of the respective winding segments 52 and 62. At least one of the brushes may be angularly adjustable with respect to shaft 80; as by release of the set screw 86, thereby facilitating the production of any desired mutual angular relation of the brushes, which correspond to brushes 17 and 27 of Fig. 1. However, that adjustment is unnecessary in the present embodiment, since relative rotation of the two housing members 50 and 60 provides an equivalent fine adjustment more conveniently.

Three insulated terminal structures are provided for each winding segment, and are typically mounted in bores in the side walls of support members 50 and 60. As illustratively shown, one terminal structure 90 of each set carries a light metal spring 87 of V-form. Spring 87 slidingly engages a groove in the metal slip ring 88, by which each brush is carried on the collar 85. Two terminal structures of each set, indicated at 91 and 92 in Fig. 3, facilitate the electrical connections, already described, to the end points of each resistance element. Those connections may be made permanently, as with solder.

If it should be desired to make those connections adjustable, any available mechanism for that purpose may be utilized. Such mechanism is represented illustratively as a screw clamp fitting, indicated schematically at 96, which is representative of a wide variety of structures by which contact may be made at a variable point of a resistive element.

The terminal structures that are connected to the winding end points corresponding to 15 and 25 of Fig. 1, may be connected together directly, either internally or externally of the housing; and if that connection is internal, those terminal structures need not extend through the housing wall. The two terminal structures carrying contact springs 87 to the brushes are similarly connected together via the unidirectional device already described, which may itself be either internal or external of the housing as preferred. That device, corresponding to 19 of Fig. 1, is represented schematically at 94 in Fig. 2, connected externally between the terminal structures 90. The appropriate one of those two terminal structures may then be utilized as the output terminal of the potentiometer, corresponding to terminal 32 of Fig. 1. The two terminal structures that are connected to the winding end points corresponding to 11 and 21 of Fig. 2 may be utilized as power or input terminals of the potentiometer.

It will be understood that many changes may be made in the particulars of the illustrative structures that have been described without departing from the proper scope of the invention. For example, many different techniques are known for shaping potentiometer windings, including the use of forms of varying section and of non-circular shape.

I claim:

1. Rotary potentiometer means, comprising in combination, two substantially circularly curved resistive elements, structure mounting the elements in coaxial relation with respect to an axis, two input terminal means connected to end connection points adjacent opposite ends of the respective elements, means electrically interconnecting the elements at respective connection points thereof that are angularly spaced from said end connection points by respective angles whose sum is substantially 360 degrees, two brush means angularly movable over the respective elements, means for rotating both brush means about the axis in fixed mutual angular relation, output terminal means, and circuit means connecting the output terminal means to both said brush means, said circuit means including means acting to prevent current flow from one brush means to the other.

2. Rotary potentiometer means as defined in claim 1, and wherein the last said means comprises a unidirectional device connected in series with one of the brush means.

3. Rotary potentiometer means as defined in claim 1, and wherein one of the resistive elements extends angularly beyond at least one of the said connection points thereof.

4. Rotary potentiometer means as defined in claim 1, and wherein one of the resistive elements extends angularly beyond at least one of said end points thereof, and wherein the last said means of claim 1 comprises a unidirectional device connected in series with the brush means of said one resistive element.

5. Rotary potentiometer means comprising in combination, two rotary potentiometer units each comprising a support, an electrical resistive element mounted on the support and brush means angularly movable over the resistive element, means for mounting the supports coaxially in definite angular relation, means for driving the two brush means in definite mutual angular relation, two input terminal means connected to opposite end points of the respective resistive elements, means electrically interconnecting the resistive elements at respective connection points thereof that are angularly spaced from said end points by respective angles whose sum is substantially 360 degrees, and output terminal means connected in parallel to the brush means of both potentiometer units.

6. Rotary potentiometer means as defined in claim 5, and including a unidirectional device connected between the output terminal means and the brush means of at least one potentiometer unit.

7. Rotary potentiometer means as defined in claim 5, and including means for adjustably varying the mutual angular relation of the supports.

References Cited in the file of this patent

UNITED STATES PATENTS

1,604,196	Potter	Oct. 26, 1926
1,695,875	Aiken	Dec. 18, 1928
2,012,392	Israel	Aug. 27, 1935
2,769,131	Immel	Oct. 30, 1956
2,850,604	Rowley	Sept. 2, 1958

FOREIGN PATENTS

679,393	Germany	Aug. 4, 1939