July 27, 1965 W. D. HULBERT 3,197,726

POTENTIOMETER

Filed Sept. 12, 1962 4 Sheets-Sheet 1

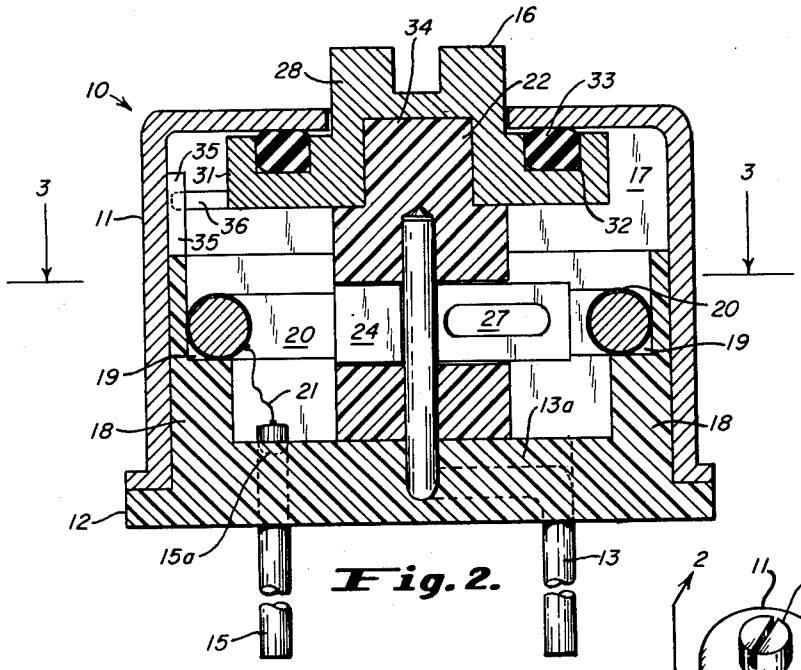

Fig. 2.

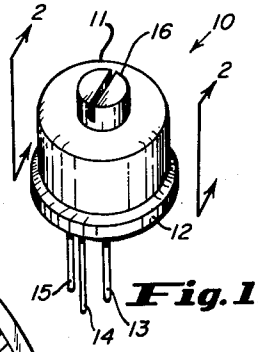

Fig. 1.

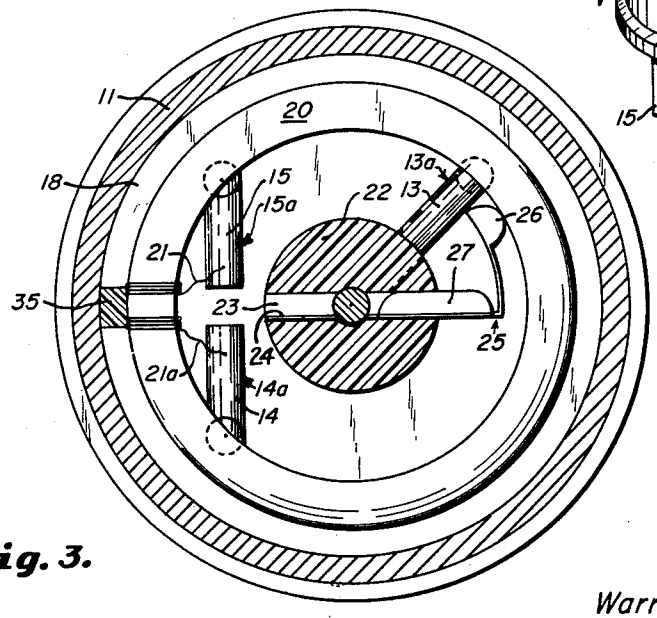

Fig. 3.

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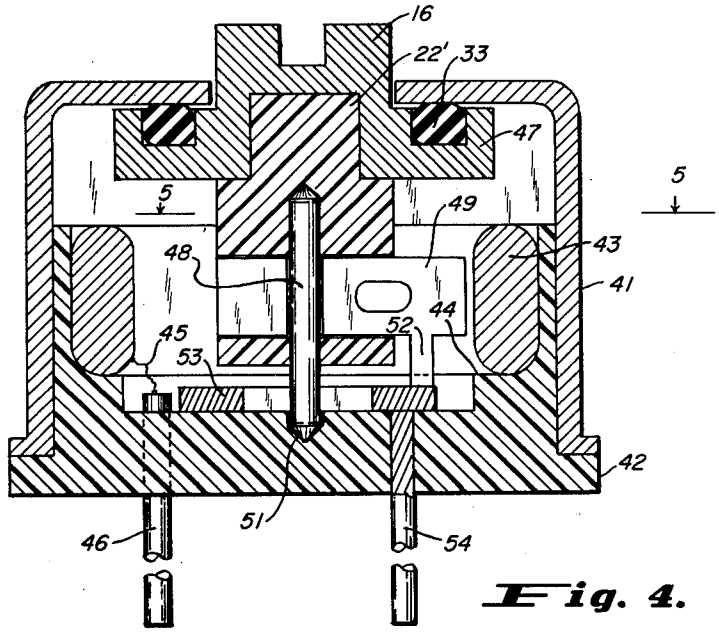

Fig. 4.

