July 15, 1969 C. S. WRIGHT 3,456,228

VARIABLE RESISTORS

Original Filed July 1, 1964

Fig. 1

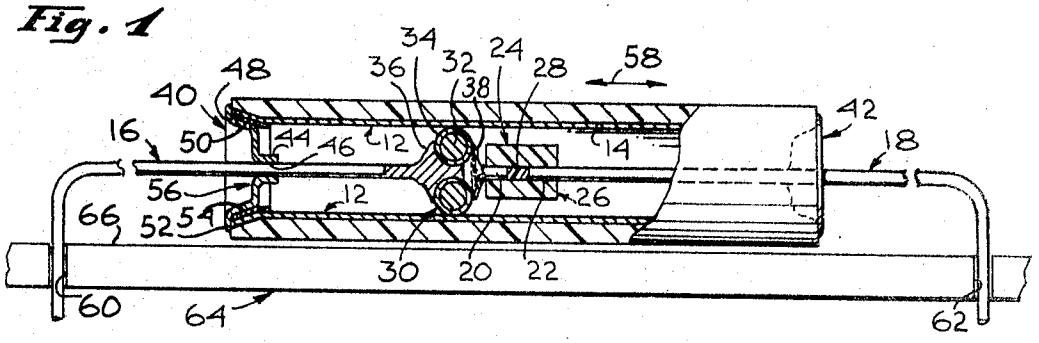


Fig. 2

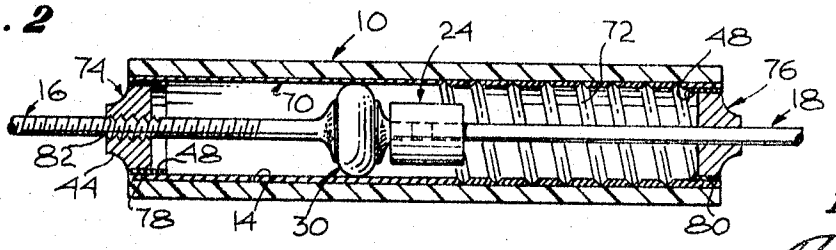


Fig. 6

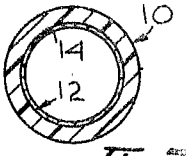


Fig. 3

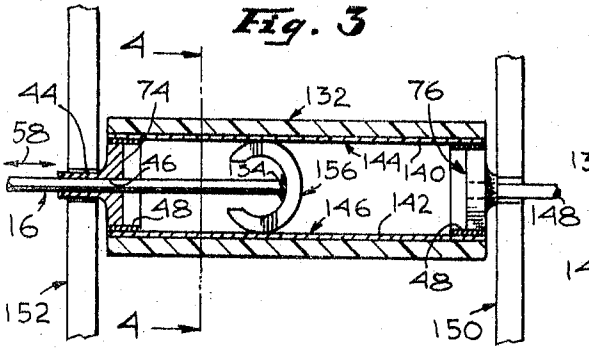


Fig. 4

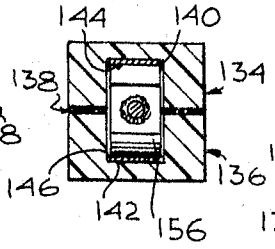


Fig. 7

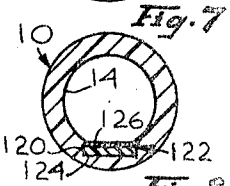


Fig. 8

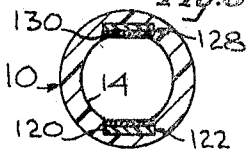


Fig. 5

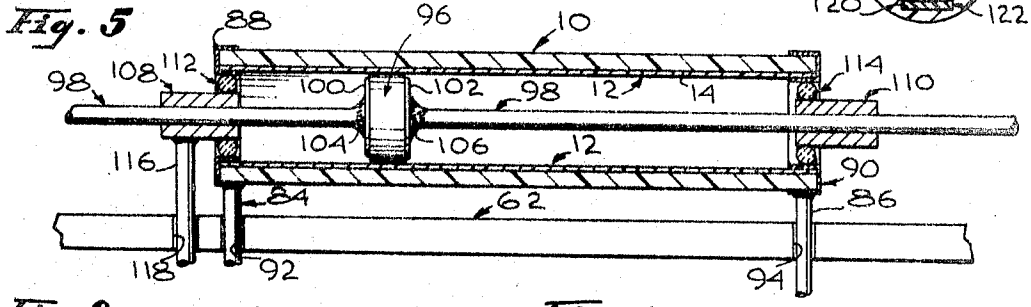


Fig. 9

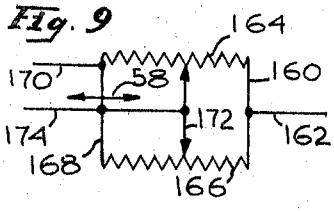
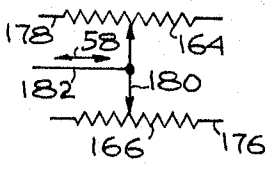


Fig. 10



INVENTOR.
CHARLES S. WRIGHT
BY Allan M. Shapiro
ATTORNEY

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3,456,228

VARIABLE RESISTORS

Charles S. Wright, Los Angeles, Calif.
(5902 Fulton Ave., Van Nuys, Calif. 91401)

Continuation of application Ser. No. 379,453, July 1, 1964. This application Mar. 18, 1968, Ser. No. 714,108
Int. Cl. H01c 5/02
U.S. Cl. 338—176 4 Claims

ABSTRACT OF THE DISCLOSURE

Variable resistors having at least one fixed value resistance element, terminal caps, and one or more relatively rigid terminal lead rods provided with a contact element whereby the resistance can be varied by relative movement of the case and the terminal lead rod or rods. Internal ends of opposite terminal rods may be rigidly interconnected, either conductively or non-conductively relative to each other and/or the contact element. A plurality of the same or differing resistance elements may be electrically connected in series or parallel for maintaining the same and/or permitting variations in one or more electrical characteristics.

This application is a continuation of co-pending United States patent application Ser. No. 379,453 for Variable Resistors filed by Charles S. Wright on July 1, 1964.

The present invention relates to variable resistors and, more particularly, to resistors of a type having a fixed value resistance element and a selectively movable contact element for making electrical contact with any desired spatially related points or regions along the effective length of the resistance element whereby the effective electrical resistance between terminals may be varied.

