United States Patent

Fujii et al.

[15] **3,676,823**

[45] **July 11, 1972**

[54] **MINIATURE VARIABLE RESISTOR WITH GUIDE MEANS FOR SLIDING CONTACTS**

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[73] Assignee: **Nippon Kogaku K.K.,** Tokyo, Japan

[22] Filed: **May 10, 1971**

[21] Appl. No.: **142,060**

Related U.S. Application Data

[63] Continuation of Ser. No. 10,366, Feb. 2, 1972, abandoned.

[30] **Foreign Application Priority Data**

Feb. 19, 1969 Japan....................................44/13811
Feb. 19, 1969 Japan....................................44/13812

[52] **U.S. Cl.**................................**338/139,** 338/92, 338/162, 338/202

[51] **Int. Cl.**..**H01c 9/02**

[58] **Field of Search**......................338/92, 95, 138, 139, 142, 338/162, 174, 175, 185, 190, 202, 308, 128, 333

[56] **References Cited**

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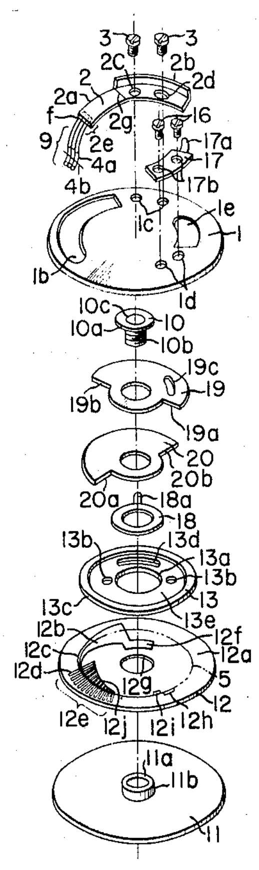
2,134,870	11/1938	Fruth	338/162 X
2,898,567	8/1959	Drewitz	338/92
3,119,089	1/1964	Murry	338/202 X

Primary Examiner—Lewis H. Myers
Assistant Examiner—Gerald P. Tolin
Attorney—Marn and Jangarathis

[57] **ABSTRACT**

A variable resistor of rotary type has a metallic thin film resistor vacuum deposited on a disk and a brush slidably contacting with said resistor. The contact member slides over the path in a plane, and a tap portion partially overlapping with a slide resistor and having a surface resistance lower than that of the resistor is disposed below the path. The resistance between the terminal at one end of the resistor and the contact is varied in response to the displacement over the path of the brush on the resistor. The contact can be assured to move along the same path in radial and circumferential directions, and the reproducability of the position of the contact is attained with high accuracy.

