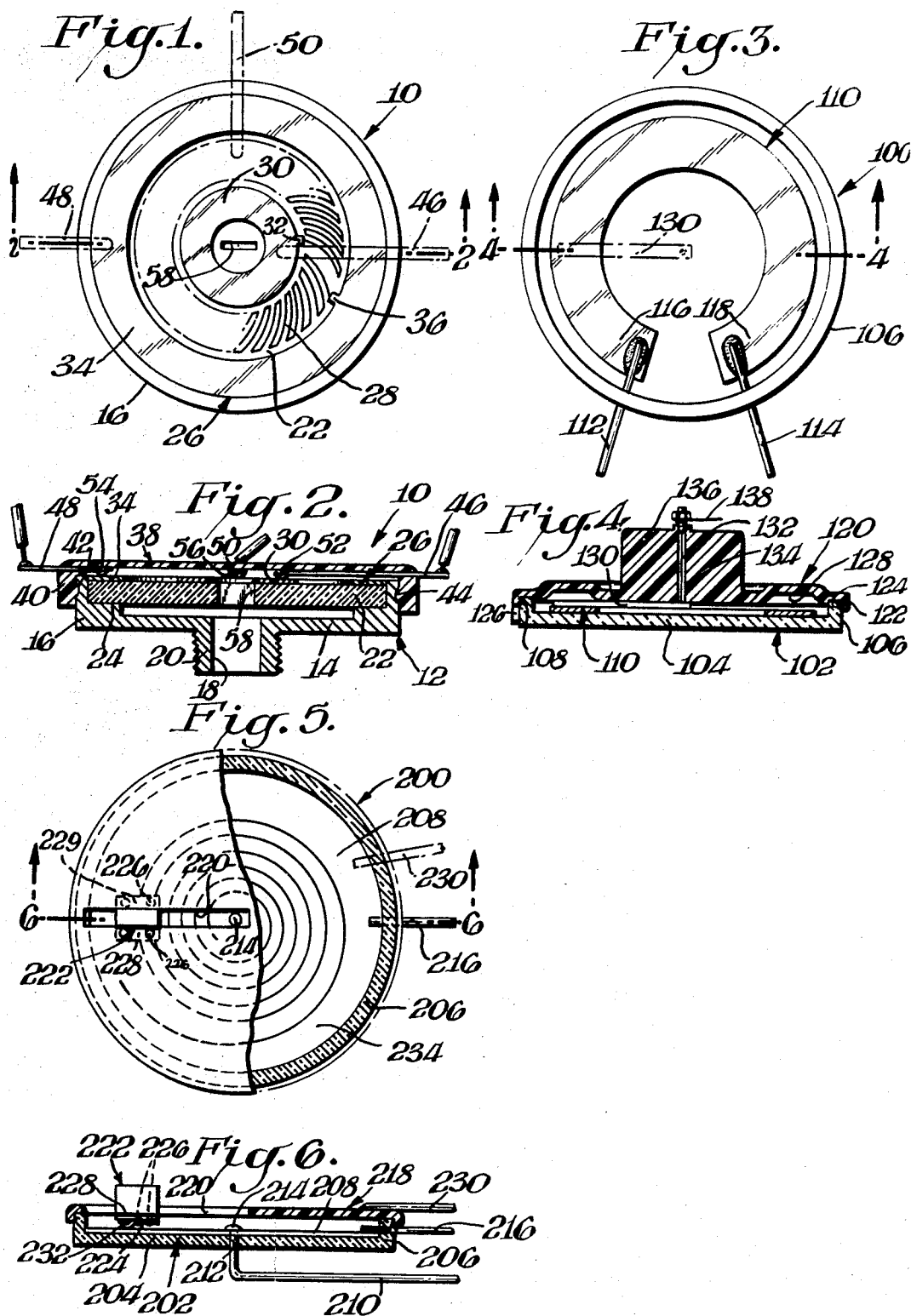


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 CERAMIC CASED CHROMIUM-NICKEL VARIABLE  
 RESISTOR WITH UNDEFORMED CONTACT  
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**CERAMIC CASED CHROMIUM-NICKEL VARIABLE RESISTOR WITH UNDEFORMED CONTACT****D'Arcy Andrews Young, Jr., Peterborough, N.H., assignor to Sprague Electric Company, North Adams, Mass., a corporation of Massachusetts**