One of the objects of the present invention is the provision of a variable resistor whereby the effective electrical resistance may be selectively varied with effectively infinite resolution where the fixed resistance element and the electrical contact element are relatively movable with respect to each other, either by maintaining the contact element in a fixed position and moving the resistance element with respect thereto or, conversely, maintaining the resistance element in a fixed position and moving the contact element with respect thereto, in either case such relative movement being either in the linear sliding or spiral rotating mode, so that variations in fixed resistance can be achieved by either the manufacturing consumer as he makes circuit adjustments or by the resistor manufacturer in supplying fixed value resistors from resistor components having fixed value resistance elements which vary greatly in their manufactured values.

Another object of the present invention is the great reduction of manufacturing costs of precision resistors by the provision of economical variable resistors which can utilize fixed value resistance elements varying greatly in their manufactured resistance values. For example, the present state of the art of manufacturing precision resistors, in quantity and other than using costly manufacturing, grading and selection techniques, provides resistors with tolerances in the order of 0.01% from the nominal value, and the resistors must be manufactured to such individual precise nominal values; by means of the present invention, resistors may be manufactured in bulk with no precision whatsoever and having nominal values in which the first significant number varies by whole orders of magnitude (e.g., 10 to 100 ohms, 1 megohm to 10 megohms, and so forth), and the final effective resistance can be fixed at any desired nominal value therebetween with precision accuracy in the order of 0.001% of such nominal value.

Another object of the present invention is the provision

of a variable resistor in which the value of resistance is not temperature sensitive, i.e., having a temperature coefficient of resistance at least approaching zero.

Another object of the present invention is the provision of a variable resistor in which the effective temperature coefficient of resistance may be selectively varied while maintaining a constant effective resistance.