7 Claims, 16 Drawing Figures



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4 Sheets-Sheet 1

FIG. 1

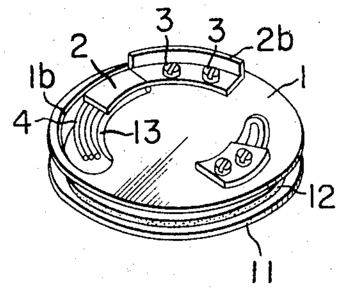

FIG. 2

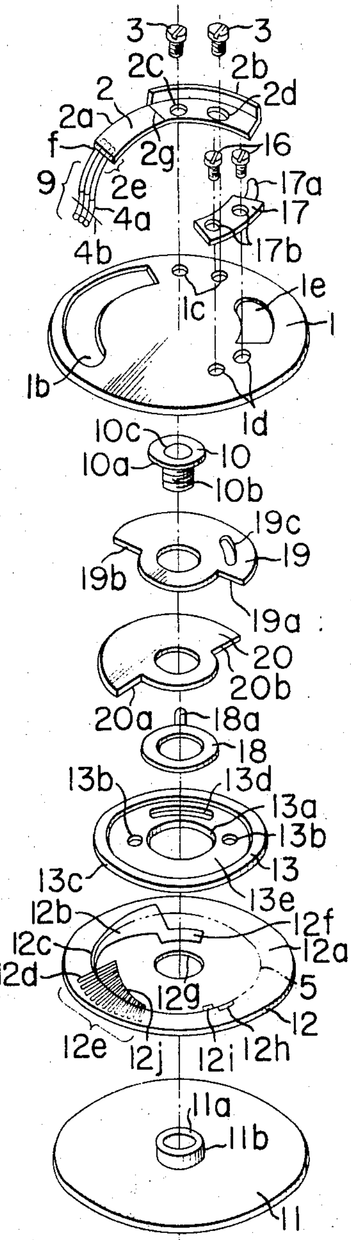

FIG. 3

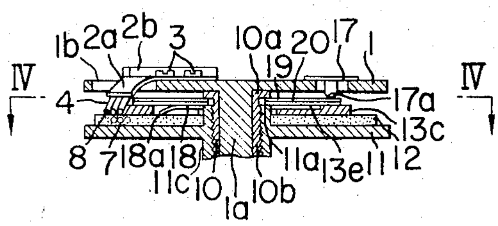

FIG. 4

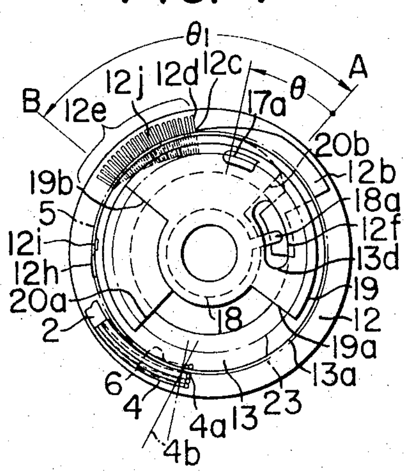

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FIG. 5

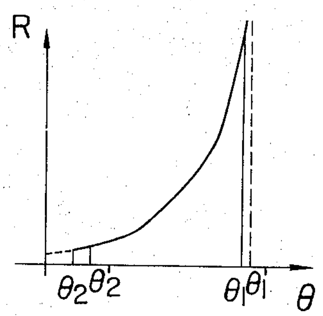


FIG. 6

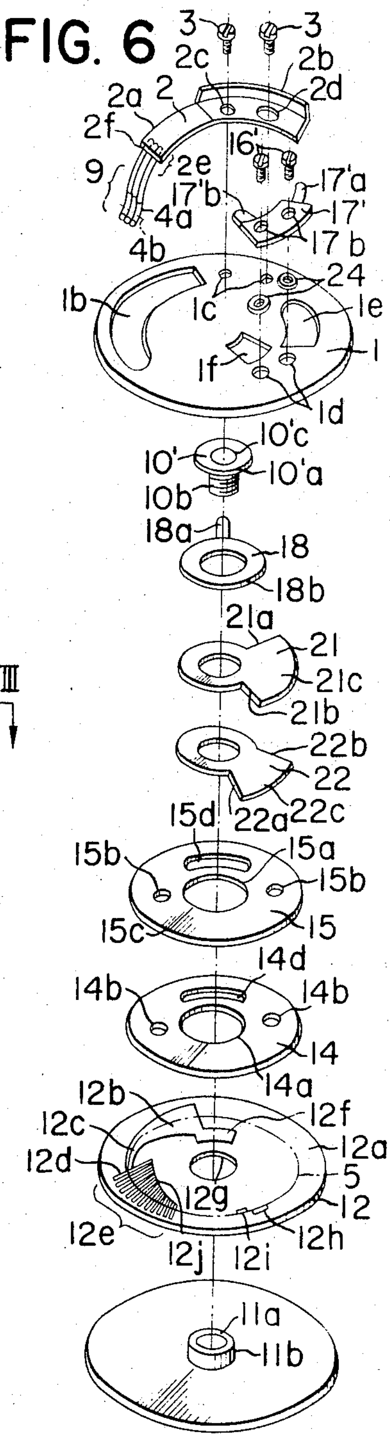


FIG. 7

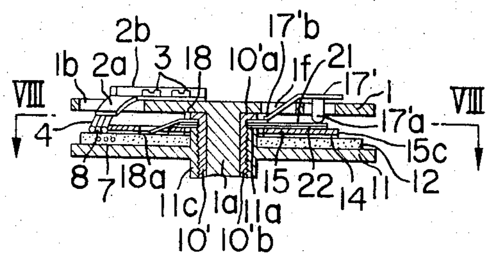


FIG. 8

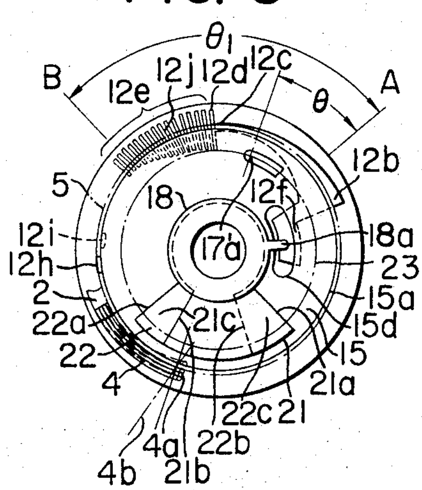


FIG. 9

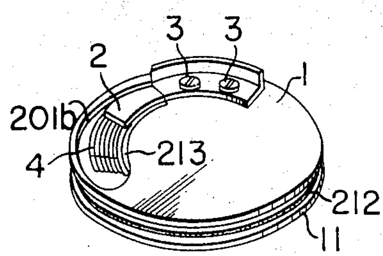


FIG. 10

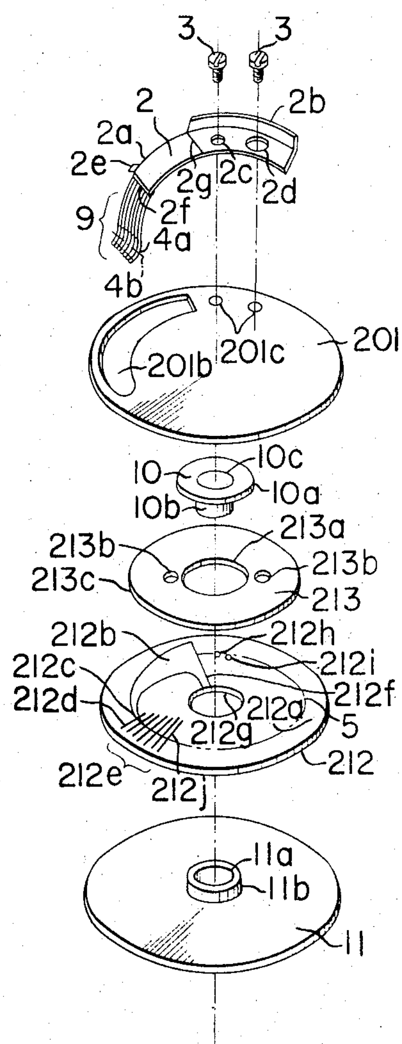


FIG. 11

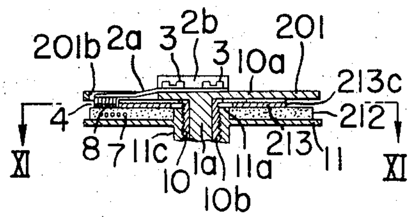


FIG. 13

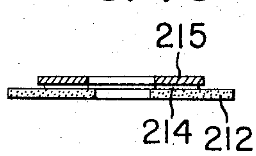


FIG. 12

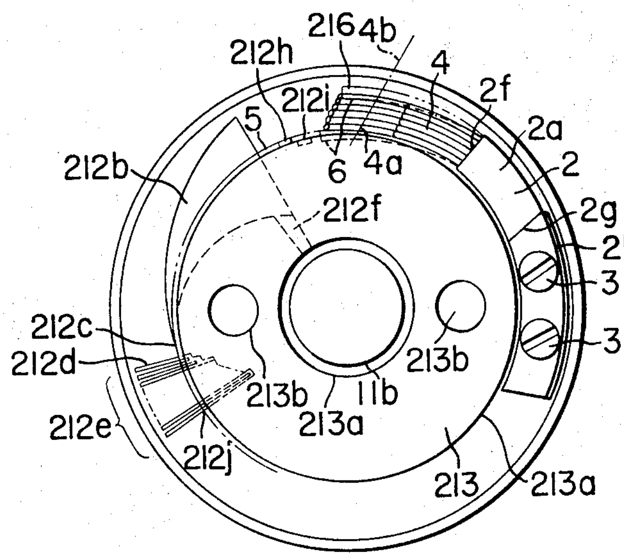


FIG. 15

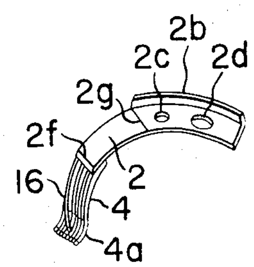


FIG. 14

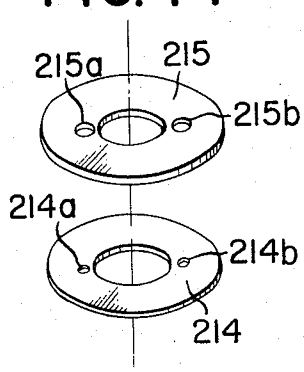
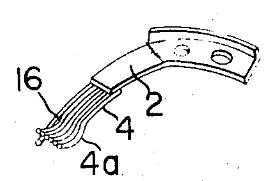


FIG. 16



MINIATURE VARIABLE RESISTOR WITH GUIDE MEANS FOR SLIDING CONTACTS

This is a continuation of Pat. application Ser. No. 10,366, filed Feb. 2, 1970, and now abandoned.

The present invention relates generally to a variable resistor and more particularly to a rotary type variable resistor comprising a metallic thin film resistor vacuum deposited upon a plate and a brush which makes a slidable contact with said resistor.

In the conventional resistor of the type described above, the terminal on the side of the lower resistance of the resistor is extended along the path of the brush toward the insulating portion having no resistor. However, the lowest resistance in the service region is normally not zero so that even when the brush passes over the lowest resistance end, there still exists a resistance approaching to zero. Therefore, an erratic measurement is made when, for example, an exposure meter uses such resistor. On the higher resistance end of the resistor, it must be insulated from the above described extended terminal on the lower resistance side so that an insulating portion having a certain width must be formed. Therefore, there is an unwanted possibility that the resistance discontinues at such portion before the short-circuit. In this case, there are provided no tolerances on both of the lower and higher resistance sides so that the short-circuit position cannot be adjusted.

As disclosed in U.S. Pat. No. 2,134,870, there has been proposed to form a conductive layer all over the inner periphery of the resistor layer and a second brush therefor. But this conductive layer is for connection in series with the resistor layer so as to function as a terminal. There has been never proposed, however, to make its portion insulative for parallel connection with the resistor layer and to dispose the second brush in the insulated portion within the service region.