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1 Claim

**ABSTRACT OF THE DISCLOSURE**

Variable resistors having a small number of parts. Contacts can be made of substantially undeformed Phosphor bronze. Resistance can be chromium-nickel film deposited on a completely oxidized film of the same type on a ceramic case.

**BACKGROUND OF THE INVENTION**

The present invention relates to resistors, and more particularly to variable resistors having Phosphor bronze contacts.

Variable resistors of the type that have their resistance varied by merely turning a knob or the like, are characterized by their relatively intricate construction which uses a large number of parts and in addition frequently suffer from contact problems.

Among the objects of the present invention is to provide a simple, reliable and easy-to-use variable resistor.

Another object of the invention is an improved film material suitable for resistive elements of a resistor.

**SUMMARY OF THE INVENTION**

According to the present invention a sliding contact of a variable resistor is a thin, straight and substantially undeformed stamping of Phosphor bronze. The contact is arranged to engage a long resistive element at various points along its length when these parts are moved relative to one another. As is well known, varying the position of the contact relative to the resistive element varies the length of the resistive path traveled by the current flowing through the resistor.

The variable resistors can have as resistive elements a film of a mixture of chromium and nickel vapor-deposited on a completely oxidized film of a mixture of chromium and nickel carried on a support. A resistive element of this construction functions particularly well to produce the desired resistance. The element can be formed directly on the base portion of a suitable resistor case or housing, or alternatively, upon a support arranged to fit within the case. Regardless of how the resistive film is supported, an appropriate pattern may be produced by machining away selected portions of the film with an electron or laser beam, for example.

The variable resistors of this invention have relatively few parts that are easily assembled by rapid mass production techniques.

**BRIEF DESCRIPTION OF THE DRAWING**

Novel features and advantages of the subject invention in addition to those mentioned above will become apparent to one skilled in the art from the following detailed description in conjunction with the accompanying drawings wherein similar reference characters refer to similar parts and in which:

FIGURE 1 is a plan view of a variable resistor according to the present invention with the cover removed and the contacts shown in phantom;

FIGURE 2 is a sectional view taken along line 2-2 of FIGURE 1 with the cover in its assembled position;

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FIGURE 3 is a plan view of another embodiment of the instant invention with the cover removed and the wiper contact shown in phantom;

FIGURE 4 is a sectional view of the embodiment of FIGURE 3 taken along line 4-4;

FIGURE 5 is a plan view of still another embodiment of the present invention with portions of the cover broken away to show detail; and

FIGURE 6 is a sectional view taken along line 6-6 of FIGURE 5.

**DETAILED DESCRIPTION OF THE INVENTION**

Referring in more particularly to the drawings, FIGURES 1 and 2 illustrate a variable resistor, such as a potentiometer 10, having a case 12 fabricated of metal. The case has a bottom wall 14 and an upstanding side wall 16 integrally connected to the peripheral portion of the bottom wall. An opening 18 is provided in the central portion of the bottom wall to permit easy access to the interior of the case, for reasons explained more fully below. The opening is surrounded by an externally threaded collar 20 integral with the bottom wall of the case. This collar provides fastening structure shown as an external thread for securing the potentiometer to a chassis (not shown) or other convenient support. In this regard, an internally threaded fastener such as a nut, may be threadably engaged about the collar to anchor the potentiometer to the chassis, as is well known.

