United States Patent [19]

Miller

[11] **3,750,081**

[45] **July 31, 1973**

[54] **WIREWOUND VARIABLE RESISTANCE CONTROL AND METHOD OF MAKING THE SAME**

[75] Inventor: **Jack L. Miller,** Elkhart, Ind.

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

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[52] **U.S. Cl.**..... **338/174,** 338/139, 338/160, 29/618

[51] **Int. Cl.**..... **H01c 5/02**

[58] **Field of Search**..... 338/118, 139, 160, 338/162, 174, 176, 183, 301; 29/610, 618

[56] **References Cited**

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3,409,855 11/1968 Bender et al. 338/118

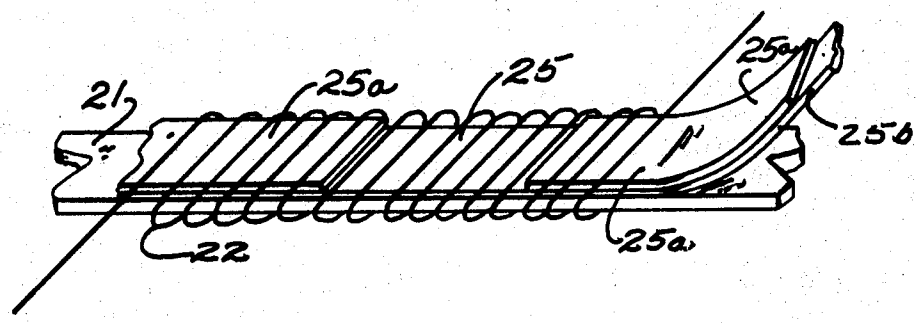
2,724,759 11/1955 Daniels ..... 338/174 X

Primary Examiner—Bernard A. Gilheany
Assistant Examiner—D. A. Tone
Attorney—John J. Gaydos

[57] **ABSTRACT**

Variable resistance control having wirewound resistance element with shorted end turns. A piece of metal secured to each end portion of an electrically nonconductive tape with a bonding material shorts several adjacent turns at each extremity of the resistance element.

