

April 23, 1968

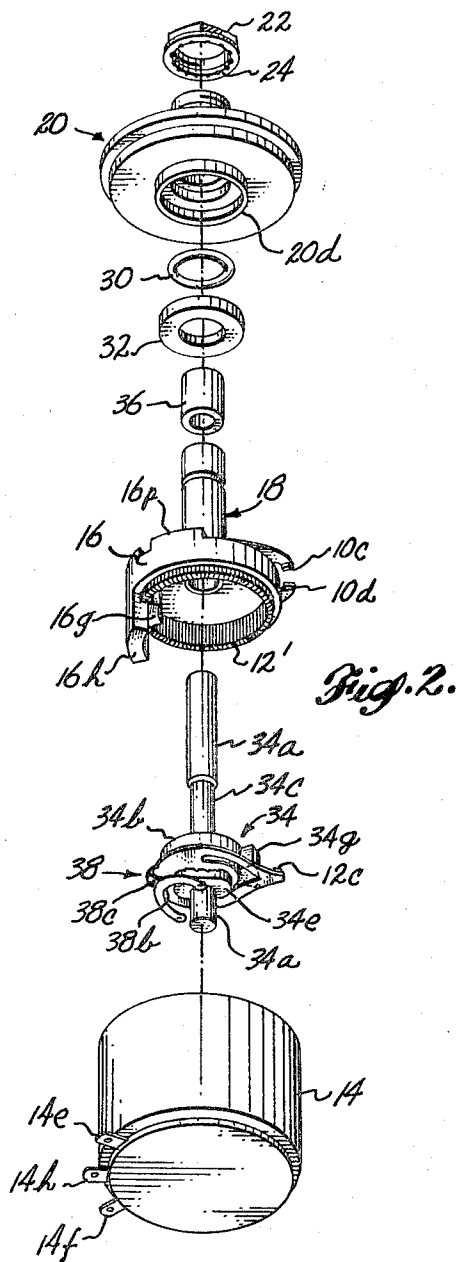
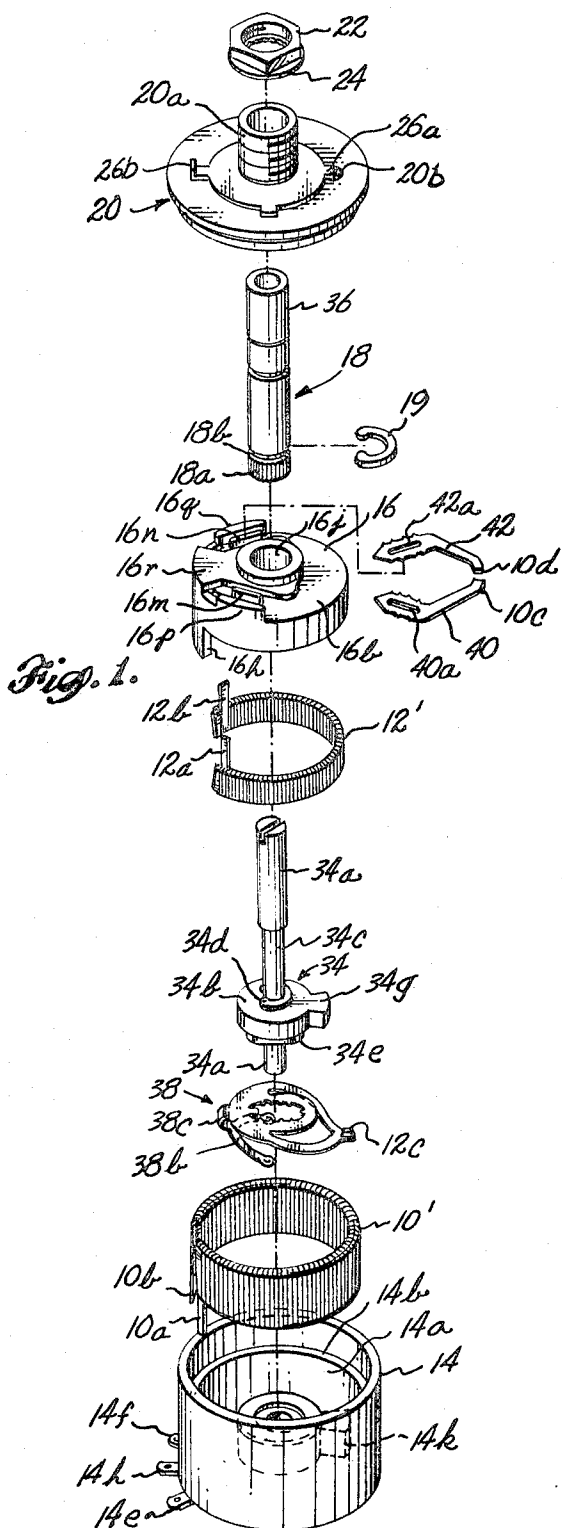
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3,380,010

