

[54] VARIABLE RESISTANCE CONTROL WITH DIFFERENTIALLY RESILIENT CONTACTS

2,177,291	10/1939	Schellenger.....	338/202 X
2,632,830	3/1953	Aust et al.	338/174 X
3,576,514	4/1971	Michik.....	338/171 X

[75] Inventors: James H. Robinson; John D. Van Benthuyzen, both of Elkhart, Ind.

[73] Assignee: CTS Corporation, Elkhart, Ind.

Primary Examiner—Bruce A. Reynolds
Attorney, Agent, or Firm—John J. Gaydos

[22] Filed: Apr. 2, 1974

[21] Appl. No.: 457,182

[52] U.S. Cl..... 338/171, 338/174, 338/202

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

[58] Field of Search 338/171, 202, 167, 169, 338/174, 175, 127

[57] ABSTRACT

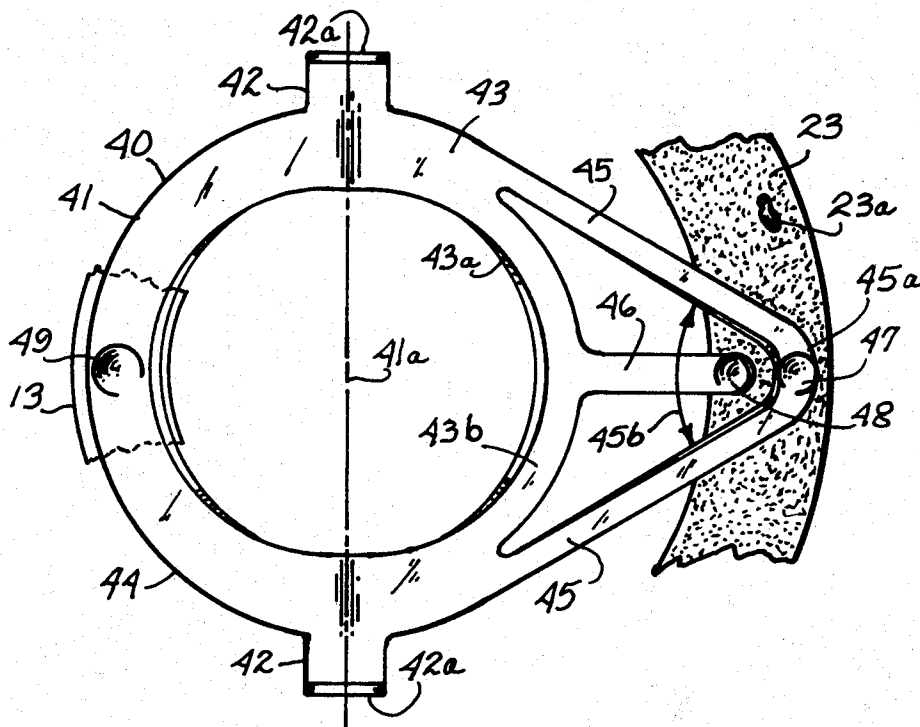
A variable resistance control having a contactor with differentially resilient contacts wipably engaging a resistance element and a collector for eliminating intermittency and decreasing dynamic contact resistance.

[56] References Cited

UNITED STATES PATENTS

2,093,252	9/1937	Schellenger.....	338/174
-----------	--------	------------------	---------