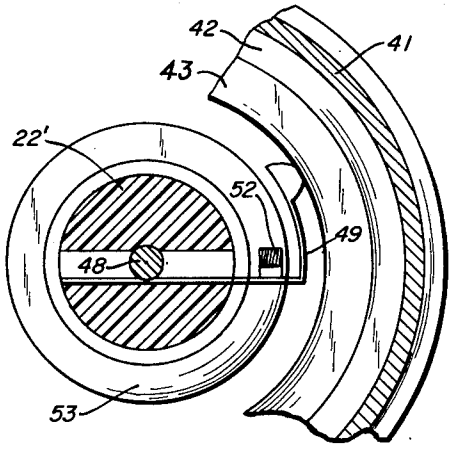

Fig. 5.

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POTENTIOMETER

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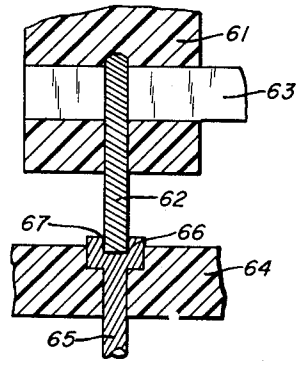

Fig. 8.

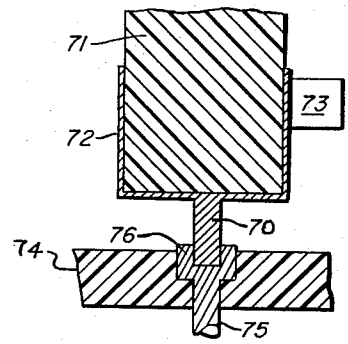

Fig. 9.

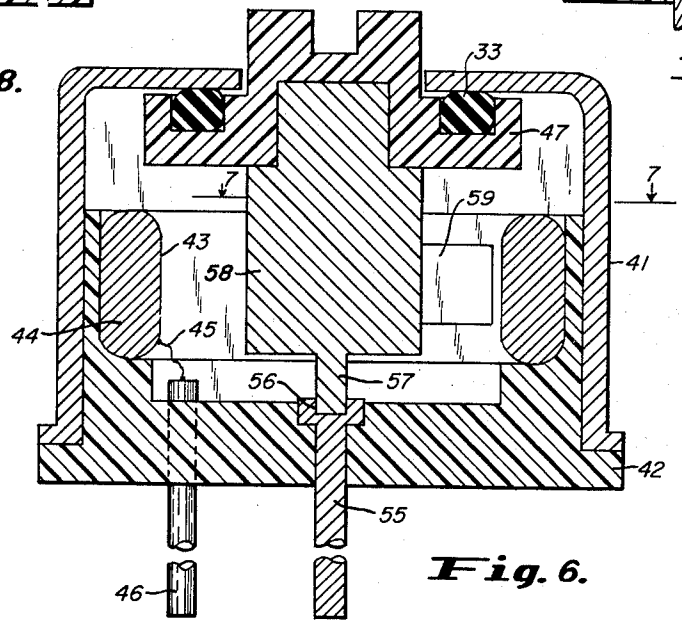

Fig. 6.

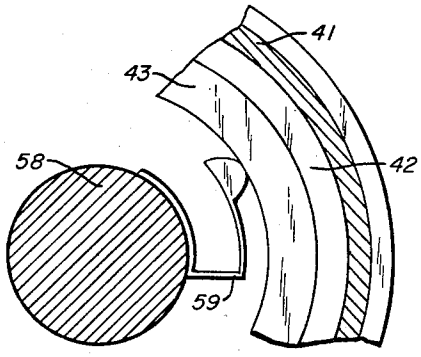

Fig. 7.

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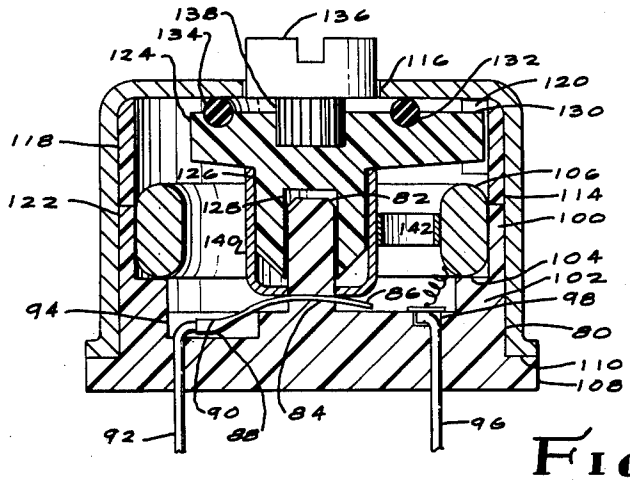