As disclosed in the Japanese Utility Model Publication No. 2215/1965, there has been proposed to fix a rigid member to a brush supporting member along its side facing its path. However, the rigid member is only attached to one side of the brush, the inward deviation or displacement of the brush cannot be prevented. When the rigid members are attached to both of the side surfaces of the brush, there is a serious problem of maintaining the spacing between the two rigid members with a higher degree of accuracy. Therefore, the brush is loosely fitted so that the vertical flexibility of the brush may be retained. Thus, there is produced a play so that the brush cannot be reproducably positioned again or the brush cannot be returned to the same position when a number of resilient parts is increased, the spacing cannot be maintained with a desired degree of accuracy so that the spacing between the rigid members to be placed upon the both side surface of the brush must be adjusted individually. This is a very time-consuming job. Furthermore, the error in the relative position between the resistor disk and the brush supporting disk, for example the eccentricity will adversely affect the relative position between the resistor pattern and the contact thereby producing the error. When the adjustments are made one by one as described above, and when the brush is for example a resilient wire member, one side of the wire member must be used as a "reference surface". But the side surface is spaced apart from the surface of the resistor, the parallax is produced so that no accurate adjustment can be expected at all.

As disclosed by, for example, the U.S. Pat. No. 2,760,036, there has been proposed to locate the longitudinal direction of the brush along the tangent of the path of the brush in order to prevent the vibration of the brush in the lateral direction. In this case, more space is required for housing the brush supporting member because the latter is extended outwardly. When a plurality of resilient members of the brush are juxtaposed in such a manner that the line passing through the contacts of these resilient members, is inclined relative to the radial direction, only one resilient member will satisfy the desired condition so that the lateral deviation of the brush cannot be prevented.

In view of the above, the primary object of the present invention is to eliminate the above described defects encountered in the conventional resistor of the character described above.

In brief, the present invention provides a variable resistor in which a brush is comprised of an arm member which is flexible in the plane at a right angle of the path of contact, a contact member extending from the arm member and a supporting member, one end of which is securely fixed in position; the contact member slides over the path in a plane, the path being curved inwardly, not outwardly; a tap portion which partially overlaps with a slide resistor and having a surface resistance lower than that of the resistor is disposed below the path; the resistor is extended substantially over the path; the resistance between the terminal at one end of the resistor and the contact is varied in response to the displacement over the path of the brush upon the resistor; the range in which the resistor changes its resistance functionally can be positively distinguished from the range in which the resistor will not change its resistance functionally; and even if the brush supporting member is directed from either direction to a predetermined position, a better reproducability of a resistance at this position can be ensured; that is, the contact can be ensured to move along the same path in both of the radial and circumferential directions.