9 Claims, 6 Drawing Figures



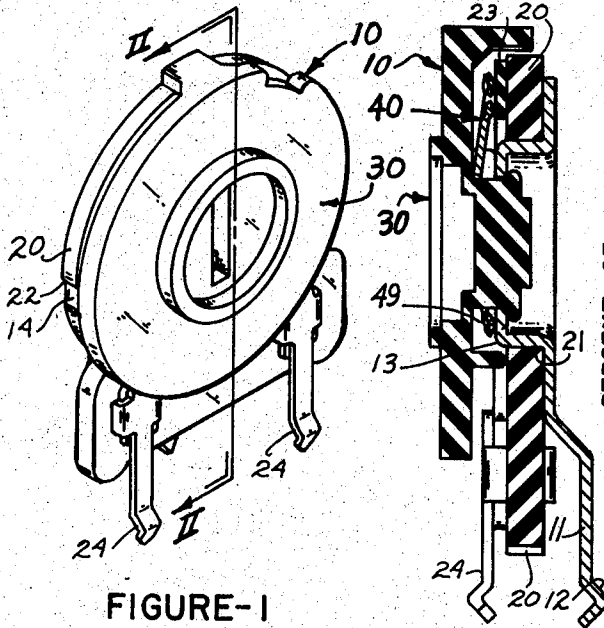


FIGURE-1

FIGURE-2

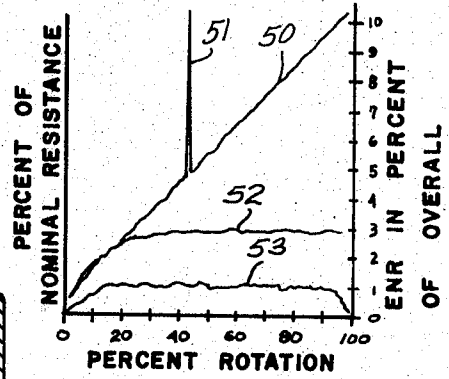


FIGURE-3

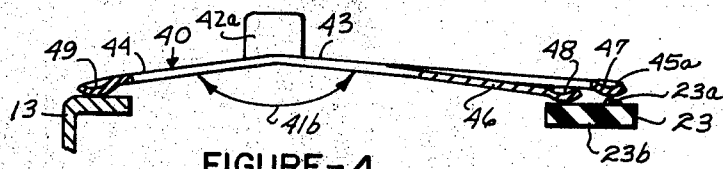


FIGURE-4

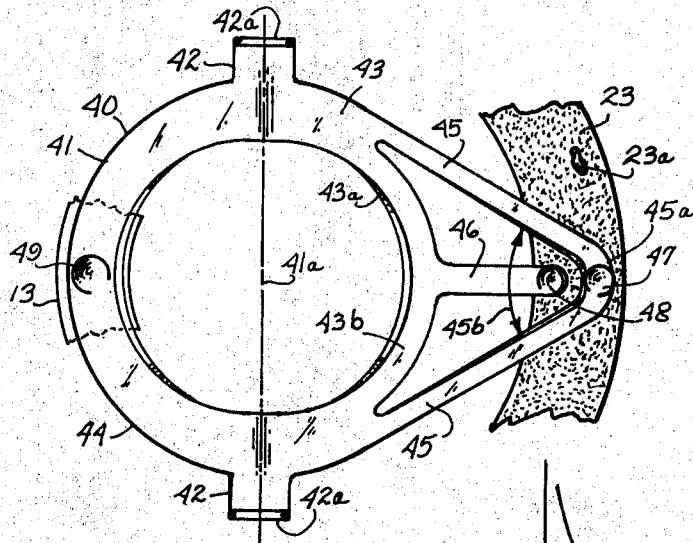


FIGURE-5

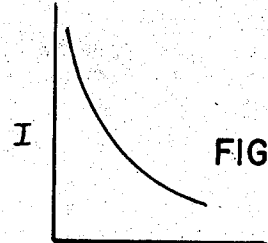


FIGURE-6

VARIABLE RESISTANCE CONTROL WITH DIFFERENTIALLY RESILIENT CONTACTS

The present invention relates to variable resistance controls, and, more particularly, to a contactor having a pair of spaced differentially resilient contacts wipably engaging the resistance element of the control.

One of the more critical problems occurring more frequently in variable resistance controls as resistivity increases and the size of the control decreases is intermittency. Higher resistivities and smaller controls are being used in ever increasing numbers as the demand for electronic equipment containing solid state devices increases. Currently there is a large and increasing demand for small preset variable resistance controls for trimming circuits in solid state television and stereo sets — hence the controls are generally referred to as preset trimmers.