FIG. 10

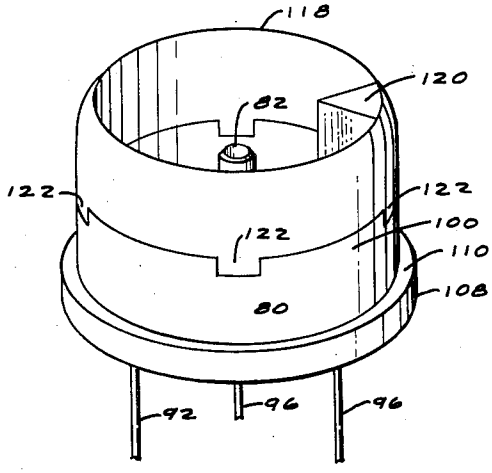

FIG. 12

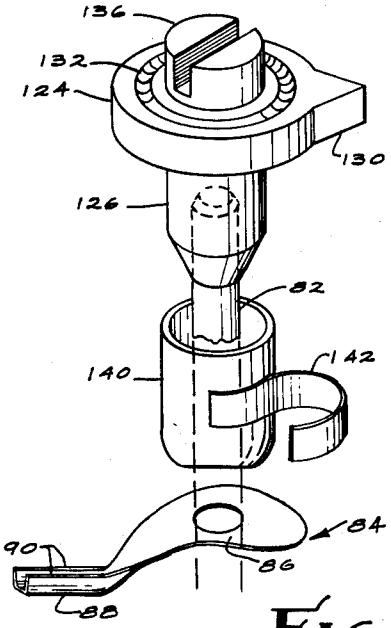

FIG. 11

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3,197,726

POTENTIOMETER

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Filed Sept. 12, 1962, Ser. No. 223,229
4 Claims. (Cl. 338—164)

This invention relates to variable resistors, and more particularly to potentiometers which may be constructed in an exceedingly small size.

The present application is a continuation-in-part of my co-pending application Serial No. 51,879, filed August 25, 1960, now abandoned.

The requirement for variable resistors of the potentiometer type to permit fine adjustment of electrical resistance in electronic and electrical circuits has long been recognized in the prior art and such potentiometers of various sizes and shapes have been developed for this purpose. For example, the rectilinear potentiometer, the lead screw actuated potentiometer and the worm screw and gear actuated potentiometer are known to the prior art. While these prior art potentiometers have been quite successful for the purposes for which they were developed, the various sizes and shapes necessitated by the particular inner mechanisms of each of the different types of potentiometer have caused them to be physically non-compatible with other circuit components such as, for example, transistors, resistors, diodes and the like. Furthermore, as a result of these physical limitations, the prior art potentiometers have not been readily adaptable for use in microcircuits applications such as printed circuits.

For the most part, the prior art potentiometers of the types above referred to have required relatively complex interior mechanisms to provide the operation which is required in the electrical and electronic circuits which utilize such potentiometers. As a result thereof, the size of these potentiometers has been greater than desired in some applications and they have not included designs permitting them to be incorporated along with other circuit components and subsequently encapsulated in plastic or other potting compounds to form a complete sealed module for use in computers and the like.

Accordingly, it is an object of the present invention to provide a potentiometer having an exceedingly small size, that is, subminiature, and which is very light in weight and which is mechanically simple, rugged, and inexpensive to manufacture.

It is another object of the present invention to provide a potentiometer which is compatible both as to size and configuration with small size electrical components.

It is another object of the present invention to provide a potentiometer which is readily adaptable for use in printed circuits.

It is another object of the present invention to provide a potentiometer which is housed in such a manner that it may be encased in plastic or other potting compounds along with additional electrical components comprising an electrical or electronic module.

Additional objects and advantages of the present invention will become apparent from a consideration of the following description taken in conjunction with the accompanying drawings in which similar parts are designated by the same reference numerals and which are presented by way of example only and are not intended as a limitation upon the scope of the present invention and in which:

FIG. 1 is a perspective view of a potentiometer in accordance with the present invention;

FIG. 2 is a cross-sectional view of the potentiometer of FIG. 1 taken about the lines 2—2;

FIG. 3 is a cross-sectional view of the potentiometer of FIG. 2 taken about the lines 3—3;

FIG. 4 is a cross-sectional view of an alternative embodiment of a potentiometer in accordance with the present invention;

FIG. 5 is a partial view of the structure of FIG. 4 taken about the lines 5—5 thereof;

FIG. 6 is an axial cross-sectional view of another alternative embodiment of a potentiometer in accordance with the present invention;

FIG. 7 is a partial view of the structure of FIG. 6 taken about the lines 7—7 thereof;

FIG. 8 is a partial, axial cross-sectional view of an alternative embodiment of a portion of a potentiometer in accordance with the present invention;

FIG. 9 is a partial, axial cross-sectional view of a portion of a potentiometer in accordance with the present invention;

FIG. 10 is an axial cross-sectional view of another example of a potentiometer constructed in accordance with the principles of the present invention;

FIG. 11 is a partially exploded perspective view of a portion of the structure illustrated in FIG. 10; and

FIG. 12 is a perspective view of a different portion of the structure illustrated in FIG. 10.

In accordance with one aspect of the present invention, there is provided a potentiometer having a housing which includes a casing and a base and which defines an internal cavity. A resistance element is positioned within the cavity and fixed electrical connection is made to the resistance element. An electrically conductive element is positioned internally of the housing and is electrically attached to means extending through the base to provide an external electrical connection. A bearing surface is also provided internally of the housing. A rotor having a wiper arm affixed thereto which makes slidable contact with the resistance element is positioned substantially at the center of the housing and includes bearing means which engages the bearing surface. The wiper arm and the electrically conductive element are electrically interconnected to provide an external electrical connection to the resistance element.