According to the present invention, the reproducability of the position of the contact, especially in the radial direction, is attained with a higher degree of accuracy so that there is no difference in resistance at any position of the brush supporting member even when the latter is brought to this position from either direction. When the brush supporting member is positioned outside of the service range, the resistor can be immediately short-circuited, so that when the resistor in accordance with the present invention is employed in an exposure meter, whether the photometry can be effected or not can be easily and immediately seen, whereby the indication of the exposure meter which cannot be operatively coupled to the associated mechanism of the camera will not be used at all. The further advantages accrued from the present invention are as follows:

1. The path of the contact can be determined with a higher degree of accuracy relative to the resistor pattern. The resistor patterns may be designed by use of those having narrow widths. In case of the tap type resistor where the resistance of the tap is important, the dispersion in resistance can be eliminated by the above described arrangement so that the above described patterns may be used more freely, whereby the zig-zag type resistor whose resistance varies over a wide range and which is less in cost may be advantageously employed. When the width of the resistor is gradually varied or tapered in order to obtain a resistor whose resistance varies functionally, the contact between the resistor and the brush can be ensured until the last narrow end of the resistor so that the resistor can vary its resistance over a wide range even when the resistor is made of a film having the same surface resistance.

2. The relative position between the path of the brush and the resistor pattern can be determined with a higher degree of accuracy even when the resistor pattern is deviated relative to the reference hole of the resistor supporting member.

3. The need for providing a space for the brush or the like at the exterior of the resistor pattern is eliminated so that the resistor in accordance with the present invention can be made compact in size and light in weight.

4. The dispersion in resistance can be corrected by selectively using one of the brush positioning members each having a different profile when the path of the brush is associated with the resistance value after the resistor is fixed to the base plate. Thus, the resistor in accordance with the present invention is inexpensive to manufacture yet has a higher degree of accuracy.

5. The resistor in accordance with the present invention has the same adjustment function as that of the resistor in which an independent semi-fixed resistor is connected in series.

6. An arbitary range of the resistance curve may be selected. This means a better yield and an inexpensive manufacturing cost. The adjustment function of the resistor for matching with other parts in an electric circuit can be increased.

The present invention provides a variable resistor having a circular path for the contact of a brush formed upon a plane characterized in that a brush positioning member has an insulating portion formed upon the surface of said brush positioning member facing the surface of a base disk having resistor bodies, said insulating portion including at least a portion of said surface of said brush positioning member which portion faces said resistor bodies, said brush positioning member having an outer vertical peripheral wall along a curve spaced apart inwardly by a predetermined distance from the innermost path of said contact of said brush, said brush positioning member being securely fixed to said surface of said base disk in such a manner that said outer vertical peripheral wall of said brush positioning member may be aligned with said curve; the innermost resilient member of brush resilient members of said brush arranged in the longitudinal direction relative to said path of said contact of said brush is pressed against said outer vertical peripheral wall, said innermost resilient member being normally pressed against said outer vertical peripheral wall at least within a predetermined range of said path where said contact of said brush rides upon a tap extended from said resistor bodies or upon said resistor bodies by the resultant force of the resilient force of said resilient member produced upon deflection thereof in the direction of the normal relative to said outer vertical peripheral wall and the pressure exerted to the opposite side of said resilient members remote from said resilient member by spring means or either of said resilient force or said pressure alone, said resilient member being adapted to bend only in the direction at a right angle relative to said surface of said base disk so that said resilient member may be normally pressed against said resistor bodies or said surface of said base disk having said tap, said resilient member being pressed toward the direction intermediate the direction toward said outer vertical peripheral wall and the direction toward said surface of said disk at a portion having a contact; and a short-circuiting member which coacts with a brush supporting member is provided, the path of the contact of said short-circuiting member being placed upon the surface opposite to said surface of said disk having said resistor bodies, said path comprising an electrically insulated portion and an electrically conductive portion, whereby within the range of rotation of said resistor one of said short-circuiting member and said conductive portion is normally short-circuited to said resilient member while the other is normally short-circuited to a semi-fixed terminal on the lower resistance side.

This invention will be described more clearly referring to the illustrative embodiments thereof shown in the attached drawings, in which:

FIG. 1 is a perspective view of a first embodiment of the present invention;

FIG. 2 is an exploded perspective view thereof;

FIG. 3 is a sectional view thereof;

FIG. 4 is a sectional view taken along the line IV—IV of FIG. 3;

FIG. 5 is a graph illustrating the relation between the angle of rotation and the resistance;

FIG. 6 is an exploded perspective view of a second embodiment of the present invention;

FIG. 7 is a sectional view thereof;

FIG. 8 is a sectional view taken along the line VIII—VIII of FIG. 7;

FIG. 9 is a perspective view of a third embodiment of the present invention;

FIG. 10 is an exploded perspective view thereof;

FIG. 11 is a sectional view thereof;

FIG. 12 is a sectional view taken along the line XI—XI of FIG. 11;

FIG. 13 is a fragmentary sectional view of a fourth embodiment of the present invention;

FIG. 14 is a perspective view thereof;

FIG. 15 is a perspective view of a brush in accordance with a fifth embodiment of the present invention, the brush being illustrated as being free; and

FIG. 16 is a view similar to FIG. 15, but illustrating brush being fixed in position.

Referring to FIGS. 1, 2 and 3, a first embodiment of the present invention will be described. A brush supporting member 1 made of a metal is provided with a shaft 1*a*, slots 1*b* and 1*e* and setscrew holes 1*c* and 1*d*. A slider 2 for brush comprises a rigid portion having a bent portion 2*b* which has a screw hole 2*c* and a large diameter hole 2*d* whose diameter is larger than that of a screw 3; a spring portion 2*a* which is resilient in the direction at a right angle relative to a base plate surface to be described hereinafter; and a leading end portion 2*e* having a contact brush 9 fixed to the undersurface of the leading end portion 2*e* by spot welding, brazing, etc., the contact brush 9 comprising a plurality of contacts 4 which are made of spring wires and arrayed in side by side relation with each other and which have contact portions 4*a*. As best shown in FIG. 4, the contacts 4 are arcuated as shown by the dotted lines 6 when they are free upon the surface of the base plate. However, it should be noted that the contacts 4 spring back when the base plate is removed so that the cross-sections 8 of the contacts 4 are positioned at 7 in FIG. 3. Thus, the contacts 4 are shaped as shown in FIG. 2.