According to the present invention, there is provided a variable resistor comprising non-conductive case means defining a longitudinal chamber substantially symmetrical about a longitudinal axis and open at its opposite ends, electrical resistance means secured to such case means and disposed within the chamber along substantially the entire length thereof parallel to the longitudinal axis and having at least two opposite ends adjacent respective case means ends, a plurality of electrical terminal means secured to respective case means ends, each of the terminal means being in electrical contact with at least one of the ends of the electrical resistance means, each of the terminal means comprising a cap member in at least partial closure relationship to its corresponding case means end, at least one of the cap members being provided with a central hole therethrough in alignment with the longitudinal axis, and digitally movable contact means comprising longitudinal rod means partially disposed within the chamber along the longitudinal axis and projecting outwardly therefrom through at least such one central hole, and an electrically conductive contact element mounted on the rod means in transverse symmetry and having a transverse periphery at least a portion of which is in slidable engagement with the resistance means whereby selective manual longitudinal displacement of the movable contact means and the case means with respect to each other causes corresponding variations in the effective electrical resistance characteristics presented between the plurality of electrical terminal means.

Specific features of various embodiments in accordance with the present invention include variations in the quantity, configuration and selected characteristics of the resistance elements comprising the electrical resistance means, variations in the construction as well as the cross-sectional interior of the case means defining the chamber, variations in the configuration and mounting of the electrical contact element, variations in the mechanical as well as electrical functions and configurations of the electrical terminal means, and variations in the electrical contact with and the configurations and mechanical support of the longitudinal rod means.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The present invention, both as to its organization and manner of operation, together with further objects and advantages thereof, may best be understood by reference to the following description, taken in connection with the accompanying drawings, in which:

FIGURE 1 is a side elevation view, partly broken away and longitudinally sectioned, of a variable resistor in accordance with the present invention;

FIGURE 2 is a view similar in aspect to FIGURE 1 of another embodiment of the present invention;

FIGURE 3 is a similar view of a third embodiment of the present invention;

FIGURE 4 is a transverse sectional view, partly in elevation, as seen along line 4—4 in FIGURE 3;

FIGURE 5 is a longitudinally sectional side view, partly in elevation, of a fourth embodiment of the present invention;

FIGURES 6, 7, and 8 are transverse sectional views of a cylindrical form of case member, showing some variations in the form of the resistance element;

FIGURE 9 is a schematic diargram of a circuit attainable in accordance with the present invention; and

FIGURE 10 is a schematic diagram of another circuit attainable in accordance with the present invention.

In the drawings, the same reference numerals occasionally refer to the same or similar elements in the various embodiments. Further, it should be understood that relative dimensions and proportions have been exaggerated and otherwise distorted for convenience and clarity of illustration and description.

Referring to FIGURE 1, there is seen a variable resistor comprising a non-conductive case means or member **10**, preferably composed of a ceramic material which defines a longitudinal chamber having a resistance element **12** disposed on the interior surface **14** of the case **10**. The configuration of the case **10**, its interior surface **14** and the resistance element **12** may be varied, as will be described hereinafter in connection with later described embodiments; however, in FIGURE 1, the case **10**, its inner surface **14** and the resistance element **12** are shown and described as being tubular or cylindrical, FIGURE 6 being an illustrative transverse sectional view thereof. A longitudinal rod means is seen to comprise a pair of axial terminal leads or rods **16** and **18** which are partially disposed within the chamber and project axially, i.e., along the longitudinal center, out of the case **10** and are mechanically joined together at their respective inner ends **20** and **22** by mechanical coupling means **24** comprising a collar member **26** composed of an electrically non-conductive material, such as ceramic, and a bonding material **28** such as an epoxy cement. The terminal rod **16** is provided with an electrically conductive contact element, indicated generally at **30**, comprising an O-ring **32** having a conductive coat **34** thereon. The O-ring **32** is preferably resilient and may be composed of rubber or any similar material, and the coat **34** is preferably composed of silver and/or gold, as by plating the O-ring **32** with a silver film and then plating with a gold film, each film being approximately 20 to 50 millionths of an inch in thickness. The transverse peripheral diameter of the contact element **30** is sufficient to ensure continuous contact with the surface of the resistance element **12**. The contact element **30** is mounted securely on the terminal lead **16** in any convenient manner such as, as illustrated, a pair of heads **36** and **38** which bracket the contact element **30** and are cold formed in the terminal lead **16** itself, leaving a portion of the terminal lead end **20** projecting therefrom for attachment of the coupling means **24** as aforesaid.