In accordance with a more specific aspect of the present invention, the bearing surface and the electrically conductive element above referred to comprise an electrical lead which is semi-rigid and which extends through the base of the housing and into the interior thereof. The rotor includes a member of electrically non-conductive material having an axial opening. The axial opening receives the portion of the electrical lead internal of the housing in such a manner that the rotor is rotatably supported upon the lead substantially at the center of the cavity. The rotor also includes a slotted opening transverse to the longitudinal axis thereof and communicating with the axial opening above referred to. One end of the wiper arm is inserted through the slotted opening and receives the electrical lead in such a manner that the wiper arm is locked in place mechanically between the electrical lead and the axial opening in the rotor and good electrical contact is provided thereby.

Referring now to the drawings, and more particularly to FIG. 1, there is illustrated a potentiometer in accordance with the present invention. As is therein shown, the potentiometer **10** includes a housing having a casing **11** and a base **12**. Protruding through and extending from the base **12** are electrical connections **13**, **14**, and **15** which preferably are electrically conductive leads which are rigid or semi-rigid in nature and which may be plugged into a proper socket member such as, for example, a transistor grid. These leads may be cemented, for example with an epoxy resin, at the base **12** to provide a

dust and moisture proof seal for the housing. A slotted head **16** protrudes from the top of the casing **11** and may be utilized to vary the resistance of the potentiometer as will be explained more fully hereinafter.

Referring now more particularly to FIGS. 2 and 3, the internal construction of a presently preferred embodiment of the potentiometer **10** is illustrated. As is illustrated, the housing defines a substantially circular internal cavity **17**. The base **12** is preferably a molded plastic material such as a phenolic resin and has an annular ring **18** extending upwardly therefrom. The outer surface of the annular ring **18** mates with the inner surface of the casing **11** and the juncture therebetween is cemented to provide a dust and moisture proof seal for the potentiometer. The annular ring **18** is reduced in thickness at its upper portion to form an internal ledge **19** upon which a resistance element **20** is supported.

The resistance element **20** is illustrated as a circular mandrel having resistance wire wound thereabout in a conventional manner. It should, however, be expressly understood that the resistance element **20** may be of any type known to the art such as, for example, a wire wound card, a film or layer of resistive material deposited upon a base therefor in accordance with well-known techniques or the like.

Electrical connection is provided to one end of the resistance element **20** by way of a connective lead **21** which is soldered, welded or otherwise electrically connected to the lead **15** extending through the base **12**. A similar electrical connection is provided to the opposite end of the resistance element **20** by connective lead **21***a* which is affixed to electrical lead **14**.

Leads **14** and **15** extend through the base **12** and are bent so as to fit within recesses **14***a* and **15***a* respectively. Such construction provides a greater surface to which the connective leads **21** and **21***a* may be attached to thereby facilitate assembly of the potentiometer. Such construction also provides a more rigid anchor for the leads. It should also be noted that lead **13** is bent intermediate its end points to provide a substantially horizontal portion which also fits within a recess **13***a* in the base **12**. As before, such construction provides greater rigidity for the lead **13** and the purpose therefor will become more apparent in the following description. The two ends of the lead **13** extend through the base **12** so that one end thereof extends externally of the housing and the other end extends internally of the housing and into the cavity **17**.

That portion of the lead **13** which extends internally of the cavity **17** is positioned substantially at the center of the base **12**. The lead **13**, as well as the leads **14** and **15**, are molded in place in the base member **12**. Preferably, however, these leads are pressed into place through openings which are provided therefor at the time the base **12** is molded. In either case, in the presently preferred embodiment of the present invention the lead **13** is preferably held stationary and provides a bearing surface for the rotor **22** which is mounted thereon. Rotor **22** is preferably an electrically non-conductive material such as Teflon, Kel F, a ceramic or the like. The rotor **22** is provided with a substantially axial opening longitudinally thereof and which extends through only a portion of its length. This opening receives the internally extending portion of lead **13** thus providing a post upon which the rotor rotates. A slotted opening **23** is provided through the rotor **22** transverse to the longitudinal axis and communicates with the axial opening which receives the internal extending portion of the lead **13**. The slotted opening **23** receives one end **24** of the wiper arm **25** which has the opposite end **26** in slidable electrical contact with the surface of the resistance element **20**. A depression **27** is provided in the end **24** of the wiper arm **25** in order to provide mechanical strength and to better support the wiper arm **25** within the slotted opening **23** of the rotor **22**. The wiper arm **25** is preferably constructed of precious metal, such as a platinum alloy, or the electrical equivalent thereof, and is stamped from a plate or sheet of the material as one continuous member having the depression **27** and contact **26**.