ROTARY VARIABLE ELECTRICAL RESISTANCE DEVICE

Filed April 1, 1966

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

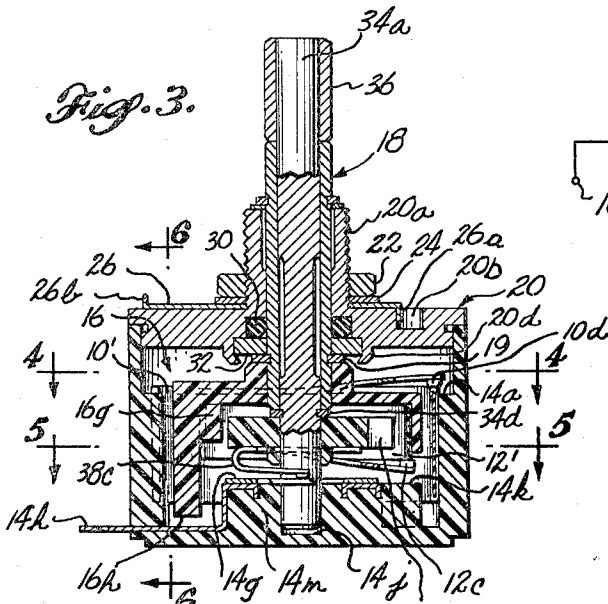


Fig. 3.

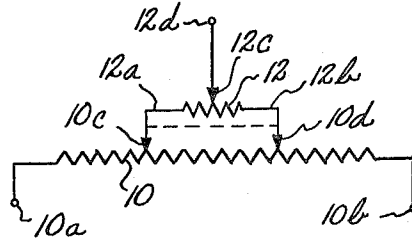


Fig. 8.

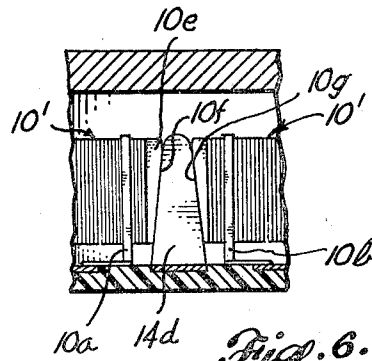


Fig. 6.

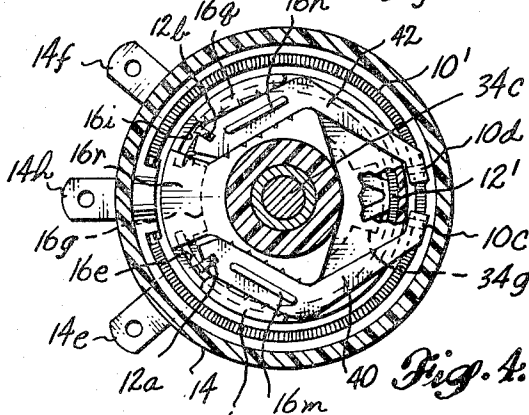


Fig. 4.

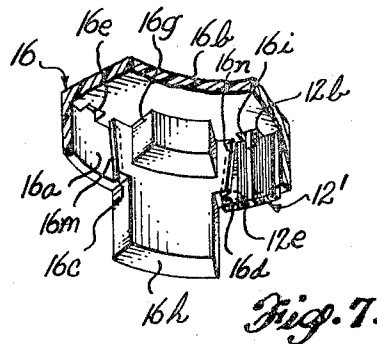


Fig. 7.