A ceramic disc 22 is configured to fit within the interior of the case where it rests on an annular rim or shoulder 24. A slight clearance between the edge of the disc and the interior surface of the side wall 16 can be provided to enable the disc to rotate within the case. The disc 22 carries an electric resistive element 26 formed in part by a series of involute curves 28, as shown best in FIGURE 1. The involute pattern is such that the current supplied thereto flows in an opposite direction through each successive leg of the resistive path to thereby provide a resistive element having an overall inductance which is substantially zero. The spacing between successive involute curves 28 is preferably about 0.001 to 0.010 inch, although the spacing is shown larger in the figure.

In addition to the portion of the resistive element formed by the involute curves 28, inner and outer annular rings are also provided for directing current from one end of the involute pattern to the other. The inner ring 30 contacts the involute pattern at end 32 while the outer ring 34 contacts end 36 of the pattern. For clarity, the thickness of the resistive element is exaggerated in the drawing. In actuality, the thickness of this element is about 50 to 200 angstroms.

A cover 38 of resilient plastic material is provided for enclosing the disc 22 within the case 12. The cover is configured to fit over the case and in this regard is provided with an outer annular flange 40 having an inwardly directed bead 42 that snugly fits within an annular recess 44 in the side wall of the case when the cover and case are assembled. The cover can be snap-fitted over the case to hold the interior surface of the cover spaced a predetermined distance away from the resistive element 26.

The cover 38 is arranged to carry the resistor contacts 46, 48, 50, each of which is made of Phosphor bronze. These contacts are preferably stamped from a Phosphor bronze sheet having a thickness of about 0.005 inch. The finished contacts are straight and undeformed except for a dimple 52, 54, 56 at one end of each contact, the dimple extending from the surface of the contact approximately 0.002 inch. As explained more fully below, such a contact operates for exceptionally long periods of time without

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the usual contact problems that develop when the contact engagement becomes too loose or too tight.

Each of the contacts 46, 48, 50 extends through the flange of the cover and can be embedded therein during the construction of the cover. The cover flange can be about twice as thick as the remaining portions to better hold the contacts in their desired positions. The contact 46 extends inwardly of the cover flange to a position where its dimple 52 engages the inner ring 30 of the resistive element. As shown in the drawing, the contact 48 is shorter than contact 46 and extends inwardly to a position where its dimple 54 engages the outer rim 34 of the resistive element. The wiper contact 50 is positioned so that its dimple 56 touches the resistive film. The location at which contact 50 connects to the resistive film is preferably such that as it moves from each curved track 28 to the next, the change in resistance is exactly the same. Depending upon the shape of the track, the contact engagement site will generally be slightly outside the midpoint between the inner and outer track margins.

As shown in FIGURE 2, the disc 22 has a central slot 58 exposed to the exterior of the case by the opening 18 in the bottom wall 14. A tool such as a screwdriver, for example, can be easily inserted into the slot to rotate the disc relative to the remaining portions of the potentiometer. The rotation is unlimited and causes the contacts 46 and 48 to slide across their associated rings 30 and 34, respectively. Contact 50 slides over the resistive track and provides a variable resistance connection.

FIGURES 3 and 4 illustrate another variable resistor 100 according to the present invention having a ceramic case 102. The case has a bottom wall 104 and an upstanding side wall 106 integrally connected to the outer periphery of the bottom wall. The side wall has an annular recessed portion 108 that cooperates with a cover for the resistor, as in the construction of FIGURES 1 and 2. In the embodiment of FIGURES 3 and 4, the base or bottom portion 104 of the case functions as the support for a resistive film 110 so that the disc 22 of the resistor of FIGURES 1 and 2 is not needed. The resistive film 110 has a band-like configuration with the ends separated from one another, as shown in FIGURE 3. In FIGURE 4 the thickness of the film is grossly exaggerated. In actuality the thickness is about 50 to 200 angstroms. Leads 112 and 114 are fixed as by soldering, brazing, or welding to the ends of the resistive film at 116 and 118 respectively, and extend through the side wall of the case.