Trimming a circuit requires the introduction of a resistance into the circuit until an optimum condition occurs. For example, if $42,000 \pm 100$ ohms of a 100,000 ohms control is required in a circuit to obtain resonance, but cannot be obtained because the resistance at the terminals of the control jumps to infinity or at least to a value substantially in excess of 42,000 ohms immediately after passing the 42,000 ohms setting and then drops down to 43,000 ohms as movement of the contactor of the control is continued, the control is intermittent and must be replaced. A control is intermittent if, in trimming a particular circuit, it is impossible to obtain within limits the precise resistance normally obtainable from the control. Very likely the same control could be connected in another virtually identical circuit and satisfactorily perform its intended function when a slightly higher or lower resistance is required because the identical electrical circuit parameters almost never are duplicated in two circuits using the same components. Obviously, the advantage of using a preset control to trim a circuit is decreased if it is necessary to replace the control before the circuit can be properly trimmed. It would therefore be desirable to manufacture a variable resistance control that can be adjusted from one end of the resistance range to the other end thereof without becoming intermittent.

Various types of tests are performed on variable resistance controls to monitor and/or graphically identify the characteristics thereof. For example, electrical noise occurs in the circuit while the contactor is being wiped across the resistance element and is normally identified as "equivalent noise resistance" (ENR). The ENR or dynamic contact resistance is measurable in ohms and as a percent of the total resistance by following standardized test procedures well known in the art. Again with the advent of solid state devices such as transistors and integrated circuits, which are extremely quiet in comparison with vacuum tubes, it has become increasingly important to reduce the ENR of variable resistance controls. Various theories are continually being propounded for decreasing the ENR of a variable resistance control. The use of double contacts as exemplified in U.S. Pat. No. 2,178,283 for wipingly engaging an arcuate resistance element can be employed to decrease the ENR of a variable resistance control. According to the prior art, the contacts should be designed to exert the same amount of pressure on the arcuate resistance element to ensure smoother and more dependable operation of the control. Such equalization of pressures exertable by a pair of contacts generally is

satisfactory for controls with low resistivities, but more problems occur when controls with higher resistivities are used with solid state devices. It would, therefore, be desirable to obtain variable resistance controls throughout the entire resistivity range with decreased ENR.

Accordingly, it is an object of the present invention to provide a new and improved variable resistance control having various desirable features as those disclosed above. Another object of the present invention is to provide a variable resistance control with a contactor having a pair of differentially resilient contacts wipably engaging the resistance element of a variable resistance control. A further object of the present invention is to provide a variable resistance control with a contactor having arms with different spring rates for supporting the contacts. Another object of the present invention is to provide a variable resistance control with an ENR lower than currently obtainable. Further objects and advantages of the present invention will become apparent as the following description proceeds, and the features of novelty characterizing the invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

Briefly, the present invention is concerned with a variable resistance control having a contactor with differentially resilient contacts wipably engaging a resistance element and a collector for eliminating intermittency and decreasing dynamic contact resistance. The contactor comprises a metal ring, a pair of outer arms integral with the metal ring and extending outwardly therefrom toward each other for supporting the differentially resilient outer contact wipably engaging the resistance element, an inner arm integral with the metal ring extending outwardly toward the outer contact and supporting the differentially resilient inner contact wipably engaging the resistance element, and a main contact on the ring wipably engaging the collector. The metal ring comprises a pair of semicircular sections performed to define an obtuse angle therebetween.