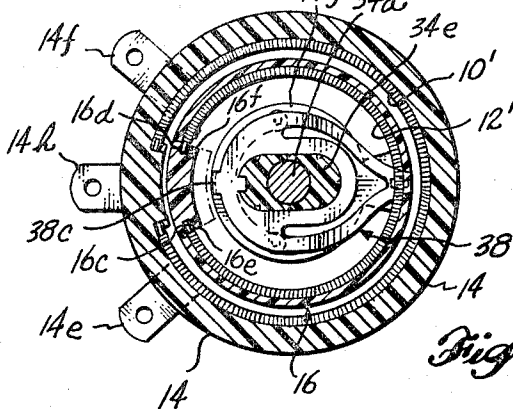


Fig. 5.

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**ROTARY VARIABLE ELECTRICAL  
RESISTANCE DEVICE**

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8 Claims. (Cl. 338-122)

**ABSTRACT OF THE DISCLOSURE**

The successively adjustable coarse and fine resistance cards of this variable electrical resistance device are coaxially mounted in generally cylindrical cup-like supports, one facing into and protectively surrounded by the other and incorporating stops defining their limits of relative rotation. Elongated resilient strips supporting the coarse winding wipers are respectively connected to the circumferentially adjacent ends of the fine resistance elements by conductors extending through the fine resistance element support wall. With this physical and electrical arrangement the fine resistance element may be long in its angular extent without necessity for cross-over of said conductors, while permitting adjustable rotation of the fine and coarse resistance wipers to their respective upper and lower extremes by movement thereof in the same direction.

This invention relates to improvements in variable electrical resistance devices of the high-resolution or vernier type having interconnected coarse and fine resistance elements successively adjustable to achieve desired resistance values (or potentiometer ratios) with a high degree of resolution and to cover the full range of adjustment of the device in less than a full revolution of the wiper of each resistance element.

Devices generally of this nature, known and used for a number of years, are referred to variously as vernier or interpolating potentiometers, or rheostats, and by other names. Directed broadly to certain unique improvements which increase the predictable accuracy and which facilitate and simplify the manufacture of devices of this type, the present invention is herein illustratively described by reference to the presently preferred embodiment thereof; however, it will be recognized that certain modifications and variations therein with respect to details may be made without departing from the essential features involved.

Another object hereof is to achieve compactness in a vernier-type variable resistance device employing relatively few and simple, easily assembled parts. It is also an object to simplify the related wiring and soldering procedures, and to provide for connecting leads which are short, direct and free of critical positioning and electrical insulation difficulties, and for improved resistance wiper supporting arrangements.

Certain features of the invention relate to the combined arrangement of coarse resistance and fine resistance card support assemblies which are generally of cylindrical cup-like form, the support for one card functioning as the outer housing for the device, and the support for the other card, facing into the interior of and being rotatively supported within the outer housing, functioning as an improved mounting and electrical connecting arrangement for the coarse resistance card wipers.

Another feature relates to the arrangement of elongated spring strips supporting the coarse winding wipers and connecting them electrically to circumferentially adjacent ends of the fine resistance element by means of conductors extending through the fine resistance element support

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wall of the support. The arrangement is such that rotation of the fine and coarse resistance wipers to corresponding (upper or lower) extreme positions occurs in the same direction without necessity for the conductors connecting the ends of the fine resistance and the coarse wiper contacts to be crossed over each other with attendant insulation and wiring problems during assembly operations.

These and other features, objects and advantages of the invention will become more fully evident from the following description thereof by reference to the accompanying drawings.

FIGURE 1 is an exploded top perspective view of the improved variable resistance device.

FIGURE 2 is an exploded bottom perspective view of the device.

FIGURE 3 is a longitudinal sectional view of the assembled device taken on a plane containing the axis of rotation of the variable resistance components.

FIGURE 4 is a transverse sectional view taken on line 4-4 in FIGURE 3.

FIGURE 5 is a transverse sectional view taken on line 5-5 in FIGURE 3.