The slot 1*b* of the supporting member 1 has such dimensions that when the slider 2 is attached to the supporting member 1 by means of the screw 3, the spring portion 2*a* and the contact brush 9 may be fitted into the slot 1*b*. The boundary line 2*g*, the end face 2*f* and the contacts 4*b* are all arranged in parallel with each other. A collar 10 made of an electrically insulating material has a hole 10*c* and an externally threaded portion 10*b* and the shaft 1*a* of the supporting member 1 is rotatably fitted into the hole 10*c*. The collar 10 serves to securely fix short-circuit plates 19 and 20 to a base plate supporting member 11. A base plate 12 made of insulating material has upon its upper surface 12*a* a first resistance layer 12*b* whose width varies along the path of movement of the contact brush to vary the electric resistance as a function of its position. The leading end 12*c* of the first resistance layer 12*b* has a narrow width of the order of 100 μ over which the contact brush 9 passes. In continuation of the leading end 12*c*, taps 12*d* are formed on a second resistance layer 12*e* with its width being varied gradually. In the instant embodiment, the second resistance layer 12*e* has a resistance per unit of area higher than that of the first resistance layer 12*b* and the tap 12*d* is formed by the same layer as the first resistance layer 12*b* and has a relatively low resistance.

It should be noted that the inward or outward displacement of the innermost contact 4*a* from the path of the brush will affect the resistance. The deviation of the resistance will result from said displacement especially when the brush is located at or in the vicinity of the leading end 12*c* of the first resistance layer 12*b*. This means that it is imperative that the contact 4*a* must be reproducably located at a predetermined position in the vicinity of the leading end 12*c* of the first resistance layer 12*b*.

A third resistance layer 12*f* connected with the other end of the first resistance layer 12*b* is made of the same material as that of the first resistance layer 12*b*. A center hole 12*g* of the base plate 12 is fitted over a hub 11*b* of the base plate supporting member 11. It is preferable that one of the taps 12*d* in the vicinity of the leading end 12*c* is partially overlaid upon the first resistance layer 12*b* and the second layer 12*e*, but it should be noted that the displacement of the contact 4*a* in a radial direction from the predetermined path of movement thereof will also cause the deviation of the resistance value especially at or in the vicinity of the leading end 12*c*.

A brush positioning member 13 is provided on the base plate 12 for guiding the end of brush 9 and is comprised of a disk having a thickness larger than the radius of each of the wires 4. For example, the brush positioning disk 13 is made of a nylon containing molybdenum dioxide which has a small coefficient of friction and is an electrically insulating material.

This disk 13 is provided with a hole 13*a* having a diameter larger than that of the hub 11*b* of the supporting member 11, holes 13*b* for temporary assembly, a finely finished outer periphery 13*c*, a slot 13*d* and a recessed portion 13*e*. The outer periphery 13*c* is circular and is engageable with the innermost contact 4*a* so that the path of movement 5 of the contact 4*a* is aligned on the leading end 12*c* of the first resistance layer 12*b* as shown in FIG. 4. The third resistance layer 12*f* is exposed through the slot 13*d*. A semi-fixed terminal 18 is fitted into the recessed portion 13*e* in such a manner that the tongue 18*a* of the semi-fixed terminal 18 is made in contact with the layer 12*f* through the slot 13*d*.

Upon the base plate 12 are formed two marks 12*h* and 12*i* which are made of the same material as that of the second resistance and which are angularly spaced apart from the end 12*c* of the first resistance layer 12*b* by about 90°. These marks 12*h* and 12*i* are vacuum-deposited at the same time when the second resistance layer is formed because a mask for forming the second resistance layer has also openings for forming these marks 12*h* and 12*i*, so that the relative positions of these marks 12*h* and 12*i* with respect to the leading end of the second resistance layer pattern may be maintained at a higher degree of accuracy. The inner side edge of the mark 12*h* and the outer side edge of the mark 12*i* are placed along the same circle which in turn is coincident with the outer periphery 13*c* of the brush positioning disk 13 as shown in FIG. 2. Therefore, it will be seen that when the position of the brush positioning disk 13 is determined by aligning the outer periphery 13*c* of the brush positioning disk 13 with the inner side edge of the mark 12*h*, the outer side edge of the mark 12*i* and the inner side edge of the leading end 12*c* of the first resistance layer, the relative positions among the leading ends of the first and second resistance layers and the path of the brush can be maintained at a higher degree of accuracy. However, when it is desired that the contact is accurately positioned relative to a point other than the leading end 12*c*, the brush positioning disk 13 is positioned with reference to this point. When the tolerance of $\pm\alpha°$ is allowed in positioning the outer periphery 13*c*, both of the inner side edge of the mark 12*h* and the outer side edge 12*i* are spaced apart from said reference circle by α.

The semi-fixed terminal 18 is previously bowed so that when it is interposed between the recessed portion 13*e* of the brush positioning disk 13 and the short-circuit plate 20 to be described in more detail hereinafter, the semi-fixed terminal 18 may be held in position and the tongue 18*a* may be displaced through a slot 19*c* of the short-circuit disk 19 relative to the third resistance layer 12*f*. That is the series-resistance value of the third resistance layer and the other resistance layers is variable.

The short-circuit disks 19 and 20 are made of an electrically conductive, thin material and are made in contact with the base plate supporting member 11 so that when the contact line 4*b* of the brush is located between A and B in FIG. 4, that is, in an angle θ_1, the resistance circuit is established by 1—2—4—12*b*—12*f*—18—20 and 11.

A short-circuit brush 17 is fixed to the brush supporting disk 1 through holes 17*b* by means of screws 16 and tapped holes 1*d*. A tongue 17*a* of the short-circuit brush is adapted to travel along the path of movement of the tongue 17*a* as shown in FIG. 4, that is over the brush positioning disk 13 and the short-circuit plates 19 and 20. The short-circuit brush 17 is electrically connected to the brush 2 through the slide supporting disk 1. That is, when the tongue 17*a* is over the short-circuit disks 19 and 20, the above described resistance circuit is short-circuited by a parallel circuit 1—17—19 or 20. When or where the short-circuit occurs depends upon the positions of one side edges 19*a* and 20*a* of the short-circuit disks 19 and 20 respectively. That is the range of resistance is determined between A and B in FIG. 4. The above described short-circuit position may be arbitrarily selected by adjusting the short-circuit disks 19 and 20 by temporarily holding them in position. That is, both ends of the resistance curve shown in FIG. 5 are not limited to θ and θ_1, but arbitrarily selected between θ_2' and θ_1'.