For a better understanding of the present invention, reference may be had to the accompanying drawings wherein the same reference numerals have been applied to like parts and wherein:

FIG. 1 is an isometric view of an improved variable resistance control built in accord with the present invention;

FIG. 2 is an enlarged sectional view taken along lines II—II of FIG. 1;

FIG. 3 is a graph depicting curves of the resistance gradient and ENR as a percent of the total resistance;

FIG. 4 is a slightly enlarged view of the contactor as shown in FIG. 2 wipably engaging the resistance element and the collector;

FIG. 5 is a top plan view of the contactor as shown in FIG. 4 assuming that FIG. 4 is not shown in sections; and

FIG. 6 is a graph depicting the current gradient along the cross-section of the arcuate resistance element shown in FIG. 5 of the drawings.

Referring now to the drawings, there is illustrated a variable resistance control, generally indicated at 10, comprising a combination collector and supporting bracket 11, a base 20, a rotatable member 30 and an equalizing contactor 40. As best seen in FIG. 2 of the drawing, the supporting bracket 11 comprises a metal

stamping having a snap-in center terminal 12 extending downwardly from the center portion of the bracket for mounting the control 10 to a panel or the like. A collector ring 13 embossed from the center portion of the bracket extends inwardly thereof into an opening 21 of the base for aligning the base with the bracket 11. Tabs 14 (see FIG. 1) projecting forwardly of the bracket 11 engage notches 22 in the base for preventing relative rotation therebetween. An arcuate carbon resistance element 23 is secured to the base 20 with a pair of end terminals 24. The contactor 40 constrained to rotate with the member 30 wipably engages the collector ring 13 and the resistance element intermediate the ends thereof for providing an infinite number of resistance values between one of the end terminals 24 and the center terminal 12 electrically connected to the collector ring 13. For a more thorough description of the control shown in FIG. 1, reference should be made to U.S. Pat. No. 3,375,478 incorporated herein by reference.

Preferably, and in accord with the present invention, the contactor 40 made from metal comprises a body portion or circular ring 41 (see FIG. 5) having a pair of pivots 42 extending outwardly from the circular ring for pivotally supporting the contactor against the rotatable member 30 thereby permitting pivotal action of the contactor with respect to the resistance element 23 and the collector ring 13. Each of the pivots 42 are provided with an upturned end 42a further constraining the contactor to move with the rotatable member 30. The circular ring 41 of the contactor 40 is folded about a line 41a passing through the pivots 42. Such folding or performing divides the circular ring in half and forms a pair of semicircular sections 43, 44 having an obtuse angle 41b therebetween. A pair of outer arms 45 integral with and extending tangentially outwardly from opposite ends of the semi-circular section 43 converge toward each other and are integrally joined together (see FIG. 5) at their extremities 45a. In a preferred form of the invention, an inner arm 46 extends radially outwardly from the semicircular section 43 of the contactor 40 toward the junction or outer extremity 45a of the outer arms 45. Although an outer contact 47 and an inner contact 48 are formed directly from the outer and inner arms, respectively, it is to be understood that the contacts 47, 48 can be fixedly secured to the extremities of the outer and inner arms. As best shown in FIG. 5 of the drawings, the outer arms 45 define an acute angle 45b and the inner arm bisects the acute angle 45b with the outer contact 47 being spaced from the inner contact 48. Moreover, in accord with the present invention, the length of each of the outer arms 45 is greater than the length of the inner arm 46 resulting in a different spring rate for the outer arm and the inner arm. The difference in spring rates of the arms 45, 46 carrying respectively the inner and outer contacts 47, 48 produces a pair of differentially resilient contacts 47, 48 wipably engaging the resistance element 23. Further, the difference in spring rate between the inner and outer arms 45, 46 is increased since the outer arms 45 flex as leaf springs throughout their length while the inner arm 46, being shorter and stiffer, flexes generally as a torsion spring because of the twisting affect of the portions 43a, 43b of the semicircular section 43 between the inner arm and the outer arms. According to the present invention, the inner contact 48 can be carried by more than one arm so long as the effective pres-

sure exerted by the inner contact 48 against the resistance element 23 is different than the pressure exerted by the outer contact 47. A main contact 49 carried by the semicircular section 44 wipably engages the collector ring 13 and electrically connects the inner and outer contacts 47, 48 wipably engaging the resistance element 23 to the center terminal 12.