12 Claims, 7 Drawing Figures



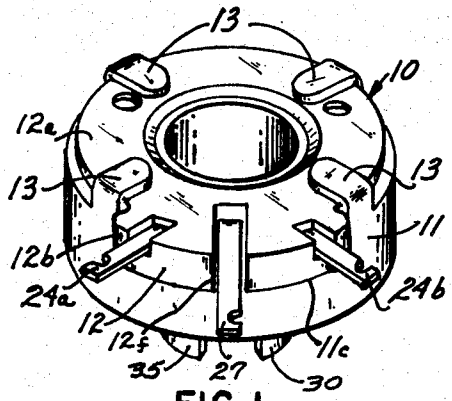


FIG. 1

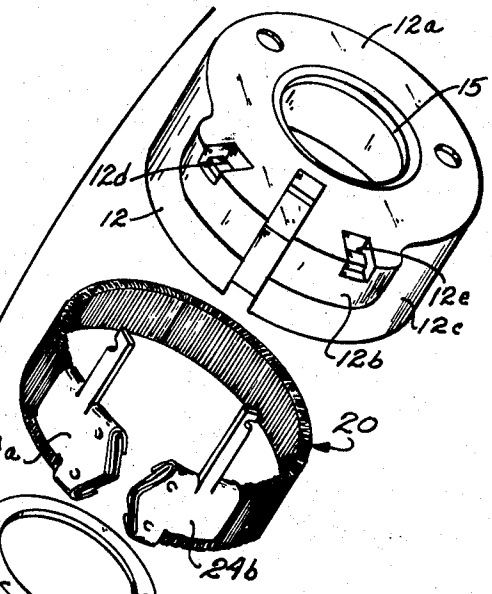


FIG. 2

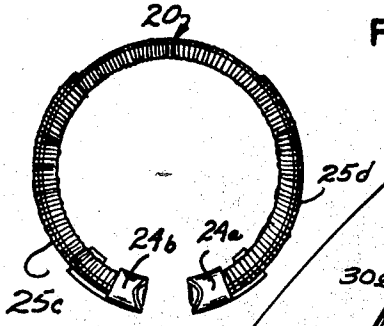
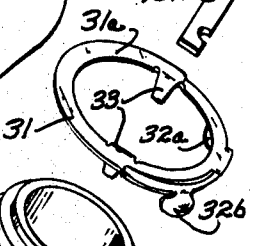
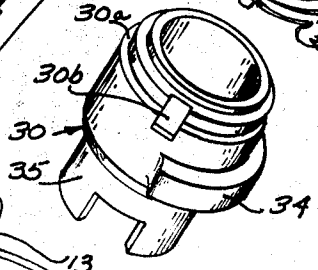


FIG. 5





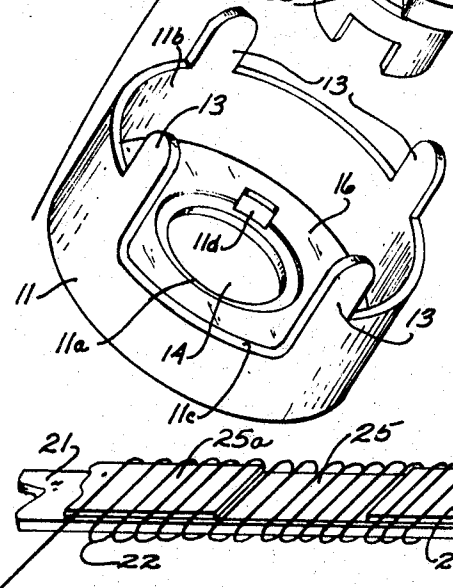


FIG. 3

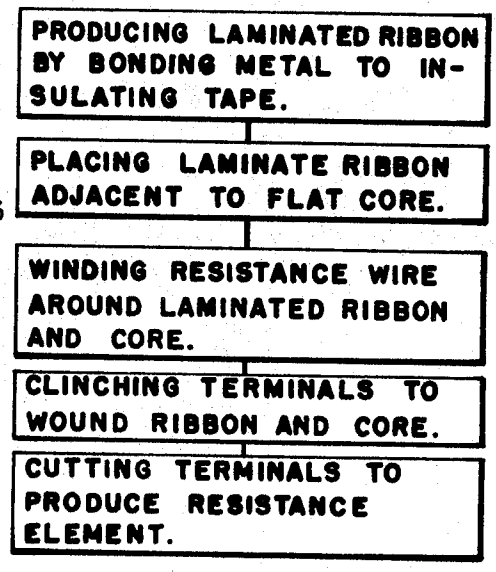


FIG. 7

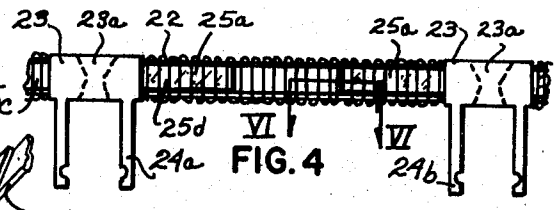


FIG. 4

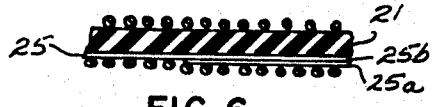


FIG. 6

WIREWOUND VARIABLE RESISTANCE CONTROL AND METHOD OF MAKING THE SAME

The present invention relates to electrical controls, and, more particularly, to a wirewound variable resistance electrical control of the type commonly referred to as a fader control and to a method of making the same.

Variable resistance fader controls are commonly employed for alternately changing the volume of a pair of loudspeakers. For example, in an automobile provided with front and rear loudspeakers, it is preferable to adjust or balance the volume of both of the loudspeakers with a single control.