The electrical terminal means may comprise a pair of identical electrically conductive circular end caps **40** and **42** secured to the opposite ends of the case **10** as by press-fit engagement, each being provided with a boss portion **44** defining an axial or central hole **46** in slip-fit engagement with the terminal rods or leads **16** and **18** for both mechanical support thereof and electrical contact therewith. In the embodiment illustrated in FIGURE **1**, each of the internal ends of the case **10** is provided with an annular chamfered surface **48**. The resistance element **12** may be formed in any convenient manner known in such art such as, for example, vacuum deposition, carbon deposit or so forth, with the resistance element **12** overlapping from the inner surface **14** into the end surface **48** so as to form an adequate mechanical and electrical bond with a layer **50** of conductive material which is superimposed upon at least that portion of the resistance element **12** whch overlaps the chamfered surface **48**. The conductive layer **50** is deposited, plated or otherwise formed in any convenient manner for making a low resistance contact with the resistance layer **12** and providing a low resistance contact for the end caps **40** and **42**, the latter including an interior lip portion **52** which abuts against the outer end of the case **10** and has a cup-shaped intermediate portion **54** which joins the lip portion **52** and the boss **44** to provide a press-fit mechanical and electrical engagement contact with the layer **50** for secure mounting of the end caps as well as

providing a solder contact region, indicated generally at **56**, for the reception of solder in the manner and for the purpose as hereinafter described in connection with the operation of the device.

In the operation of the device illustrated in FIGURE 1, axial or longitudinal movement in either direction (as indicated by the arrow **58**) of either the case **10** or the digitally movable contact means comprising the terminal leads **16** and **18** causes relative displacement of the resistance element **12** with respect to the electrical contact element **30**. The original nominal or fixed magnitude of resistance of the resistor, as presented between the terminal end caps **40** and **42**, is that of the full resistance element **12** which resides between such end caps **40** and **42**; however, the effective electrical resistance of the resistor is presented by that portion of the resistance element **12** residing between the movable contact element **30** and the end cap **42** due to the short circuiting of the remainder of the resistance element **12** through the effectively zero resistance path afforded by the contact means comprising its contact element **30** and its longitudinal terminal rod **16**. Thus, relative axial or longitudinal displacement of the movable contact means with respect to the electrical resistance element **12** causes selective variation in the effective resistance presented by the resistor. One form of preferred mounting of the resistor is illustrated in FIGURE 1 wherein the terminal rods **16** and **18** are immovably secured near their ends as by being bent to project through respective apertures **60** and **62** in a circuit board **64** for mounting of the case **10** upon the surface **66** of the circuit board **64**. In this manner, the user of the resistor can merely mount the resistor in the position illustrated, make the appropriate circuit connections on the circuit board to the terminal rods **16** and **18**, and then adjust the value of the effective resistance required for proper circuit operation by merely moving the case **10** in an axial direction **58** in accordance with appropriate indications presented by any convenient associated test equipment and/or the output of the circuitry itself. If desired, and usually preferred, the user may place a drop of solder in the region **56** in either or both of the end caps **40** and **42** so as to solder the terminal leads to their respective end caps for mechanical and electrical security once the desired effective resistance has been obtained. Of course, later readjustments can be made by merely removing or loosening such solder connections by the application of the appropriate soldering heat.