FIGURE 6 is a fragmentary longitudinal section taken on line 6-6 in FIGURE 3 to show the cooperative relationship between the wedging means and coarse electrical resistance card in the outer housing.

FIGURE 7 is a fragmentary bottom perspective view of a portion of the inner housing and associated fine electrical resistance card mounted therein, including positioning stops comprising elements of the housing.

FIGURE 8 is a schematic electrical diagram of the illustrative embodiment.

As depicted in FIGURE 8, the illustrated variable resistance device is shown connected as a potentiometer and comprises a coarse winding 10 having terminals 10a and 10b. Coarse winding wipers 10c and 10d slidably contact the coarse winding at points spaced along its length which subtend preferably a small fraction of its total resistance, these wipers 10c and 10d being physically interconnected to be movable conjointly along the winding to any desired position from one end to the other. Through conductors 12a and 12b, respectively, the wipers 10c and 10d are electrically connected to the ends of the fine resistance winding 12, the total resistance value of which is preferably a small fraction of the total resistance value of the coarse winding resistance 10. An adjustable wiper 12c connected to a terminal 12d slidably contacts the fine winding 12 and is movable to any selected position along the length of the latter.

While schematically illustrated in FIGURE 8 in a lineal or straight-line form, it will be appreciated that the coarse and fine resistance elements 10 and 12 are actually of circular form and that for achieving maximum resolution or precision of setting values within a given bulk of the total device each resistance element extends over nearly a full circle. Also, it will be evident that by omitting (or disconnecting) one of the wipers 10c or 10d and one of the terminals 10a or 10b, the device maybe converted from a potentiometer to a rheostat. In either application the coarse resistance adjustment effected by movement of coarse winding wiper means (10c and/or 10d) approximates the desired potentiometer or rheostat setting, whereas subsequent positioning of the fine winding wiper means 12c permits attainment of the desired ultimate setting with a high degree of accuracy or resolution.

In the illustrative physical embodiment, as depicted in FIGURES 1 through 7, the coarse resistance element 10 is preferably formed as an elongated, flat, thin wire-wound card 10' of a flexible nature permitting it to be bent into a circular cylindrical form with ends slightly separated. While there are other methods of making up resistances of circular form, the wire-wound method is

preferred for well known reasons (i.e. stability, uniform resistance change per unit of card length, inherent availability of a low-noise, wear-resistant wiper contact surface, etc.). In accordance with features of this invention, the resistance card 10' is received in a cup-shaped support and housing 14 having a circular cylindrical inside wall 14a of the desired diameter to accommodate and impart cylindrical shape to and rigidly support the flexible resistance card. Near the rim of housing 14 its inside wall is increased in diameter through a step 14b. Preferably the upper or outer narrow edge of the coarse resistance card 10' in its seated position, as shown in FIGURE 3, projects slightly above the shoulder or ledge 14b so as to afford radial clearance around this edge to accommodate any over-projection of the rotary coarse resistance wipers engaging such edge, as will later appear.

Referring to FIGURE 6, the coarse resistance wire on card 10' is wound on a suitable flexible fibrous or plastic strip of insulative card material 10e bent into a near-circle with ends 10f and 10g spaced apart and angled slightly with inward mutual divergence. The divergence angle corresponds to the acute angle defined between opposite side surfaces of the wedging means 14d slidably engaged by the respective card ends 10f or 10g. The wedging means 14d causes progressive expansion of the resistance card 10' with insertion of the card downwardly into the housing 14. Because of the angular conformity between the ends of the card and the adjacent side surfaces of the wedging means 14d, the expansion forces created in the card are uniform across the vertical width of the card and the latter is caused to be pressed into firmly held form-imparting contact with the cylindrical housing wall 14a. While bonding adhesive may be used to hold the card more securely in the housing 14, it will be appreciated that the friction force produced by expansion of the card in seated position may be considered a sufficient holding force for many applications.

Wedging means 14d also functions as a positional indexing device for the card 10' automatically locating the end terminals 10a and 10b for the coarse resistance 10 in positions to contact and to be soldered or welded directly to the exposed inner ends of conductors forming the projecting terminal lugs 14e and 14f which are embedded in the base of the housing cup 14.