Many types of fader controls are available on the market. In one particular type of fader control, the end turns of the resistance element are coated with a conductive paint to short circuit the end turns of the resistance element. Conductive paints are, to a certain degree, brittle, and flexing or jarring of the resistance element frequently causes a crack in the conductive paint thereby increasing the resistance between adjacent end turns. In other fader controls the end turns of the resistance element are covered with a metal strip. Such construction, however, causes a step to be formed between the resistance path and the edge of the strip resulting in an uneven feel or jump in the shaft as the contactor is wiped across the step. Attempts to short the end turns together with solder have been unsuccessful since the resistnce wire, e.g., Nichrome wire, forming the end turns generally contains chromium which is not readily wettable by solder. Another method of making a fader control, as shown in Bender et al. U.S. Pat. No. 3,409,855, and assigned to the same assignee as the present invention, utilizes a continuous metal foil disposed between the turns of resistance wire and the insulating core. After attaching terminals to the wirewound resistance element, the metal foil is severed at two places between the end terminals, and the center portion of the metal foil is removed. The remaining end portions of the metal foil preferably are wetted with solder, depending on the application. Although such fader controls are satisfactory, the cost per salable control remains high since the foil cutting operation invariably produces some elements having severed or damaged turns which can later break creating a field failure and, therefore, must be scrapped. Also, removal of the center portion of the foil is a slow and tedious manual operation resulting in damage to some elements. It would, therefore, be desirable to provide an improved fader control employing a laminated ribbon containing prespaced pieces of metal bonded to an insulating tape for shorting the end turns of a resistance element and to an improved method of making a resistance element for a fader control having shorted adjacent end turns.

Accordingly, it is an object of the present invention to provide an improved fader control. Another object of the present invention is to provide an improved method for shorting adjacent end turns of a resistance element employed in a fader control. A further object of the present invention is to provide an electrical control with a wirewound resistance element having a portion of the turns of wire electrically connected to prespaced pieces of metal. Still another object of the present invention is to provide a method of shorting end turns of a resistance element by coating an insulating tape with a bonding material having a lower softening temperature than the insulating tape, thermally bonding an elongated strip of metal to the insulating tape, removing pieces of metal bonded to the tape to produce a laminated ribbon with precisely spaced pieces of metal, and winding a resistance wire around the ribbon. 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.

Specifically, the present invention is concerned with an improved wirewound resistance element for a variable resistance fader control having precisely prespaced pieces of conductive metal bonded to an electrically nonconductive tape for shorting the end turns of the resistance element. In a preferred embodiment a clad exterior conductive layer is deposited on the metal to protect the metal from undesirable oxidation effects. The present invention is also concerned with an improved method of making the wirewound resistance element by bonding precisely spaced pieces of metal to an electrically nonconductive tape to produce a laminated ribbon. A resistance wire is then wound around the laminated ribbon. The laminated ribbon comprising the spaced pieces of metal and tape can also be combined with an insulating core and the resistance wire is then wound around the laminated ribbon and the core to produce a wirewound resistance element. Pairs of terminals are located at the midpoints of the pieces of metal and are secured to the resistance winding thereby effecting an electrical connection between the piece of metal, the resistance wire, and the terminals. The elements are then cut to an appropriate length. If the element is mounted in a cylindrical housing, the element preferably is formed to the shape of the housing to facilitate assembly.

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 electrical control made in accord with the present invention;

FIG. 2 is an exploded view of the control shown in FIG. 1;

FIG. 3 shows the relationship between an insulating core, a laminated ribbon, and a resistance wire during the winding operation;

FIG. 4 is a side view of a wound resistance strip shown in FIG. 2 with unsevered pairs of terminals secured to the strip;

FIG. 5 is a top plan view of the resistance element of FIG. 4 after the terminal cutting and forming operation;

FIG. 6 is a grossly enlarged fragmentary section of the resistance element taken along line VI—VI of FIG. 4; and

FIG. 7 is a diagrammatical representation of the invention.