In assembly, the brush positioning disk 13 is overlaid upon the base plate 12 and held in position with respect to the reference position 12*c* of the base plate 12 and the marks 12*h* and 12*i* by use of a profile projector or the like. When the width of the leading end 12*c* is larger than the diameter of the wire 4, the inner side edge 12*c* is aligned with the outer periphery 13*c* of the brush positioning disk 13 so that the portion spaced apart from the outer periphery 13*c* by a distance equal to the radius of the wire 4 of the brush positioning disk 13 is securely overlaid upon the resistance layer. On the other hand, when the width of the leading end 12*c* is smaller than the diameter of the wire 4, a mark for alignment with the outer periphery 13*c* may be formed inwardly of the leading end 12*c* of the resistance pattern as in the case of the mark 12*i*. Alternatively, by use of a profile projector and a chart, outer periphery 13*c* of the brush positioning disk 13 may be positioned relative to the leading end 12*c* of the resistance pattern. The lower side edge of the outer periphery 13*c* of the brush positioning disk 13 is in close contact with the surface of the base plate 12 so that there is no fear that the brush positioning disk 13 is set at a wrong position because of parallax. It should be noted that the outer periphery 13*c* of the brush positioning disk 13 is so located that the periphery 13*c* is not spaced apart from the marks 12*h* and 12*i*. After the outer periphery 13*c* of the brush positioning disk 13 having been positioned, a suitable adhesive is applied through the slot 13*b* of the brush positioning disk 13 so that it is securely fixed to the base plate 12. When the center of contact travels along the path spaced apart from the outer periphery 13*c* by a distance equal to the radius of the wire 4, the above path is determined accurately with respect to at least the leading end 12*c* and other portions or positions which are important in the function of the resistor. Next thus assembled brush positioning disk 13 and the base plate 12 are fitted over the base plate supporting member 11 and the semi-fixed terminal 18, and the short-circuit disks 20 and 19 are assembled in the order named and held in position by means of the collar 10. The slider 2 is fixed to the brush supporting disk 1 by means of the setscrews 3, but since there is a relatively large gap between the slot 2*d* and the setscrew 3, the leading ends of the wires 4 may be displaced outwardly about the hole 2*c*. Next the shaft 1*a* of the brush supporting disk 1 is fitted into the hole 10*c* of the collar 10. When the undersurface of the brush supporting disk 1 is made in contact with the upper surface of the collar 10, both of the shaft 1*a* and a shaft 11*c* of the base plate 11 are coupled to a driving member (not shown) through a bearing (not shown). After setting the slider by rotating the same about the hole 2*c* as described hereinabove so as to extend slightly outwardly, the slider 2 is held in position so that the contact 4*a* is pressed against the outer periphery 13*c* of the brush positioning disk 13 and other contacts are pressed against each other. When the setscrews 3 are tightened, the contact 4*a* is also pressed against the base plate 12. When the brush supporting member 1 is rotated relative to the base plate supporting member 11 by means of a driving member (not shown), the contact 4*a* always engages with the outer periphery 13*c* of the brush positioning disk 13. The tongue 18*a* is so positioned through the hole 1*b* and the hole 19*c* that a desired resistance value may be obtained especially when low resistance values are desired. The positions of the side edges 19*a* and 20*a* which determine the range of the resistance used are determined by displacing suitably the short-circuit disks 19 and 20 through the slot 1*e* while the collar 10 is loosely fixed. When the positions as well as the dimensions of the holes 1*b* and 1*e* are not sufficient enough for positional adjustment of the tongue 18*a*, the sides edges 19*a* and 20*a* of the short-circuit disks 19 and 20, the to additional slots or the like may be formed in the brush supporting member 1 for this purpose. The brush positioning disk 13 may be made of an electrically insulating thin film sheet overlaid upon a conductive metallic disk.