Another method of use relates to the fixed resistor field wherein the manufacturer supplies a fixed resistor having a nominal resistance value and stated tolerances of accuracy of the nominal value, usually stated in plus and/or minus percentages of the nominal value. Of course, a precisely accurate resistor requires smaller permissible tolerances, thereby requiring greater precision in the manufacture and/or selection of resistance values with concomitant greater expense. By means of the present invention, resistors can be manufactured in a relatively in exact manner insofar as the values of the resistance elements **12** are concerned, with the nominal resistances varying greatly, and the manufacturer can make the adjustment of the effective resistance of the resistor "to order" within extremely low tolerance limits by merely making the aforesaid adjustment in the manner hereinabove described and soldering either or both of the terminal rod leads **16** and **18** to a respective end cap **40** and/or **42** to provide a fixed value resistor. The manufacturing adjustment can be relatively automated, as by the application of electrical balance bridge techniques. Still further, whereas the present state of the art of fixed value resistors is such that manufactured tolerances can be obtained in the order of 0.01 percent of nominal value, the present invention permits the economical attainment of more precise tolerances by at least a whole order of magnitude.

Referring to FIGURE 2, there is seen an embodiment in accordance with the present invention comprising several

modifications of the resistor illustrated in FIGURE 1. The cylindrical inner surface 14 of the case member 10 is provided with a resistance element 70 which has a spiral groove 72 therethrough over a substantial portion but not all of its length. The inner surface 14 of the case 10 is cylindrical throughout its length, and the identical end caps 74 and 76 are washer-like in shape with the boss 44 directed outwardly and the annular peripheries 78 and 80 soldered to the annular conductive layers 48 for mechanical engagement and electrical contact. The terminal lead 16 is threaded along at least a portion of its length, as is the axial hole surface 82 in the end cap 74, so that rotational movement of the case 10 and the terminal leads 16 and 18 with respect to each other causes spiral relative movement of the contact element 30 with respect to the resistance element 70. Because of such spiral rotation, the rate of axial displacement is substantially less for any given amount of rotational force applied than if such force were applied directly in an axial direction, thus increasing the degree of digital control over axial displacement for finer variations in adjustments of the effective resistance value of the resistor. Still further, the adjustments in effective resistance value are made preferably over that portion of the resistance element 70 that is not spirally grooved so that even finer variations in resistance are attained.

Referring to FIGURE 5, there is seen another embodiment of a resistor in accordance with the present invention of the type more commonly known as a potentiometer, illustrated as mounted on a circuit board 62 and having terminal means comprising a pair of terminal leads 84 and 86 in contact with the resistance element 12 at opposite ends thereof by means of respective conductive rings 88 and 90 and extending through respective apertures 92 and 94 in the circuit board 62. The movable contact means comprises an electrical contact element 96 mounted on a longitudinally or axially reciprocable terminal rod 98 by means of a pair of washers 100 and 102 soldered at 104 and 106. The terminal rod 98 extends axially in both directions out through the ends of the case 10 through a pair of electrically conductive mounting elements 108 and 110 which are electrically insulated from the pair of conductive rings 88 and 90 by means of respective annular glass headers 112 and 114. The mounting member 108 is provided with a terminal lead 116 which passes through an aperture 118 in the circuit board 62 in the same manner as the other terminal leads 84 and 86.

The conductive rings 88 and 90 may be in any desirable shape or configuration for securing mechanical mounting of the terminal leads 84 and 86 and electrical contact thereby with the resistance element 12. In the device illustrated, the axial mounting member 110 need not be electrically conductive but is so shown as a construction convenience, the end configuration being generically analogous to the end caps described in connection with the other embodiments. The contact element 96 may be the same as the previously described contact element 30 or may comprise a structure commonly known as a "fuzz button," being gold-plated steel wool of fine texture and highly compressed so as to form a substantially integral structure of cylindrical shape.

In operation, the electrical contact element 96 is caused to be longitudinally displaced with respect to the electrical resistance element 12 by axial or longitudinal displacing movement of the rod 98 with respect to the case 10 in the manner previously described. The rod 98 functions as an electrical terminal because of its electrical connection with the terminal lead 116 so that the potential occurring at the latter, as referenced to the potential appearing at either of the other electrical terminals 84 or 86, represents the potential obtained by the selectively displaced location of the contact 96 on the resistance element 12.