Housing 14 is of molded plastic material. A stationary slip ring 14g coaxially mounted on molded circular boss 14m formed centrally on the bottom of the housing cup 14 is electrically connected to an intermediate terminal lug 14h (FIGURE 3) also projecting outwardly through the wall of the housing 14 for purposes of external circuit connections. An axial circular socket hole 14j formed on the housing axis in this boss serves as a journal support for the inner end of a shaft comprising part of the fine resistance rotor assembly to be described. A stop 14k on the interior wall of the housing bottom is preferably located diametrically opposite the wedging means 14d, and occupies preferably only a few degrees of arc angle.

Similar to card 10' and housing 14, a fine resistance card 12' is formed by resistance wire 12 wound on an elongated flexible flat and thin card 12e adapted to be pressed into the cup-like support housing 16. The latter has a circular cylindrical inside wall 16a and a transversely extending bottom wall 16b, with wedging means at a side location having opposed inwardly divergent wedging surfaces 16c and 16d. These wedging surfaces are slidably engaged by the ends of the card so as to expand the card progressively into close conformity with the cylindrical wall 16a as the card is pressed to a seat against the bottom 16b of cup-shaped housing 16. Preferably the wedging surfaces 16c and 16d in this case are recessed in the side faces of the molded protuberance forming the wedging means, being adjoined along their lengths by respective flanges 16m and 16n disposed to overlap the card ends and thus prevent them from springing radially inward and out of engagement with the wed-

ing surfaces 16c and 16d during or after insertion of the card. As with card 10', card 12' is angularly indexed by its wedging means such that the conductive strips 12a and 12b electrically connected to the end portions of the fine resistance wire 12 are located to register with passages 16e and 16i for connection to wiper support arms to be described.

The fine resistance card 12' is thus firmly wedged in place seated in the housing support 16 and because its ends are angled conformably with the divergence angle between the wedging surfaces 16c and 16d, the card is expanded uniformly into shape imparting contact with the interior wall 16a as desired. A rotation stop 16g mounted in the base of the housing 16 at a selected angular position occupies a small fraction of the circular circumference thereof and another rotation stop 16h at a like annular position projects endwise from the side wall 16a, likewise occupying a small fraction of the total circumference. With the parts assembled, the housing 16 carrying its fine resistance card 12' is received inside the outer housing 14 with the cup-shaped members 14 and 16 facing toward each other and with the stop 16h projecting into proximity with the base or bottom of the outer housing 14 into such a position that it will contact the stop 14k by relative rotation between the two supports so as to define the limits of such rotation (FIGURE 3). Stop 16g performs a different function which will be described.

In order to support the fine resistance card 12' and its supportive housing 16 coaxially for purposes of rotation within the outer housing 14, the transverse bottom wall 16b has a central circular bore 16j which accommodates a tubular shaft 18 having a serrated end 18a which when pressed into the plastic material of the bore wall provides an anti-rotational connection between the shaft and the housing 16. A snap washer 19 engages releasably in a groove 18b in the shaft 18 so as to limit depth of penetration of the shaft into the housing 16. Hollow shaft 18 is rotatably received in the externally threaded sleeve extension 20a of outer housing cover plate 20. The cover plate is press-fitted and preferably suitably bonded into and against the rim of housing 14, as shown (FIGURE 3). The sleeve extension 20a carries a threaded nut 22 and lock washer 24 used in conventional manner for mounting the resistance device in an apertured panel. A locating hole 20b in the outer face of cover 20 receives an intumed tab 26a of a positioning plate 26 having a locating tab 26b projecting outwardly from the face of the cover 20, so as to afford a physical indexing means for positioning the device in correct rotational relationship to an indicator dial or the like.

In order to provide a moisture seal and frictional restraint between the hollow shaft 18 and the interior bore of cover 20, the inside face of the cover has a stepped annular recess surrounding its bore in order to accommodate a rubber O-ring 30 and a washer 32 which clamps the O-ring against the base of the recess and thereby flattens it into contact with the shaft 18 and surrounding sleeve. The washer is held in position by the annular flange 20d bent inwardly to form a lock. Snap ring 19 is located between the washer 32 and the adjacent end of support 16.