When the tap 12*d* is superposed upon the first resistance layer 12*b* and the leading end 12*c*, the displacement of the path of the contacts in the radial direction will affect the resultant resistance. In this case, when the brush positioning disk 13 is provided with the outer peripheral cam face, a slightly varying resistance may be attained from the same resistance pattern. The variation or error in resistance due to the dispersion of the surface resistance of the coacted resistor film may be suitably corrected by selecting a brush positioning disk having a different outer peripheral profile. Next referring to FIGS. 6, 7 and 8, the second embodiment of the present invention will be described hereinafter. The brush positioning disk is comprised of a metallic disk 15 and an electrically insulating sheet-like disk 14 both of which are overlaid one upon another in the second embodiment. As best shown in FIG. 6, the metallic disk 15 is provided with a slot 15*d* into which is fitted a semi-fixed resistor terminal 18*a*, a hole 15*b* which is used for attachment by an adhesive and a center hole 15*a* whose diameter is sufficiently larger than that of the hub 11*b* of the base plate supporting member 11. The contacts 4 are adapted to press against the outer periphery 15*c* of metallic disk 15 so as to guided by the outer periphery 15*c*. The outer diameter of the insulating disk 4 is slightly smaller than that of the metallic disk 15 and is provided with a hole 14*a*, a hole 14*b* and a slot 14*d* which mate with the holes 15*a*, 15*b* and the slot 15*d* respectively. The diameter of the hole 14*b* is slightly smaller than that of the hole 15*b*. When the insulating disk 14 is overlaid upon the metallic disk 15 in coaxial relation therewith there is a space upon the metallic disk 15 over which is not overlaid the insulating disk 14 and which may be therefore used for bonding both of the disks 14 and 15 together. The assembly of the metallic disk 15 and the insulating disk 14 is positioned relative to the base plate 12 as in the case of the first embodiment so that the assembly may be bonded to the base plate 12 through the hole 15*b*. Insulating segment disks 21 and 22 are so formed that when they are assembled as best shown in FIG. 8, their segment portions 21*c* and 22*c* are overlapped with each other at such a position which corresponds to the position in FIG. 4 where there exists no projections of the short-circuit disks 19 and 20. Therefore, the path of the tongue 17'*a* corresponding to the tongue 17 in the first embodiment alternately changes from the segment disks 21 and 22 to the metallic disk 15 and vice versa. That is, when the tongue 17'*a* passes along the path 23, it will be electrically disconnected or insulated from the metallic disk 15, and consequently the contact wires 4 when the tongue 17'*a* is over either of the segment portions 21*c* or 22*c*. On the other hand, upon the metallic disk 15 the tongue 17'*a* is short-circuited. Upon the segment disk 21 is overlaid the semi-fixed terminal 18 whose outer periphery 18*b* is made slightly larger than that of the flange 10'*a* of the collar 10' and the tongue 17'*b* of the short-circuiting brush 17' is normally made in contact with the semi-fixed terminal 18 through an aperture 1*f* formed on the brush supporting member 1. The short-circuiting brush 17' is fixed to the brush supporting member 1 by means of setscrews 16' which are made of an insulating material through insulating washers 24. The tongue 17'*a* is fitted into the slot 1*e* while the tongue 17'*b* is fitted into the aperture 1*f* and both of the tongues 17'*a* and 17'*b* are spaced apart from the brush supporting member 1 so that the short-circuiting brush 17' is electrically insulated from the brush supporting member 1 when they are held in position. The collar 10' is made of an electrically insulating material such as ABS resin and has the under surface of the flange 10'*a* and threaded portion 10'*b* applied with a metal coating. Therefore, the semi-fixed terminal 18 is electrically connected to the base supporting member 11 through the collar 10', but they are electrically insulated from the brush supporting member 1. The collar 10' is fitted over the shaft 1*a* of the brush supporting member 1 and when the collar 10' is tightened the semi-fixed terminal 18 and the segment disks 21 and 22 are securely held in position between the flange 10'*a* of the collar 10' and the upper surface 11*a* of the hub 11*b* of the base supporting member 11. In this case, the upper surface of the shaft 11*a* is so arranged as to become coplanar relative to the upper surface with the metallic disk 15. Other arrangements are same as in the first embodiment.

When the contacting point line 4*b* of the brush is within the range defined between A and B in FIG. 8, there is established a resistor circuit consisting of the brush supporting member, the slider 2, the first resistance layer 12*b*, the third resistance layer 12*f*, the semi-fixed terminal 18 and the base plate supporting member 11. When the contact line 4*b* is out of the range between A and B, the tongue 17'*a* of the short-circuiting brush 17' is short-circuited to the metallic positioning disk 15 so that the short-circuited circuit consisting of the brush supporting member 1, the brush spring portion 2, the metallic positioning disk 15, the short-circuiting brush 17', the semi-fixed terminal 18 and the base supporting member 11 is established and the resistance variable range is limited as shown in FIG. 5.

Next the third embodiment of the present invention will be described hereinafter with reference to FIGS. 9, 10, 11 and 12. A metallic brush supporting member 201 is provided with a shaft 210*a*, a slot 201*b* and setscrew holes 201*c*.

As best shown in FIG. 12, when contacts 4 are disposed freely upon the base disk, they are so shaped as to be positioned as shown by the dotted lines 6 in FIG. 12. The slot 201*b* of the brush supporting member 201 has sufficient dimensions that when the brush is fixed by means of the setscrews 3, the spring portion 2*a* and the contact brush 9 can be fitted into the slot 201*b*. The boundary line 2*g* of the spring portion 2*a*, the end face 2*f* and the contacting point line of contacts 4*b* are arranged substantially in parallel with each other. A collar 10 is made of an electrically insulating material and provided with a flange 10*a*, a hole 10*c* and an externally threaded portion 10*b*. Into the hole 10*c* is fitted the shaft 201*a* of the brush supporting member 201. By the threadable engagement of the externally threaded portion 10*b* of the collar 10, a base plate 212 and a brush positioning disk 213 to be described in more detail hereinafter are fixed to the base supporting member 11. Upon a resistance disk 212 is formed a resistor layer 212*b* whose width is gradually varied or tapered and the leading end 212*c* is of the order of 100 μ in width. The contacts must be in contact with this resistor layer 212*b*. In continuation of the leading end 212*c* is formed a zig-zag shaped resistor portion 212*e* with a stripe 212*d* made of resistance layer. In the instant embodiment, both of the tap and resistor portions are vacuum-deposited simultaneously. That is, they are made of the same material and have the same thickness. The stripe 212*d* has also a resistance so that the radially outward or inward deviation of the innermost contact 4*a* from the innermost path 5 affects the resultant resistance. At the zig-zag shaped resistor portion, the nearer the contact 4*a* to the terminal 212*f* to be described hereinafter, the more the effect of the above described deviation becomes and the larger the relative error becomes. This means that it is imperative to reproducably position the contact 4*a* in the vicinity of the leading end 212*c*. The terminal 212*f* is formed from an electrically conductive paint so that after the base plate 212 has been temporarily bonded to the base plate supporting member 11, the end face 11*a* of the hub 116 is further short-circuited to the electrically conductive paint. The hub 11*b* of the base plate supporting member 11 is fitted into the hole 212*g*. The brush positioning disk 213 is made of an insulating material having a small coefficient of friction such as molybdenum dioxide and has a thickness larger than the radius of the contact 4. The brush positioning disk 213 is provided with a hole 213*a* whose diameter is sufficiently larger than the outer diameter of the hub 11*b* of the base plate supporting member 11, holes 213*b* for temporarily bonding and a fine finished peripheral side edges or wall 213*c*, which is circular in shape.