Referring to FIGURE 6, there is seen a transverse section of one form of case 10 which defines a cylindrical chamber and is provided with a resistance element 12 in the form of a layer of substantially uniform thickness and adhered or cohered onto the entire circumference of the inner surface 14 of the case 10, the layer 12 being such as has been described as the resistance element 12, in FIGURES 1 and 5, and as the resistance element 70 in FIGURE 2 prior to the formation of the spiral groove 72. The present invention not being concerned with the composition of the resistance element except in the context of its employment in this invention, the resistance element may be formed in any convenient manner known in such art such as, for example, by techniques commonly referred to as sputtering, vacuum deposition, dipping, and so forth, and may be composed of any appropriate metallic or non-metallic material having electrical resistance properties or characteristics, either inherently and/or when disposed and/or treated in accordance with the techniques of such art. For simplicity and convenience of illustration, the previously described embodiments have been shown with a resistance element 12 or 70 of the general form illustrated in FIGURE 6; however, it is expressly noted and should be understood that many other types, shapes and configurations of resistance element or elements may be employed in any or all of such embodiments with corresponding efficacy in accordance with the applications, and uses and parameters of operation desired, all in accordance with the present invention. Some additional configurations and combinations will be described hereinafter.

Referring to FIGURE 7, there is seen a cylindrical case 10 which is provided with a longitudinal channel 120 in its inner surface 14 into which is bonded a resistance element 122 comprising a non-conductive substrate 124 having a resistance layer 126 formed or deposited thereon in any convenient manner known in the art, the planar shape being a convenient form for many such techniques. The planar resistance element 122 may be used in lieu of the cylindrical element 12 in either of the embodiments shown in FIGURES 1 and 5, without modification of the other members except to the extent that the hermetically sealed engagement of the end caps may be obtained by appropriate alteration of end cap configuration. Thus, the present invention permits the usage of resistance elements 122 which can be manufactured and supplied separately utilizing formation techniques not readily adaptable directly within the case 10.

Referring to FIGURE 8, there is seen a modification of the combination shown in FIGURE 7 wherein the case 10 is provided with a pair of planar resistance elements 122 and 128 disposed in respective longitudinal channels 120 and 130 in the cylindrical inner surface 14, shown disposed in diametric opposition for security of electrical and mechanical contact therewith but which may be disposed in any convenient circumferentially spaced relationship. Of course, an additional plurality of resistance elements may be disposed in corresponding numbers of channels. It may be noted that the channels 120 and 130 provide a particularly convenient means of mounting the resistance elements 122 and 128.

Referring to FIGURES 3 and 4, there is seen another embodiment of a resistor in accordance with the present invention in which the case 132 is rectanguloid in configuration and comprises an upper shell 134 and a lower shell 136 which are joined together, as by epoxy cement 138 or other convenient material, to form a unitary case. The shells 134 and 136 have respective planar longitudinal surfaces 140 and 142 opposing each other and upon which opposing resistance elements 144 and 146 are disposed. As shown, the longitudinal surfaces 140 and 142 may constitute substrate surfaces upon which the resistance elements 144 and 146 are directly and separately deposited or otherwise formed in accordance with the techniques known in such art, or else the resistance elements 122 and 128 of FIGURE 8 may be disposed thereon.

A pair of end caps 74 and 76 are rectangular in end

configuration and are soldered or brazed to respective conductive layers **48** for mechanical engagement with the case **132** and electrical contact with respective ends of both of the resistance elements **144** and **146**, as shown, so that such resistance elements are in electrical parallel between the end caps **74** and **76**. The end cap **76** is provided with a terminal lead **148** extending through a circuit board **150**, and the end cap **74** is provided with a boss **44** extendable through another circuit board **152** which is parallel to the opposing circuit board **150**. The end cap **74** defines a central or axial hole **46** through which terminal rod lead **16** is reciprocable in slip-fit engagement. The terminal lead **16** terminates interiorly of the case **132** and is provided at its interior end **154** with a contact element **156** of C-shaped configuration. Preferably, the contact element **156** is slightly resilient to ensure positive mechanical and electrical contact with both of the resistance elements **144** and **146** in its slidable engagement therewith.