Hollow shaft 18 also serves as a rotational support for a rotary fine resistance wiper assembly 34. Rotary assembly 34 comprises the elongated shaft 34a extending through the hollow shaft 18 and carrying the molded wiper support block 34b in fixed position thereon. The end of shaft 34a projects through and slightly beyond the block 34b into bore 14j as a rotational guide for the shaft. Intermediate its ends the shaft 34a is reduced in diameter over a portion of its length, 34c, so as to minimize rotational friction within the shaft 34a and is lodged between the upper side of block 34b and the inner end of hollow shaft 18. A sleeve 36 fixedly mounted on the outer end of the shaft 34a abuts the

outer end of hollow shaft 18 and serves as a restraint against inward shifting of shaft 34a in shaft 18 as well as a mounting base for a control knob or the like (not shown).

Rotor block 34b has a generally elliptical boss 34e projecting from its inner or lower face (FIGURE 2) surrounding the projecting end portion of shaft 34a. This boss and the surrounding flat surface of the block 34b serve as a locating support for the resilient metal wiper support fitting 38 which has a central aperture therein conformed to the outline of boss 34e with its edge having teeth projecting inwardly. When the fitting is pressed to a seat against the adjacent face of the block 34b over the boss 34e, the teeth bite into the plastic block material to hold it in place. The fitting is cut with a relief aperture and an outer peripheral configuration forming an elongated laterally deflectable wishbone which forms a resilient support for wiper 12c. In order to deflect the wiper support and thereby establish predetermined contact pressure with its wiper, the adjacent edge of fine resistance card 12' projects a short distance beyond the rim of support cup 16. On the side of the resilient fitting 38 opposite wiper 12c the material is bent reversely and formed as a bifurcation 38b straddling shaft 34a and connected by a strip 38c to the main body of material, with the tips of the bifurcation arms being adapted to press in sliding contact against the slip ring 14g (FIGURE 3). By this means the fine resistance wiper 12c is maintained in continuous electrical contact with the exterior terminal lug 14h, and may be rotated to any desired position around the circumference of the fine resistance 12.

A rotary stop 34g projects from the side of molded block 34b to engage the stop 16g at the opposite ends of travel of the rotary wiper 12c. Between these positions the rotor is turned by turning the shaft 34a independently of the frictionally restrained hollow shaft 18. However, when the stop 34g engages either side of the stop 16g, continued rotation of the shaft 34a in the same direction causes the fine winding assembly 12, 16 to be rotated with it. This causes movement of coarse resistance wipers 10c and 10d into new positions along the coarse resistance. For this purpose wipers 10c and 10d are carried on the tips of elongated flat spring strips 40 and 42 respectively. The base ends of these strips are mounted against the cup bottom 16 at respective locations adjacent opposite sides of the central bore 16j near the fine winding terminal strips 12a and 12b to which wiper supports 40 and 42 are soldered or welded. Mounting of the strips 40 and 42 in this manner is accomplished by means of apertures 40a and 42a therein which are pressed onto keys 16m and 16n on the cup base 16. Teeth projecting from opposite edges of the base ends of spring strips 40 and 42 bite into the surfaces of the adjacent keys 16p and 16q and the opposing side surfaces of a central rib 16r so as to hold the strips securely in place. The strips 40 and 42 then extend transversely across the cup base of support 16 and beyond the peripheral edge thereof into position to make sliding contact with the adjacent edge of the coarse winding 10, which deflects the strips sufficiently to establish desired wiper pressure thereon.

With the parts assembled, it will be noted that the generally parallel strips 40 and 42 are relatively long, such that uniform contact pressure is maintained by the wipers 10c and 10d despite any slight irregularities in the edge surface of the winding 10 contacted by these wipers. Also each strip provides a direct soldered or welded connection between its wiper and a winding terminal 12a or 12b without necessity for difficult wiring operations. With the strips extending generally across the diameter of fine resistance card 12' from the mutually adjacent side locations of its terminal ends 12a or 12b so as to position the coarse resistance wipers 10c and 10d at mutually adjacent opposite side loca-

tions it is not necessary to employ cross-over connections in order that the upper setting of wiper 12c is achieved by the same direction of rotation of wipers 10c and 10d to their upper settings.