Referring now to the drawings, there is illustrated an electrical control generally referred to as a variable resistance fader control and indicated at 10 comprising a cup-shaped metal housing 11 supporting a resistance element 20 and a rotor 30. Telescopically mounted within the housing 11 and closing the open end of the cup-shaped housing 11 is an inverted cup-shaped insert 12 molded of a suitable insulating material. As shown in FIG. 1, the end wall 12*a* of the insert 12 forms one

of the outer end walls of the control **10** and the end wall **11***a* of the housing **11** forms the other outer end wall thereof. The open end **11***b* of the housing **11** is provided with a cutaway section **11***c* and an arcuate boss **12***b* extending radially outwardly from the insert **12** fits into the cutaway section **11***c* of the housing **11** to orient the insert **12** with the housing **11.** A skirt **12***c* depending from the end wall **12***a* and mounted within the housing **11** insulates the resistance element **20** from the metal housing **11.** A plurality of tabs **13** integral with the housing **11** are folded over the end wall **12***a* of the insert **12** to secure the housing to the insert. Both of the end walls **11***a* and **12***a* of the housing **11** and the insert **12** respectively are provided with apertures **14** and **15** and the rotor **30** is journaled therein.

The resistance element **20** circumposes the rotor **30** and abuts against the inner wall of the depending skirt **12***c* of the insert **12.** More particularly, the resistance element **20** comprises a core **21** of insulating material and a laminated ribbon **25** containing pieces of metal **25***a* bonded to a tape **25***b* of insulating material (see FIG. 3) having a plurality of turns of resistance wire **22** wound thereon. When the tape **25***b* is of sufficient thickness, the resistance wire can be wound directly on the laminated ribbon without use of the core **21.** The pieces of metal **25***a* preferably are pieces of metal foil, e.g., copper, having a nickel plate on one side and of a width substantially the same as the tape. Any type of wire, e.g., Nichrome wire, having the proper resistance per unit length can be used. SUitable end terminals **24***a* and **24***b* are clinched to the insulating core **21** and the resistance wire **22** thereby effecting an electrical contact with the resistance wire **22** and the metal foil **25***a* of the laminated ribbon **25.** The resistance element **20** is disposed in the insert **12** with the upper edge of the resistance element **20** abutting against the end wall **12***a*. A washer **16** made of an appropriate insulating material is disposed in the housing **11** and abuts against the end wall **11***a* to provide an insulating barrier between the lower edge of the resistance element **20** and the end wall **11***a* of the housing **11.** The end terminals **24***a* and **24***b* project upwardly through slots **12**d and **12**e provided in the insert **12** and the end portions are formed radially outwardly beyond the slots (see FIG. 1). The end portions of the terminals are partially supported by the walls defining the lower side of the slots. A collector ring **26** having an opening **26***a* abuts against the end wall **12***a* of the insert **12** and a center terminal **27** extends radially outwardly from the collector ring **26** through a slot **12***f* provided in the insert **12.** The rotor **30** molded of a suitable insulating material is provided with a cylindrical shoulder **30***a* engaging the inner edge of the opening **26***a* for positioning the collector ring coaxially with the apertures **14** and **15.**

For the purpose of transferring electric current from the resistance element **20** to the collector ring **26,** a contactor **31** having a pair of spaced contact fingers **32***a* and **32***b* electrically connected to each other wipingly engages the resistance element **20.** The contactor **31** comprises a ring portion **31**a in slideable engagement with the collector ring **26,** and a pair of downwardly extending ears **33** integral with the ring portion **31***a* and received in a pair of diametrically disposed grooves **30***b* provided in the rotor constrain the contactor **31** to rotate with the rotor **30.** In order to limit rotation of the contactor **31,** the rotor is provided with an arcuate boss **34** engageable with a stop **11***d* (see FIG. **2**) extending inwardly from the end wall **11***a* of the housing **11.** A hollow shaft **35,** of appropriate design, fixedly secured to the rotor **30** extends outwardly of the housing.