A cover 120 of resilient plastic material is provided for enclosing the resistive element 110 within the case 102. The cover has an annular outer flange 122 with an inwardly extending annular bead 124 that snaps into the recess 108 in the case when the resistor is assembled. However, this snap-in engagement is loose enough to permit the cover to rotate relative to the case. Such rotation is limited in each direction by a downwardly extending stop 126 on the cover that abuts the leads 112 and 114 when the cover is rotated relative to the case. Cover 120 also has an outwardly directed annular recess 128 directly above the resistive element 110 which provides a clearance for the leads 112, 114.

The cover 120 carries a Phosphor bronze wiper contact 130 secured thereto by a fastener 132 of electrically conductive material which extends through an axial passageway 134 in the center of the cover. The wiper contact is a thin, straight and totally undeformed stamping of Phosphor bronze metal.

Cover 120 has a knob 136 through which the axial passageway 134 extends. As shown in FIGURE 4, the fastener 132 is disposed in the passageway and the wiper contact is secured to the inside end of the fastener. A suitable lead 138 may be attached to the fastener at its outside end to connect the contact 130 in the desired circuit. Thus, as the wiper contact moves across the resistive element 110 by rotating the cover relative to the case, the lead 138 is prevented from winding itself upon the knob. Although

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the lead is twisted slightly, this twisting is less than 360° since the cover 120 can only rotate relative to the case 102 over a limited range determined by the stop 126 and the position of the leads 112, 114.

FIGURES 5 and 6 illustrate still another embodiment 200 of the present invention. Here, as in the other examples, the variable resistor may be a potentiometer having a case 202 of ceramic material with a base portion 204 and an upwardly extending side wall 206. The base portion serves as a support for a spiral-shaped resistive film 208 made of chromium and nickel, as explained below. The spacing between adjacent turns of the spiral can be about 0.001 to 0.010 inch although this spacing is exaggerated in the drawing for convenience and clarity. The center of the resistive film is connected to a lead 210 that extends through an opening 212 in the base portion of the case. Solder 214 may be used to attach the free end of the lead to the resistive element, as shown in FIGURE 5. The outer portion of the resistive element is also attached to a lead 216 that conveniently extends through the side wall of the case. Alternatively, the leads 210 and 216 may be embedded in the case during its fabrication so that the desired connection is obtained when the inside bottom wall is coated with the chromium and nickel mixture.

The potentiometer 200 has a cover 218 of electrically conductive material that snaps over the case 202 to enclose the resistive element. No rotary movement is utilized to vary the voltage drop across the resistive element and the cover may therefore be dimensioned to fit the case tightly. The cover 218 has a radially extending slot 220 that functions as a guide for a contact button assembly 222. The assembly has an inverted T-shaped cross-section of plastic or similar nonconductive material and the horizontal or cross-bar portion of the "T" extends beneath the cover beyond both sides of the slot. This arrangement allows the assembly to slide within the slot but prevents removal of the assembly once the cover is positioned on the case.

The bottom of the contact button assembly 222 carries a Phosphor bronze wiper contact 224 attached to the horizontal portion of the "T" by electrically conductive rivets 226. The rivets also function to secure phosphor bronze strips 228, 229 to the portion of the "T" in engagement with the underside of the cover. A lead 230, soldered to the conductive cover completes the connection of the contact 224 to the desired circuit when that lead is attached in the circuit. Like the Phosphor bronze contacts illustrated in FIGURES 1 and 2, the contact 224 is a thin, straight stamping of Phosphor bronze which is substantially undeformed except for a dimple 232 at one end thereof that extends about 0.002 inch from the surface of the contact.

As can readily be understood, sliding movement of the button assembly 222 is easily accomplished by manually moving the button from one end of the slot to the other. This causes the dimple 232 to ride across the resistive element and thereby vary the length of the resistive path traveled by the current flowing through the potentiometer.

As shown in FIGURE 5, the constantly increasing radius of curvature of the spacing between adjacent portions of the spiral-shaped resistive element 208 can increase sharply at the outer end of the path. The widened resistive track portion 234 thus formed has comparatively little resistance when compared to the resistance of the remaining portions of the film between the closely spaced turns of the spiral. This further permits the lead 216 to be attached to the outer portion of the resistive element at any point close to its periphery without significantly affecting the operation of the resistor.