These and other advantages and aspects of the invention will be evident to those skilled in the art having reference to the foregoing description and accompanying drawings as exemplary of the novel features involved.

We claim as our invention:

1. A variable rotary electrical resistance device comprising a cup-like housing having a circular cylindrical interior, an electrical resistance card conformably received in the housing with ends of the resistance separated circumferentially, electrical conductors electrically connected to opposite end portions of the resistance and extending therefrom through the housing to the exterior thereof at circumferentially spaced locations, sliding contactors to which the respective electrical conductors are connected, said contactors being circumferentially spaced apart and projecting radially outwardly from the housing at side locations thereon which are generally opposite from the resistance ends, and a circular electrical resistance means engaged by said contactors and surrounding the housing and mechanically connected therewith to permit relative motion therebetween.

2. The device defined in claim 1, wherein the circular electrical resistance means comprises a second electrical resistance card, and a second housing receiving said second card and surrounding and rotationally supporting the first housing.

3. A vernier rotary electrical resistance device comprising first and second interconnected supports relatively rotatable about a common axis, first and second electrical resistance means of generally circular form fixedly carried by the respective supports and each being of arcuate length corresponding to a major part of a circle, said second resistance means having ends separated by a minor fraction of its circumference, said second support comprising a member disposed transverse to the axis with one face thereof adjacent to the second resistance means, a pair of electrical wipers fixedly carried by the second support at locations generally opposite the ends of the second resistance means to slidably contact the first resistance means at spaced points thereon which subtend a minor fraction of its circumference, each member of said pair being electrically connected to the circumferentially adjacent end of said second resistance means by a conductor extending through said support member and across a face thereof, and a rotary assembly including a wiper rotatively mounted in relation to said supports and slidably contacting the second resistance means for independent rotative positioning thereon.

4. The device defined in claim 3, wherein the supports are of generally circular cylindrical cupped form, the first support comprising an outer housing surrounding and facing oppositely to the second support, and with the first and second resistance means comprising circular cylindrical resistance cards conformably retained against the cylindrical inside walls of their respective supports in mutually overlapping relationship, the transverse member of the second support comprising the bottom wall of its cup.

5. The device defined in claim 4, wherein the rotary assembly includes a rotor extending axially through said bottom wall and carrying the wiper in position to contact the second resistance card's outer edge, mutually interengageable stops, one fixed inside the second support cup adjacent its bottom and the other fixed to the rotor and operable to limit independent relative rotational displacement between the rotor and second support.

6. The device defined in claim 5, further comprising a second set of mutually interengageable stops, one fixed in the base of the outer housing and the other projecting edgewise from the side wall of the second support cup,

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the relative locations and circumferential lengths of all the stops being such as to permit the pair of wipers to traverse substantially the full circumferential length of the first resistance card by relative rotation of the second support and to permit the rotary assembly wiper to traverse substantially the full circumferential length of the second resistance card by independent relative rotation of the rotary assembly.

7. The device defined in claim 4, wherein the conductors comprise elongated spring strips extending across the outer face of the cup's bottom wall at opposite sides of the axis deflected under tension away from such wall by contact of their respective wipers against the edge of the first resistance means card.

8. A vernier rotary electrical resistance device comprising a first cup-shaped support of generally circular cylindrical form having a base and an opposite open end, a coarse resistance means extending circumferentially around the interior of said support, a cover for said open end, a second cup-shaped support of generally circular cylindrical form having a base and an opposite open end and being smaller than the first support, said second support being mounted coaxially within the first support for relative rotation therein and with its open end facing the base of the first support, a fine resistance means extend-

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ing circumferentially around the interior of the second support in overlapping relationship with the coarse resistance means, circumferentially spaced wipers, resilient support arms for such wipers having base ends mounted on the bottom of said second support and projecting radially therefrom for pressing the respective wipers into sliding contact with the first resistance means to subtend a small fraction of the total resistance thereof, said wipers being electrically connected through such arms to opposite end portions of the second resistance means, and an independently rotatable wiper means mounted coaxially within the two supports in position to slidably contact the second resistance means.

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