A rotor head **28** includes a flange **31** having a recess **32** therein. Within the recess **32** there is disposed a washer or o-ring **33**, which is preferably constructed of silicone rubber, and which provides a dust and moisture proof seal between casing **11** and the internal cavity **17** of the housing. A recess **34** is provided within the rotor head **28** for receiving the upper portion of the rotor **22** in a press fit or by insert molding or the like. Although the rotor head **28** is illustrated as a metallic substance such as stainless steel, it is to be expressly undertood that it may be an electrically non-conducting material such as nylon or the like and the rotor **22** and rotor head **28** may be constructed as one integral unit.

In assembling the potentiometer as illustrated in FIGS. 2 and 3, the resistance element **20** is placed upon the ledge **19** of the base **12** having leads therein and the connective leads **21** and **21***a* are attached to the leads **15** and **14** respectively. The wiper arm **25** is inserted into the slotted opening **23**; and the rotor **22** with the wiper arm thus contained is pressed over the internally extending portion of the lead **13**. As the rotor is pressed over the lead **13**, the lead contacts the end **24** of the wiper arm **25** and forces it into the position as illustrated in FIG. 3. That is, the end **24** of the wiper arm **25** is caused to become depressed and to conform to the surface of the recess provided by the longitudinal axial opening through the rotor **22**. In this manner, firm, mechanical locking for the wiper arm **25** is provided between the surfaces of the lead **13** and the longitudinal axial opening through the rotor **22**. At the same time, positive electrical connection is also provided between the wiper arm **25** and the lead **13**. Alternatively, the end **24** of the wiper arm **25** may have a slight depression formed therein during its manufacture. This depression then fits into the recess provided by the axial opening in the rotor **22**. In any event the wiper arm is arranged so that positive mechanical locking is effected between the lead **13** and the rotor **22** and good electrical connection is provided. After the rotor **22** is pressed into place, it may be positioned so that the wiper arm slidably contacts the resistance element **20** at the desired position. The O-ring is then dropped in place and the casing **11** is pressed over the annular ring **18** and cemented to provide a dust and moisture proof sealed housing.

It should be noted that the O-ring **33** and the mating surfaces between the casing **11** and the annular ring **18** provide a housing which is sealed against the entry of moisture, dust, or other foreign matter. This sealed housing permits a potentiometer in accordance with the present invention to be completely immersed in a potting compound without fear of leakage. All known prior art devices are subject to such leakage and as a result thereof attempts at potting have been unsuccessful.

If desired, the interior cavity of the potentiometer may be at least partially filled with a viscous liquid such as silicone grease. The presence of such a liquid aids in damping any vibrations which may occur in the wiper arm contact with the resistance element if the potentiometer is subjected to severe stress. The liquid also suspends any wear products that may be generated by use of the potentiometer and thereby prevents them from possibly interferring with the operation of the potentiometer. In addition to the foregoing, the silicone grease provides an excellent lubricant and heat sink which improves the operation and characteristics of the potentiometer.

If such is desired, a potentiometer in accordance with the present invention may include a stop mechanism which, for example, may be an extension **35** of the molded base **12** which extends upwardly from the annular ring

18 so that a projection 36 from the rotor head 28 will contact it at the desired point thereby preventing the wiper arm from rotating past a desired point on the resistance element. The stop mechanism may also include other means well known to the art, such as an inward indentation in the casing 11 and an eccentric rotor head or the like.

The illustrations of the presently preferred embodiment of a potentiometer in accordance with the present invention are greatly exaggerated in size for clarity of illustration and ease of description. A typical potentiometer in accordance with the present invention is no larger in size than the standard transistor and, for example, may have, exclusive of the internally extending portions of the electrical leads, a diameter of .345 inch and a height of .276 inch and a weight of approximately 1 gram. Because of these magnitudes of geometric dimensions, such embodiments of the invention are typically designated as "subminiature." Utilizing a housing of the above dimensions and a structure such as that above described and shown in the drawings, the potentiometer may have a total resistance of 50,000 ohms and may dissipate 1 watt at 70° C. ambient.

Although in presently preferred embodiments of the invention above described the base member for the housing is constructed of an electrically non-conductive material, it should be expressly understood that in those instances where it is desired to dissipate larger amounts of power the base may be constructed of a material having better heat conduction such as aluminum. When such material is utilized for the base, a very thin insulative material is disposed between the resistance element and the base. An example of such material may be anodized aluminum or the like. Each of the electrical leads extending through the base member are then surrounded by an insulating material which is bonded to the metallic base in accordance with well known techniques as to provide a seal between the lead and the base and yet maintain the base insulated from the electrical connections. By using a base of the type above described, the potentiometer may dissipate 2 watts at 70° C. ambient.

Referring now more particularly to FIGS. 4 and 5 there is illustrated an alternative embodiment of a potentiometer in accordance with the present invention. As is therein shown there is provided a housing having a casing 41 and a base 42. A resistance element 43 is seated upon a ledge 44 which is molded into the base 42 similar to that above described. It should be noted that the resistance element 43 is constructed of an elliptical mandrel or card upon which there is wound a resistance wire in accordance with well known techniques. Appropriate electrical connection is made to the resistance element 43 by way of a connective lead 45 and is carried externally of the housing by lead 46. Similar external electrical connection is provided to the opposite end of resistance element 43. An electrically non-conductive rotor 22' having a rotor head 47 which is sealed by way of an O-ring 33 is positioned substantially at the center of the housing upon a spindle 48. The spindle 48 fits within an axial opening in the rotor 22 and mechanically locks the wiper arm 49 into appropriate position to contact the resistance element 43.