In operation, the resistor illustrated in FIGURE 3 may be adjusted by either the manufacturer or the user for the desired effective resistance value by merely causing longitudinal displacement of the electrical contact element **156** with respect to the resistance elements **144** and **146** by selective longitudinal movement of either the terminal lead rod **16** of the movable contact means or the case **132** with respect to the other, prior to insertion between the circuit boards **150** and **152**, and soldering the lead rod **16** to the boss **44** when the desired value is obtained, or inserting the resistor between such circuit boards and then longitudinally displacing the lead rod **16**. Of course, appropriate electrical terminal connection is made to the end cap **74** as at the boss **44**, which may be by printed circuit connection (not shown).

Referring to FIGURE 9, there is seen a diagrammatic illustration of a resistor in accordance with the present invention which may have a mechanical configuration in accordance with those embodiments previously described. A terminal means end cap **160** and its terminal lead **162** are in electrical contact with one end of each of two resistance elements **164** and **166** which may be disposed within the case in the manner illustrated in FIGURES 3, 4 and 8. The other terminal means end cap **168** and its terminal lead **170** are in electrical contact with the opposite ends of the resistance elements **164** and **166** so that such elements are in parallel electrically between the terminal leads **162** and **170**. The movable contact element **172** and its terminal rod **174** are in electrical contact with the end cap **168** and in slidable mechanical and electrical contact with both of the resistance element **164** and **166** along the lengths thereof. Thus, by longitudinal displacement movement of the contact element **172** by means of its manual terminal rod **174** in either of the directions indicated by the arrow **58**, the effective resistance presented between the terminal leads **162** and **170** can be variably adjusted. In accordance with a further aspect of the present invention, it is intended that, as another application of the inventive concepts described herein, the resistance elements **164** and **166** be chosen to have equal nominal values of resistance but having equal and opposite values of temperature coefficient of resistance (hereinafter referred to as "resistance T.C.") so that the effect of variations in temperature caused by changes in the ambient temperature and/or joulean heat will be in equal values but in opposite directions in the resistance elements **164** and **166**, thereby approaching a cancellation of such effects and resulting in a resistance device having a selectively variable effective resistance and a constant resistance T.C., a highly desirable and advantageous combination of parameters. It being generally desirable to have a resistor having as low a resistance T.C. as possible, for reasons which are well known in the art, considerable effort has been expended in the past and is being expended today to perfect manufacturing techniques so as to be able to consistently, predictably and economically produce resistance elements having "negligible" resistance T.C., one of the difficulties being that the normal range of resistance T.C. obtained in a given group of manufactured elements varies considerably and unpredictably, with only a relatively small proportion of the elements having so called "negligible" resistance T.C.'s. By means of the present invention, no particular care to expense need be exercised in the manufacture or purchase of large groups of resistance elements, it being merely a matter of selection of those elements having equal but opposite resistance T.C.'s for pairing in the resistor. For example, normal sorting techniques will permit the selection of a resistance element **164** having a resistance T.C. of, say, +600 millionths and a resistance element **140** having a resistance T.C. of −600 millionths which, upon pairing in the manner shown in FIGURES 3 and 4 or 8, will cause the effective variable resistance to have an effective resistance T.C. of −0.36 millionths, a relatively negligible value.