Referring now particularly to a preferred method of making the resistance element **20,** precisely cut pieces of metal foil **25***a* are bonded to a suitable elongated insulating tape **25***b*, e.g., a polyester tape. Preferably the insulating tape is coated with a bonding material, e.g., a polyethylene coating, having a lower softening temperature than the tape **25***b* for thermally bonding the pieces of metal foil at spaced intervals to the tape. The bonding material can be readily softened by applying heat to the metal foil and the tape to secure the metal foil to the tape. The tape **25***b* with the metal foil bonded thereto is commonly referred to as a laminated ribbon **25.** Any type of suitable cement can also be employed for securing the metal foil to the insulating tape. Instead of precisely locating and securing the individual pieces of metal foil **25***b* on the insulating tape **25***a* at spaced intervals, a continuous metal foil can be secured to the insulating tape and precisely spaced portions of metal foil can be readily removed, e.g., by chemical etching. The laminated ribbon **25** with spaced pieces of metal foil is then placed against the core of insulating mateial **21** preferably a flat strip with the tape side of the laminated ribbon **25** flush against a flat side of the core. The insulating core **21** and the ribbon **25** are then fed into a winding machine and the resistance wire **22** is wound around the insulating core **21** and the ribbon **25** securing the ribbon to the core and producing a wound resistance strip containing spaced pieces of metal foil **25***a* shorting adjacent turns of resistance wire. When the tape **25***b* is of sufficient thickness such as to avoid buckling, the resistance wire **22** can be wound directly on the laminated ribbon. At the present time since the insulating core **21** is cheaper than the tape **25**b, the laminated ribbon **25** is preferably combined with the core **21** and wound with the resistance wire **22.** At the midpoints of each of the metal foils **25**a of the ribbon **25,** pairs of terminals **23** (see FIG. **4**) are clinched to the wound resistance strip electrically connecting the resistance wire **22** and the metal foil **25***a* of the ribbon to the terminal pairs **23.** The wound resistance strip is then cut to short lengths by removing a section **23***a* from each pair of terminals **23** to produce a resistance element **20** having a pair of end terminals **24***a* and **24***b* at the ends thereof. The cutting operation also divides each of the pieces of metal foil **25***a* of the laminated ribbon **25** into two separate parts **25***c* and **25***d*. In specific applications solder may be applied to the pieces of metal foil to increase the electrical contact between the wire **22** and the metal foil **25***a*. In a particular embodiment, a laminated ribbon **25,** 0.197 inches wide, comprising pieces of nickel plated 1 oz. copper foil 1.55 inches in length bonded to a 0.0025 inch thick polyester insulating tape with 0.410 inches between each piece of metal foil, was positioned on an insulating core 0.200 inches wide.

By connecting the end terminals **24***a* and **24***b* of the resistance element of the fader control **10** to a pair of not-shown loudspeakers and the center terminal **27** to one side of a not-shown input signal, turning of the shaft **35** of the fader control **10** between one end of rotation to midpoint rotation causes the resistance that the control **10** introduces into the one loudspeaker circuit to decrease, while the resistance introduced into

the second loudspeaker circuit remains essentially zero. Therefore, the volume of the first loudspeaker increases from a minimum to a maximum value while the volume of the second loudspeaker remains at maximum. At midpoint rotation, the resistance introduced into each loudspeaker circuit is essentially zero and both loudspeakers are at maximum volume. While continuing to turn the shaft **35** in the same direction from midpoint rotation to full rotation, the resistance introduced by the control **10** into the first loudspeaker circuit remains essentially zero while the resistance introduced into the second loudspeaker circuit increases. Therefore, over the second half of the rotation of the shaft **35**, the volume of the first loudspeaker remains at a maximum while the volume of the second loudspeaker decreases from a maximum value to a minimum value. The angle between the contact fingers **32***a* and **32***b* generally is at least as large as the angle defined by the unshorted portion of the resistance element. Otherwise, all the resistance could not be removed from both loudspeaker circuits when the shaft is at midpoint rotation.