It should be noted that rotor 22' does not extend to the top surface of the base 42 but instead is spaced therefrom. The spindle 48 protrudes a short distance from the rotor 22' and seats into a bearing surface 51 at the center of the base. In this manner the spindle 48 positions and supports the rotor 22' so that it is rotatably positioned substantially at the center of the potentiometer. As the rotor is manually rotated the wiper arm slides upon the surface of the resistance element 43. It should be noted that the rotor head 47 is constructed of an electrically non-conductive material.

External electrical connection is provided to the wiper arm in the presently preferred alternative embodiment, by

providing a second arm 52 extending downwardly to slidably engage an electrically conductive collector bar 53 positioned concentrically with the rotor 22' upon the base 42. The collector bar 53 electrically contacts lead 54 to provide the external electrical connection. The remaining portions of the potentiometer tre similar in construction and operation to that above described.

Referring now more particularly to FIGS. 6 and 7, there is illustrated another alternative embodiment of a potentiometer in accordance with the present invention. As is indicated by the use of the same reference numerals the potentiometer includes, for the most part, structure similar to that of FIGS. 4 and 5. However, particular attention is directed to the manner in which external electrical connections are made to the wiper arm. This external electrical connection is provided by a lead 55 having a cup-shaped bearing surface 56 which receives an extension 57 of the rotor 58. As is illustrated in FIG. 6, rotor 58 is preferably a metallic electrically conductive member. The rotor head 47 is therefore an electrically non-conductive material such as Teflon or the like to insulate the wiper arm from the casing 41. The construction of the rotor head is similar to that above described with respect to FIGS. 2 and 3, and includes provision for an O-ring 33 in order to provide a dust and moisture proof seal. A wiper arm 59 is affixed to the rotor 58 in order to provide slidable electrical contact with the resistance element 43. As is illustrated more clearly in FIG. 7, the wiper arm 59 is affixed to the rotor 58 by spotwelding, soldering or the like. It is therefore seen that in accordance with this embodiment of a potentiometer in accordance with the present invention, electrical contact to the resistance element is provided by way of the wiper arm 59, the electrical conductor which comprises the rotor 58 and through the bearing surface 56 and the extension 57 of the rotor 58 to the external lead 55.

The rotor mechanism in accordance with the present invention may also be constructed in additional alternative forms. For example, as is illustrated in FIG. 8, the rotor may include a non-conductive member 61 having an axial opening adapted to receive a pin member 62 therethrough. The wiper arm 63 is inserted within a transverse slotted opening which communicates with the axial opening in the rotor 61 and is mechanically locked in place in a manner similar to that above described in connection with FIGS. 2 and 3. The base 64 of the housing has molded as a part thereof an external electrical connection 65 having an inner surface 66. The inner surface 66 provides a bearing surface 67 into which the pin member 62 is seated in bearing engagement to provide support for the rotor 61. The rotor 61 supports the wiper arm 63 which provides electrical connectioin to the resistance element (not shown) which is mounted within the housing.

FIG. 9 illustrates another alternative embodiment of the rotor mechanism, and as therein illustrated, includes a rotor 71 constructed of a non-metallic insulating type material having a cap or sleeve 72 about the outer surface thereof. A wiper arm 73 is welded, soldered or otherwise mechanically and electrically connected to the sleeve 72. The sleeve 72 also includes a projection 70 extending therefrom. The base 74 has molded therein an external electrical connection 65 having an inner surface 76 which provides a bearing surface similar to that described in conjunction with FIG. 6. Electrical connection of the rotor construction to the resistance element is provided by way of wiper arm 73, cap 72 and the extension thereof 70 to the external electrical lead 75. The bearing surface 76 provides mechanical support for the rotor mechanism 71 as well as electriccal connection.

Referring to FIG. 10 an alternative arrangement of the invention is illustrated, in which a non-conductive base support member 80 is formed with a center post 82 which projects upwardly from the base support member 80 into a cylindrical space defined thereby and extending along

the cylindrical axis thereof. Disposed about the base of the center post there is shown a slip-ring member 84 which has a substantially annular portion 86 and a conductor gripping trough portion 88 which extends radially outwardly from the annular portion 86. The upper lips 90 of the trough portion 88 may be crimped over the end of an external conductor 92 which enters the interior of the potentiometer housing through the bottom of the base support member 80. The bottom of the base support member 80 may be relieved in its top surface to form an open depression 94 for holding the crimped trough portion 88 and the end of the conductor 92 securely against any angular displacement about the center post 82. The annular portion 86 above the slip-ring member may be axially distorted as shown in order to provide an axial resiliency in the member for purposes to be discussed below.

Other conductive leads 96, one only of which is illustrated in the sectional figure are similarly brought through the bottom of the base support member 80 and may be terminated in a smaller depression 98 formed in the top of the base support member 80. In all cases the conductive leads are substantially hermetically sealed to the base support member and are mechanically tightly gripped thereby.