Two marks 212*h* and 212*i* are formed upon the base plate 212 as well as marks 12*h* and 12*i* as shown in FIG. 1. When it is desired to locate the point of contact accurately relative to positions other than the leading end 212*c* of the resistor pattern (for example, a point indicated by 212*j*), the brush positioning disk 213 is positioned relative to such "reference" position.

In assembly, the brush positioning disk **213** is overlaid upon the base plate **212** and by use of a profile projector or the like the outer periphery **213***c* of the brush positioning disk **213** is determined relative to the important leading end **212***c* and the marks **212***h* and **212***i* upon the base plate **212**.

After the positioning disk **213** is positioned as described above, an adhesive agent is filled into the holes **213***b* thereby temporarily assembling the resistor disk **212** and the brush positioning disk **213** into a unitary construction. The assembly of the brush positioning disk **213** and the base plate **212** is fixed to the base plate supporting member **11** so that the end face **11***a* of the member **11** is short-circuited by the conductive paint described hereinabove and thereafter the collar **10** is tightened.

The slider **2** is fixed to the brush supporting disk **201** by means of the setscrews **3** and since the spacing between the slot **2***d* and the screw **3** is large, the brush spring portion **2** may be rotated outwardly about the hole **2***c* so that the leading ends of the wire members **4** may be displaced outwardly. In this state, the shaft **201***a* of the brush supporting disk **201** is fitted into the hole **10***c* of the collar **10**. When the brush supporting disk **201** makes a contact with the upper surface of the collar **10**, both of the shaft **201***a* and the lower shaft **11***c* of the base supporting member **11** are journalled by a bearing (not shown) and coupled to a driving member (not shown).

Since the above described rotation of the slider **2** about the hole **2***c*, the contact **4***a* may be normally pressed against the outer periphery **213** and the adjacent wire members are also closely pressed against each other. When the set screws **3** are tightened, the contact **4***a* is pressed against the upper surface of the base plate **212***a*. Next the brush supporting member **201** is rotated relative to the base supporting member **11** by means of a driving member (not shown) so that the contact **4***a* effectively and accurately moves over the variable resistance range in which the resistance layers **212***b* and **212***d* are formed on the base plate. The brush positioning disk **213** may be constructed with two elements as shown in FIGS. **13** and **14**. In this case, the brush positioning disk is comprised of an electrically insulating thin sheet-like member or disk **214** and an electrically conductive metallic disk **215** both of which are overlaid one upon the other. The outer diameter of the thin disk **214** is smaller than that of the metallic disk **215** and holes **215***a* and **215***b* which are used for bonding are larger than holes **214***a* and **214***b* of the insulating disk **214** and are aligned with them when the disks **214** and **215** are assembled. Therefore both of the disks **214** and **215** may be assembled into a unitary construction temporarily before they are completely assembled with other parts. The undersurface of the metallic disk **215** may be coated with an electrically insulating film or partially recessed so that the insulating thin film-like disk **214** may be eliminated.

Next, other embodiments of the slider will be described with reference to FIGS. **15** and **16** illustrating the contact brush in its free position and fixed position respectively. A spring wire member **16** is disposed in juxtaposed relation with the contacts **4** so that the force or pressure for pressing the contact against the outer periphery **213***c* of the brush positioning disk **213** may be attained partially or completely by the deflection of the spring member **16**. In this embodiment, when the brush is free, the contacts spring back downwardly while the spring member **16** springs back inwardly. On the other hand, when the brush is held in position, since the contact **4***a* is pressed against the base plate **212**, the contacts **4** are held in the same plane as that of the spring member **16** as shown in FIG. **16** but the spring member **16** may be positioned outwardly of the contacts **4**. The same function and effect can be attained by the spring member **16** and the contacts **4** shown in FIGS. **4**, **8** and **12** by the chain lines.

What is claimed is:

1. A variable resistor comprising

a base plate of insulating material having a hole at its center portion and a plurality of tapered resistance layers on the surface of said base plate and connected in series about said hole,

a base plate supporting member having a hub at its center portion and inserted into said hole of said base plate,

a brush supporting member rotatably supported by said hub,

an insulating collar provided between said base plate supporting member and said brush supporting member for electrically insulating each other,

a slider fixed on said brush supporting member, having a plurality of resilient contacts slidable along said layers, and arranged in tangential direction relative to the path of movement thereof, and

a brush positioning member fixed on the surface of said base plate and having an outer periphery insulated wall slidably engaged with the end of the innermost contact of said contacts for guiding the end of said contact along the predetermined path of movement thereof.

2. A variable resistor according to claim **1**, wherein said contacts are constructed in parallel to each other and are curved along the outer periphery of said brush positioning member.

3. A variable resistor according to claim **1**, wherein said base plate further has a mark on the surface thereof for positioning the outer periphery of said brush positioning member.

4. A variable resistor according to claim **1**, wherein the lower end portion of said tapered resistance layers extends to the inner surface of said hole of said base plate so as to be electrically connected to said base plate supporting member.

5. A variable resistor according to claim **1** further comprising:

a further resistance layer on said base plate positioning out of the path of movement of said contacts and connected in series to the lowest resistance end portion of said tapered resistance layers,

a radially spaced slot on the surface of said brush positioning member, and

a semi-fixed terminal provided on the surface of said brush positioning member and having a tongue engaged with said further resistance layer passing through said slot, whereby the relative position of said tongue to said further resistance layer is adjustable.

6. A variable resistor according to claim **5** further comprising:

a pair of segment disks of conductive material provided on said semi-fixed terminal and rotatable with said base plate, and

a short-circuiting member provided on said brush supporting member and engageable with said segment disks when a predetermined relative angular movement between said base plate and said brush supporting member is obtained.

7. A variable resistor according to claim **5** wherein said brush positioning member includes a conduction portion comprising:

a pair of segment disks of insulating materials provided on said brush positioning member and rotatable therewith, and

a short-circuiting member provided on said brush supporting member and successively engageable with said segment disks and said conductive portion of said brush positioning member in accordance with the relative movement between said base plate and said brush supporting member.

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