Referring to FIGURE 10, there is seen a diagrammatic illustration of another embodiment of a resistor in accordance with the present invention wherein the pair of resistance elements **164** and **166** again are chosen to have the same nominal value of resistance and the same but opposing values of resistance T.C. such as previously described in connection with FIGURE 9. A terminal lead **176** is connected to one end of only one of the resistance elements **166**, and another terminal lead **178** is connected to the opposing end of only the other resistance element **164**. A movable contact element **180** is carried by its rod **182** in slidable mechanical and electrical contact with both of the resistance elements **164** and **166** along the lengths thereof. The contact element **180** completes a series circuit path between the terminal leads **176** and **178** via those portions of resistance elements **164** and **166** between the points of contact of the contact element **180** and the respective terminal leads **178** and **176**. Thus, by longitudinal displacement movement of the contact element **180** by means of its manual rod **182** in either of the directions indicated by the arrow **58**, the amount of resistance added to or subtracted from the circuit by means of resistance element **164** equals the amount of resistance conversely subtracted from or added to the circuit by means of resistance element **166**, resulting in the effective resistance presented between the terminal leads **178** and **176** being a constant nominal value. However, using the previous exemplary values of plus and minus 600 millionths as the resistance T.C. of resistance elements **164** and **166** respectively, the selective longitudinal displacement movement of the contact element **180** causes the addition and subtraction of opposing proportionate effective values of the resistance T.C. parameters of the resistance elements **164** and **166**. Hence, the effective resistance T.C. of the constant value resistance presented between terminal leads **178** and **176** may be continuously varied and adjusted between the extremes of −600 millionths and + 600 millionths by longitudinal displacement location of the contact element **180** from the extreme left to the extreme right when viewed as in FIGURE 10. Consequently, such a resistor has extremely valuable and novel applications as a compensating element in circuitry wherein the operating parameters are such that the other circuit elements require a counterbalancing resistance T.C. effect for proper and/or desired function. Of course, the terminal rod **182** must be electrically insulated from the terminal means leads **176** and **178**, as by the glass header end cap arrangement shown in FIGURE 5.

It should be understood that the variations in the features of the specific embodiments illustrated are not meant to be restricted in their utilization to only those combinations specifically illustrated. In other words, features shown in connection with one embodiment are generally compatible with and applicable to the other embodiments illustrated, in accordance within the teachings contained herein, and their interchangeability and application now

will be obvious to anyone having ordinary skill in the art.

While particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects, and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

What is claimed is:

1. A variable resistor comprising:

non-conductive case means having a pair of parallel planar interior surfaces and defining a longitudinal chamber substantially symmetrical about a longitudinal axis and open at its opposite ends;

electrical resistance means comprising a pair of planar resistance elements each secured to a respective one of said interior surfaces;

each of said resistance elements having two opposite ends adjacent respective such case means ends;

a pair of electrical terminal means secured to respective such case means ends, each of said pair of terminal means being in electrical and mechanical contact with at least one of said resistance element ends, each of said terminal means comprising a cap member in at least partial closure relationship to its corresponding case means end, at least one of said cap members being provided with a central hole therethrough in alignment with such longitudinal axis; and

digitally movable contact means comprising longitudinal rod means partially disposed within said chamber along such longitudinal axis and projecting outwardly therefrom through at least such one central hole, and an electrically conductive contact element mounted on said rod means in transverse symmetry and having a transverse periphery at least a portion of which is in slidable engagement with said resistance means whereby selective manual longitudinal displacement of said movable contact means and said case means with respect to each other causes corresponding variations in the effective electrical resistance characteristics presented between said pair of electrical terminal means.

2. A variable resistor in accordance with claim 1 wherein:

both of said resistance elements have the same nominal value of resistance and equal but opposite temperature coefficients of resistance and said resistance elements are in parallel electrically whereby the effective temperature coefficient of resistance of the effective resistance presented between said pair of electrical terminal means is substantially equal to the algebraic sum of said opposite temperature coefficients.

3. A variable resistor in accordance with claim 1 wherein:

both of said resistance elements have the same nominal value of resistance and equal but opposite temperature coefficients of resistance and respective portions of said resistance elements in opposite directions from said contact element are in series electrically through said contact element whereby the selective displacement of said movable contact means and said case means with respect to each other causes selective variations of the effective temperature coefficient of resistance presented between said pair of terminal means.

4. A variable resistor in accordance with claim 1 wherein:

said contact element comprises a C-shaped transversely resilient member; and

said rod means comprises an electrically conductive terminal rod secured to the geometric center of said contact element member and in slip-fit engagement with its corresponding cap member for mechanical support thereby and electrical contact therewith.

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RICHARD M. WOOD, Primary Examiner

J. G. SMITH, Assistant Examiner

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