While there has been illustrated and described what is at present considered to be a preferred embodiment of the present invention and a method of making the same, 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 housing, a wirewound resistance element disposed in said housing, said resistance element comprising an insulating tape, a first piece and a second piece of metal spaced from the first piece bonded to the insulating tape, a resistance wire wound around the tape with adjacent turns spaced from each other, the first piece of metal shorting a plurality of the turns of the resistance wire at one end thereof to define a first shorted portion, the second piece of metal shorting a plurality of the turns of the resistance wire at the other end thereof to define a second shorted portion, said resistance wire having a single unshorted portion extending between the first and second shorted portions, a first end terminal electrically connected to said first shorted portion of the resistance wire, a second end terminal electrically connected to said second shorted portion of the resistance wire, a contactor comprising a pair of spaced fingers wipingly engaging the resistance element between the ends thereof, and a third terminal electrically connected with the contactor.

2. The control of claim **1**, wherein an insulating core is disposed adjacent to the tape and the resistance wire is wound around the tape and the core.

3. The control of claim **1**, wherein said first and second pieces of metal comprise copper with a clad exterior surface of nickel engaging the resistance wire.

4. The control of claim **1**, wherein a bonding material having a lower softening temperature than the insulating tape is disposed between the metal and the tape, and said first and second pieces of metal are thermally bonded to the insulating tape.

5. The control of claim **4**, wherein the insulating tape is a polyester tape and the bonding material is polyethylene.

6. The control of claim **5**, wherein the polyethylene bonding material is a coating on the polyester insulating tape.

7. A variable resistance control comprising a housing, a wirewound resistance element disposed in said housing, said resistance element comprising an insulating core, an insulating tape in juxtaposition to the insulating core, a first piece and a second piece of metal foil spaced from the first piece bonded to the insulating tape, a resistance wire wound around the core and the tape with adjacent turns spaced from each other, the metal foil having a width substantially equal to the width of the tape, the first piece of metal foil shorting a plurality of the turns of the resistance wire at one end thereof to define a first shorted portion, the second piece of metal foil shorting a plurality of the turns of the resistance wire at the other end thereof to define a second shorted portion, said resistance wire having a single unshorted portion extending between the first and second shorted portions, a first end terminal electrically connected to said first shorted portion of the resistance wire, a second end terminal electrically connected to said second shorted portion of the resistance wire, a contactor comprising a pair of spaced fingers wipingly engaging the resistance element between the ends thereof, and a third terminal electrically connected with the contactor.

8. A method of shorting a portion of a wirewound resistance element comprising the steps of bonding pieces of metal to an insulating tape to produce a laminated ribbon, winding a resistance wire around the laminated ribbon with adjacent convolutions of the resistance wire spaced from each other and in electrical contact with said pieces of metal, and securing a plurality of electrically conductive terminals to the resistance wire.

9. The method of claim **8**, wherein the step of bonding pieces of metal to an insulating tape comprises the step of coating the insulating tape with a bonding material, securing an elongated strip of metal to the insulating tape wih the bonding material, and removing spaced pieces of metal bonded to the insulating tape to produce a laminated ribbon with precisely spaced pieces of metal.

10. The method of claim **9**, wherein the insulating tape is a polyester and the bonding material is a polyethylene.

11. The method of claim **9**, wherein the first mentioned spaced pieces of metal are removed by chemical etching.

12. The method of claim **9**, wherein the step of securing an elongated strip of metal to the insulating tape includes the step of heating the bonding material until sufficiently soft to effect a bond between the metal and the tape.

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