The inner diameter of the upper portion 100 of the base support member 80 is enlarged with respect to that at its lower portion 102 at a step which forms an annular ledge 104 between the two cylindrical portions. A toroidal resistance element 106 having an outer diameter approximately equal to that of the inner diameter of the upper portion 100 may be mounted within the portion 100 upon the annular ledge 104. The resistance element 106 may be a wire wound coil or an annularly shaped resistance card. Tap or end connections may be made between electrical points on the toroidal resistance element 106 and the external leads 96.

The outer diameter of the base support member 80 is substantially constant along its cylindrical length except for a lip portion 108 about the periphery of its bottom surface to form a retaining shoulder 110 for an overall metallic sealing cap 112. The diameter of the inner surface 114 of the sealing cap 112 substantially matches the outer diameter of the portions 100, 102 of the base support member 80. The upper end of the sealing cap is cup-shaped and is substantially closed except for a central opening 116.

Disposed axially between the upper end of the sealing cap 112 and the portion 100 of the base support member 80 is a stop ring member 118 which has the form generally of a short hollow cylinder with an outer diameter equal approximately to that of the surface 114 of the sealing cap 112. The inner diameter of the ring stop member 118 is approximately equal to that of the upper portion 100. Disposed on the inner surface of the ring stop member 118 is a stopping block 120 which extends radially inwardly for a small fraction of the diameter of the ring stop member 118. The particular shape and function of the stopping block 120 will be discussed in further detail in connection with the subsequent figures. The ring stop member 118 may be formed integrally with the base support member 80 or may as in the example of the present figure be formed separately and include a series of angularly interlocking keys 122 which secure the ring stop member 118 from angular displacement with respect to the base support member 80 and which will be discussed in further detail below.

Disposed over the center post 823 there is shown a rotor 124 which includes a lower substantially cylindrical portion 126 which is axially relieved to form a bore 128 which forms the rotational bearing for the rotor on the center post 82. The upper portion of the rotor 124 may be of enlarged cross-sectional dimension and include a radially extending stopping arm 130 which extends outwardly toward but just short of the inner diameter of the ring stop member 118, but beyond the inwardly extending stopping block 120. The upper surface of the rotor 124 is relieved to define an angular trough or channel 132 which is disposed concentrically about the axis of the cylindrical toroidal components heretofore described including the central opening 116 in the sealing cap 112. A resilient O-ring 134 may be disposed in the trough 132 and compressed axially between the rotor 124 and the inner surface of the upper portion of the sealing cap 112. A rotor position control 136 may include a screwdriver slot and project upwardly from the rotor 124 through the centrol opening 116 in the sealing cap. The position control 136 may be integrally formed with the rotor 124 or may be as illustrated in the present figure, a separate structure having a fluted or knurled cylindrical portion 138 which is pressed into a central opening in the top surface of the rotor 124.

A cup-shaped bushing 140 formed of a conductive material is disposed in a press-fitted relationship over the lower cylindrical portion 126 of the rotor 124. The lower end of the bushing is substantially closed except for a central opening about the center post 82 and is nonrotatably secured over the cylindrical portion of the rotor. Thus it may be seen that the lower portions of the cup-shaped bushing 140 bear in rotationally sliding engagement with the annular portion 86 of the slip-ring member 84. The rotor is thereby compressed axially between the distored annular slip-ring and the axially compressible O-ring 134, thus assuring electrical contact between the bushing and the slip-ring, and a hermetic seal between the O-ring, the sealing cap, and the rotor.

Affixed as by welding or soldering to the outer cylindrical surface of the conductive bushing 140 is disposed a conductive wiper arm 142 which is radially resilient and is compressed between a positive contact on the inner toroidal surface of the resistance element 106 and the conductive bushing 140.

Referring to FIG. 11 a portion of the structure depicted in FIG. 10 is illustrated in perspective view for clarity. The rotor 124 is shown mounted in a rotational bearing relationship on the center post 82. The channel or trough 132 for the sealing O-ring 134 (not shown in the figure) is illustrated as a depression formed in the top surface of the rotor 124. Extending upwardly from the central portion of the rotor is shown the rotor position control 136. The radially outwardly extending stopping arm 130 is shown projecting to the right as seen in the figure.

The conductive bushing 140 is shown in axially exploded pictorial relationship with respect to its actual position tightly fitted over the lower, cylindrical portion 126 of the rotor 124. The radially resilient wiper arm 142 is illustrated in its somewhat radially extended position from which it would be radially compressed when urged inwardly by contact with the toroidal resistance element 106. The slip-ring member 84 is illustrated at the lower portion of the figure and is seen clearly to include, in this example, an annular portion 86 which is axially slightly distorted and a conductive lead-gripping portion 88 extending to the left, in the figure, and including a pair of lips 90 which may be crimped over the eelctrical conductor to be attached during the assembly of the potentiometer.

Referring to FIG. 12 the base support member 80 is illustrated with its base flange 108, the retaining shoulder 110 and the upper cylindrical portion 100. The external conductive leads 92, 96 are shown projecting from the bottom of the base support member for connection to external circuitry. The bearing, center post 82 is shown projecting upwardly from the bottom of the base support member into the substantially cylindrical space within the base support member and the ring-stop member 118. The angularly interlocking keys 122 are shown in place within matching circumferential key ways in the upper portion 100 of the base support member 80. The stop-

ping block 120 is shown extending inwardly from the periphery of the ring-stop member 118 to form a positive stop for limiting the rotation of the rotor 124 by virtue of the stopping arm 130 extending therefrom.