The resistive elements of the present invention can be made by depositing a film of a mixture of chromium and nickel on a completely oxidized film of a mixture of chromium and nickel carried on a support. Various support surfaces are available such as the ceramic disc illustrated in FIGURES 1 and 2, or simply the inside bottom

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wall surface of the cases shown in FIGURES 3-6. An initial film of 80% chromium and 20% nickel simultaneously vapor deposited in a vacuum on the support to a thickness of approximately 25 to 50 angstroms can be used. This initial film is then oxidized by heating it in an atmosphere of air at 500° C. for about two hours. A second film of a mixture of 80% chromium and 20% nickel is then vapor deposited on the oxidized film in the same manner at the first and the second film is not completely oxidized. The second film may have a thickness of about 25 to 100 angstroms and can be baked at 450° C. for 30 minutes to improve its stability. The second film can also have up to about 10% manganese added to further improve it.

The desired resistive pattern, whether it is the involute curves of FIGURE 3 or the spiral of FIGURE 5, can be produced by an electron or laser beam machining operation. For example, the spiral-shaped element shown in FIGURE 5 may be produced by clamping the filmed ceramic case 202 by its edges in a chuck, rotating the chuck and causing an electron beam to scan the film of resistive material moving from near the center of the case to an adjacent edge portion. This will cut a film-free spiral track in the resistive film, and the scanning can be automatically terminated when the resistance of the cut film reaches the desired value, as disclosed in U.S. Patent application Ser. No. 354,649, filed Mar. 25, 1964, or Ser. No. 544,731, filed Apr. 25, 1966. For greater accuracy when the cutting takes place at high speed, the very last portion of the scan after the resistance has come within about one or two percent of the desired value can be speeded up to increase the spacing or pitch of the final turn or two of the cutting. This increased spacing causes the final portion of the scan to produce a very gradual increase in resistance so that the termination of the cutting can be made with great precision notwithstanding the rapid rotation of the case.

Phosphor bronze is relatively hard and tough, and contacts constructed of this material function extremely well for long periods of time. When undeformed or having only about 0.002 inch deformation, such contacts maintain much more constant contact forces.

The resistive film or track in the variable resistors of

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the present invention can be of uniform resistance throughout its length, or the resistance can vary or taper. By way of example for use as a volume control the film 110 of the construction of FIGURES 3 and 4 can vary in thickness as by having it very thick at 116, very thin at 118 and smoothly changing in thickness in a logarithmic or linear fashion from the thick to the thin portions. Alternatively, the film 110 can have its width vary in a similar manner, or if desired both its thickness and width can be simultaneously varied.

What is claimed is:

1. A variable resistor having a ceramic case, a long resistive coating of a film of a mixture of chromium and nickel vapor deposited on a completely oxidized film of a mixture of chromium and nickel on the inside of the case, a cover for enclosing the case, and a contact of a stamping of thin Phosphor bronze sheet not deformed more than about 0.002 inch carried by the cover, the contact engages the resistive coating when the cover and case are assembled, the contact engaging the resistive coating at various points along its length when the contact and the case are moved relative to one another.

#### References Cited

##### UNITED STATES PATENTS

|           |         |                  |           |
|-----------|---------|------------------|-----------|
| 2,935,717 | 5/1960  | Solow            | 338—308   |
| 2,974,299 | 3/1961  | Youngbeck et al. | 338—163   |
| 3,354,418 | 11/1967 | Casey et al.     | 338—163 X |
| 3,377,606 | 4/1968  | Ferrell          | 338—174   |

##### FOREIGN PATENTS

|           |         |         |
|-----------|---------|---------|
| 1,308,750 | 12/1962 | France. |
|-----------|---------|---------|

##### OTHER REFERENCES

Dummer, G. W. A., Variable Resistors, 1963, pages 80, 81, 90, 91.

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U.S. Cl. X.R.

338—308