A large number of controls as exemplified and shown in FIG. 1 of the drawings are employed for trimming electronic circuits. The controls are adjusted to make the equipment operable and then usually are not adjusted unless certain components are replaced in the circuit. Such controls are designated as factory adjust controls while other controls adjusted periodically by the user are commonly referred to as user adjust controls. When the control 10 is employed for trimming electronic circuits, e.g., one of the circuits in a television set, it is imperative that a particular resistance value be obtainable from the control otherwise the circuit cannot be properly trimmed. A control is intermittent when a particular resistance value cannot be obtained because the contactor 40 as best shown in FIG. 4 is electrically insulated from the resistance element, i.e., the contact 47 rests on a nonconductive portion of the resistance element, assuming that contact 48 is not a part of the contactor 40. A thorough study indicates that the nonconductive portion 23a of the resistance element 23 is usually a clump of nonconductive binder or a small particle produced during the shearing operation of the laminated fiber forming the substrate 23b of the resistance element and bonded to the substrate with the binder. Such laminated fiber particles 23a are frequently electrostatically attracted to the substrate and are very difficult to remove prior to application of the carbon resistance paint onto the substrate.

The resistance obtainable between one of the end terminals 24 of the control 10 and the center terminal 12 as the contactor is moved from one end of the resistance element to the other is graphically depicted in FIG. 3 of the drawings, and is commonly referred to as a resistance gradient wave 50. The resistance gradient curve 50 of a control depicts the change in resistance obtained by measuring the resistance between the contact wipingly engaging the resistance element and one of the end terminals as a function of rotation or movement of the contactor from one end of the resistance element to the other end thereof. An ideal resistance gradient curve would be depicted as a straight line having a slope determined by the total resistance as a function of total rotation. A careful study of intermittent controls, that is, controls having an excessively high or infinite resistance at some degree of rotation between the center terminal and one of the end terminals reveals that such controls produce a spike 51 in the resistance gradient curve such as shown in FIG. 3.

When trimming a circuit, if the optimum or desired resistance cannot be obtained because the single contact of a control rests on an insulated particle, the control would be intermittent. But, in accord with the present invention, when such condition exists, the inner contact 48 is still wipingly engaging the resistance element permitting further adjustment of the control to obtain the optimum resistance for trimming the circuit. The likelihood of having both the inner and outer contacts simultaneously resting on insulated particles is rather remote. It is, therefore, apparent that the control

is no longer intermittent since the spike 51 will disappear on the resistance gradient curve 50.

When the control 10 is designed in a circuit as a user adjust control, it is necessary that the contact resistance be kept to a minimum. Contact resistance is of little importance when the control 10 is used as a trimmer since any resistance in or between the contact and the resistance element of the control becomes a part of the total resistance in the circuit. However, in certain applications where the control is frequently adjusted by the user, it is preferable that the contact resistance commonly referred to as equivalent noise resistance (ENR) be kept to a minimum and/or as uniform as possible. As shown in FIG. 3, the ENR curve 52 of a control with a single contact is greater than the ENR curve 53 of a double contact such as when the inner and outer contacts of the present invention wipably engage the resistance element. ENR is essentially a measurement of the contact resistance as the contact wipingly moves across the resistance element. During such dynamic conditions, the contact resistance becomes substantial, e.g., the ENR curve can become as high as 10 percent. Generally an ENR curve for a single contact control is considered satisfactory if below three percent. The average ENR curve for controls employing the contactor 40 is less than 1½ percent and slightly higher for prior art double paddle contactors. An increase in contact resistance from a static to a dynamic condition results from the movement and bouncing of the contacts across the resistance element. Since the pair of arms 45 functioning as springs supporting the outer contact 47 have a different spring rate than the arm 46 supporting the inner contact 48, and since the outer arms 45 function generally as leaf springs while the inner arm remains more rigid and generally functions as a torsion spring resulting from twisting of the semicircular sections extending from opposite sides of the inner arm, the spring rate of the inner contact 48 will be different from the spring rate of the outer contact 47. This difference in spring rate between the two springs effectively alters the bounce or frequency of the two contacts wipingly engaging the resistance element and apparently results in a slightly lower ENR than would otherwise be obtained. Further, the current density or gradient through a mid section of the resistance element 23 from the inner edge to the outer edge thereof generally follows an exponential curve such as shown in FIG. 6 of the drawings, the high current density being at the inner edge of the element 23. It has been found that by making the pressure of the inner contact 48 at least several percent greater than the pressure of the outer contact 47 against the element a slightly improved ENR curve is obtainable.