From the foregoing description of the various embodiments of the potentiometer in accordance with the present invention, it is seen that in each case there is provided a substantially centrally located rotor mechanism which carries a wiper arm which provides a slidable electrical connection to the resistance element. Electrical connection is then provided between the wiper arm and an electrical lead extending through the housing, preferably the base member, to provide an external electrical connection. It should be noted that in each case the rotor is a mechanically simple and preferably unitary member which permits construction of an exceedingly small or subminiature potentiometer. It is also seen that in each case the rotor head and rotor body are constructed of materials in such a manner that the wiper arm is electrically insulated from the casing of the housing.

There has thus been disclosed a potentiometer which is capable of being constructed in exceedingly small that is, subminiature size and which is simple, rugged, inexpensive to manufacture and is compatible with other modern electronic and electrical components, and is adaptable for utilization in printed circuits.

What is claimed is:

1. A potentiometer comprising: a sealing housing having a substantially cylindrical inner wall portion and including a non-conductive base member having a non-conductive supporting bearing post extension disposed within said housing along the axis of said cylindrical inner wall; a toroidal resistance element disposed within and coaxially with said housing along said cylindrical inner wall; a non-conductive rotor member having a substantially cylindrical end portion which is axially relieved and rotatably supported upon said supporting post extension; a conductive cup bushing member disposed rotationally grippingly over said cylindrical end portion of said rotor member and having an axially relieved end portion disposed between said rotor end portion and said non-conductive base member radially closely about said supporting post extension; a radially resilient conductive wiper member conductively affixed to said cup bushing member and disposed in circumferentially slidable electrical contact with said resistance element; an axially resilient conductive slip-ring element having a substantially annular portion disposed about said supporting post member in effective axial compression between said cup bushing member and said base member in slidable electric contact with the former and in non-rotating contact with the latter; means rotatably affixed to said rotor for revolving said bushing and wiper arm with respect to said base member; a cap member disposed over at least a portion of said base member and said rotor and being affixed to the former, whereby the latter is actually urged toward said axially resilient slip-ring element, said cap member being centrally relieved to define an access opening for said means for revolving said bushing and wiper arm; an axially compressible sealing means interposed between said cap member and rotor member; and a rotor stop-ring means interposed between said cap member and said base member for limiting the rotational freedom of said rotor member.

2. The invention according to claim 1 in which said rotor member includes a radially extending stopping arm and in which said rotor stop-ring means includes a short, hollow, open-ended cylindrical segment which is rotationally secured to said base member and which has an outer said cap member, and further includes a circumferentially diameter approximately equal to the inner diameter of minor, inwardly extending portion of its inner cylindrical surface.

3. A potentiometer comprising: a sealing housing including a substantially cylindrical non-conductive wall and closed end base member which includes a non-conductive supporting post extending from said closed end into the enclosure of said wall and base member along the cylindrical axis thereof; a ring-stop member including a short cylindrical portion whose outer diameter is approximately equal to that of said wall and base member and which is angularly interlocked thereto; a cup-shaped sealing member which is centrally relieved to from an access aperture disposed over said ring-stop member and said wall and base member and being substantially sealed about its cup-lip periphery to said wall and base member, thereby axially securing said ring-stop member to said wall and base member; a rotor having a cylindrical end portion which is axially relieved to define a bore therewithin, which end is disposed over said supporting post whereby the latter is in rotational bearing relationship with said bore; a conductive bushing member angularly securely disposed over said first end of said rotor; a conductive slip-ring element angularly affixed to said base member about said supporting post in rotationally sliding electrical contact with said bushing member; an O-ring sealing disposed concentrically about said axis between said rotor and said cup-shaped sealing member radially continuously about said axis aperture, said O-ring being in axial compression for sealing said rotor to said cup-shaped sealing member and for providing positive electrical contact between said slip-ring element and said conductive bushing member.

4. A sealed subminiature potentiometer comprising: a housing having enclosing walls defining a substantially cylindrical internal cavity, a resistance element positioned about the periphery of said cavity, a pair of fixed electrical connections to said resistance element, and extending through said housing, an electrically conductive slip-ring element extending externally of said housing, and defining a substantially annular bearing surface internally of said housing disposed coaxially therewith at the center thereof, a rotor positioned substantially at the center of said housing and upon said bearing surface, a conductive rotor casing disposed over a portion of said rotor, including that portion positioned upon said bearing surface, a wiper arm affixed to said rotor casing and having slidable engagement with said resistance element, thereby electrically interconnecting said electrically conductive element to a movable point on said resistance element intermediate said pair of fixed electrical conductions, said electrically conductive element and said electrical connections extending through said housing being secured to said housing and forming therewith substantially sealed portions of said enclosing walls, a rotor position control connected to said rotor, and rotation freedom providing sealing means disposed between said rotor and said housing forming therewith a substantially sealed portion of said enclosing walls.

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