While there has been illustrated and described what is at present considered to be a preferred embodiment of the present invention, it will be appreciated that numerous changes and modifications are likely to occur to those skilled in the art, and it is intended in the appended claims to cover all those changes and modifications which fall within the true spirit and scope of the present invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A variable resistance control comprising a resistance element, a collector in spaced relationship to the resistance element, an electrically conductive contactor engaging the resistance element and the collector,

means for moving the contactor intermediate the ends of the resistance element, said contactor comprising a circular ring, a pair of pivots extending outwardly from the body portion and pivotally supporting the contactor against the resistance element and the collector, each of the pivots being provided with an upturned end constraining the contactor to move with the above mentioned means, the circular body portion being creased through its pivots and defining a pair of semicircular sections, each of the semicircular sections of the circular body portion being preformed and defining an obtuse angle therebetween, a pair of outer arms extending tangentially outwardly from one of the semicircular sections and converging toward each other and joined together at the extremities, an outer contact carried by the arms, an inner arm extending radially outwardly from the one of the semicircular sections toward the outer contact, an inner contact carried by the end of the inner arm, and spaced from outer contact, the outer contact and the inner contact wipably engaging the resistance element, the outer arms defining an acute angle, and the inner arm bisecting the acute angle, the length of the outer arms being greater than the length of the inner arm resulting in a different rate for the inner arm and the outer arms, and a main contact carried by the circular body portion and wipably engaging the collector.

2. The variable resistance control of claim 1, wherein the inner contact exerts a greater pressure against the resistance element than the outer contact.

3. In a variable resistance control having a resistance element, a collector in spaced relationship to the resistance element, an electrically conductive contactor engaging the resistance element and the collector, means for moving the contactor intermediate the ends of the resistance element, said contactor comprising a body portion, a pair of outer arms extending outwardly from opposite sides of the body portion and converging toward each other, an outer contact carried by the arms and wipably engaging the resistance element, an inner arm integral with the body portion and extending outwardly therefrom toward the outer contact, the end of said inner arm being spaced from the outer contact, an inner contact disposed on the distal end of the inner arm in spaced relationship to the outer contact and wipably engaging the resistance element, and a main contact carried by the body portion and wipably engaging the collector.

4. The variable resistance control of claim 3, wherein the body portion of the contactor is a metal ring defined by a pair of semicircular sections, each of the semicircular sections of the ring being preformed and defining an obtuse angle therebetween.

5. The variable resistance control of claim 4, wherein the outer and inner arms are integral with one of the semicircular sections of the metal ring, and the main contact is integral with the other of the semicircular sections of the metal ring.

6. The variable resistance control of claim 3, wherein the outer arms define an acute angle and the inner arm bisects the acute angle.

7. The variable resistance control of claim 3, wherein the length of each of the outer arms is greater than the length of the inner arm resulting in a different spring rate for the inner arm and the outer arms.

8. The variable resistance control of claim 4, wherein the outer arms extend tangentially outwardly from the one of the semicircular sections and the inner arm extends radially outwardly from the one of the semicircular sections.

9. The variable resistance control of claim 3, wherein the inner contact exerts a greater pressure against the resistance element than the outer contact.