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3,222,629

VARIABLE RESISTANCE BRIDGE

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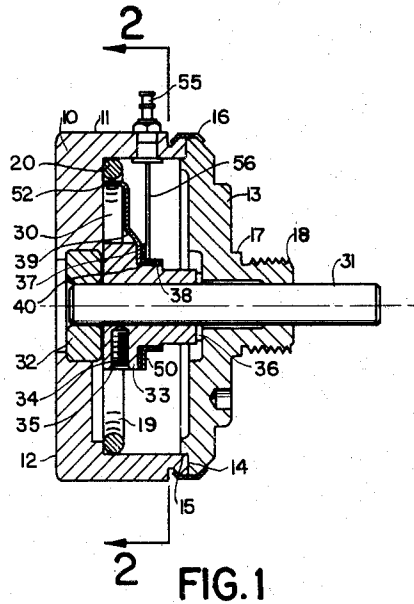


FIG. 1

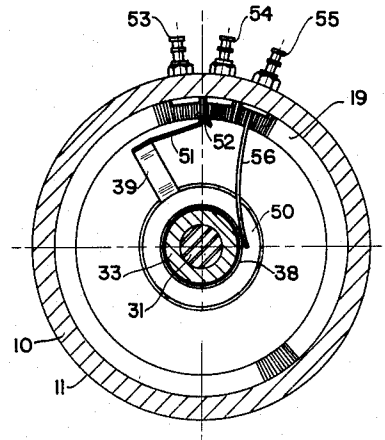


FIG. 2

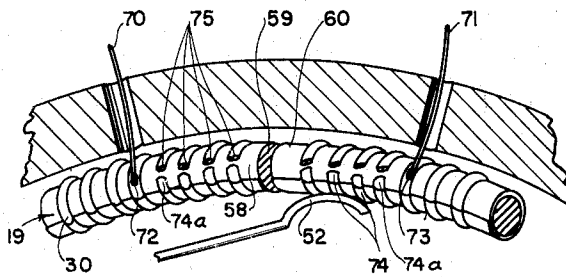


FIG. 4

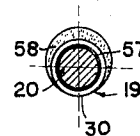


FIG. 3

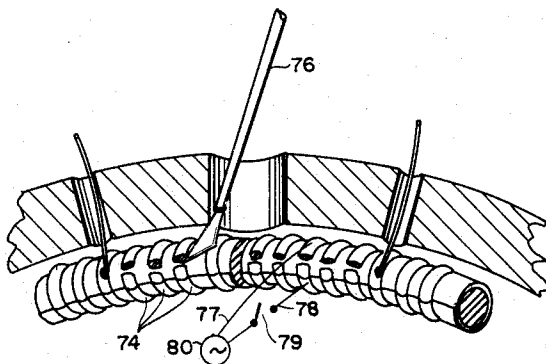


FIG. 5

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3,222,629

VARIABLE RESISTANCE BRIDGE

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The present invention relates generally to variable resistances and, more particularly, to an improved variable resistance bridge and method for making such bridge.

Many single-turn potentiometers, variable resistors, rheostats and the like are presently constructed with the movable wiper adapted to be continuously rotated in either or both directions of rotation. In this type of component, it is conventional practice to provide a void or dead space in the resistance element of sufficient length so that the potentiometer wiper will not cause an electrical short circuit between the conductive ends of the resistive element when traversing that area. It is desirable, however, that the arcuate length of this void be held to a minimum so as to limit the period of time, at any given speed of rotation of the wiper, during which a discontinuity exists between the wiper and the electrically active area of the resistive element. For example, military specifications establish minimum and maximum angles of electrical rotation for single-turn potentiometers which, in turn, dictate the length of the circumferential dead space between the end terminals of the potentiometer resistive element.

Many potentiometers, variable resistors, rheostats, and the like employ resistance wire around about and supported by a mandrel. It is this type of resistance element with which this invention is concerned. Generally, the dead space in this type of resistance element has been secured by the removal of a portion of the resistance wire from the mandrel by unwinding from each end of the element. As the rotating wiper passes over the space thus provided, it will drop into the space due to the biasing force exerted upon the wiper and, with continued rotation, will be lifted out of the space as it contacts the terminal ends of the resistive element. To reduce the varying torque which results when the wiper passes through this dead space, and to minimize the damage to the end turns of the resistive element due to impact of the wiper as it is lifted out of the dead space, a bridge is normally formed over the dead space. This bridge has taken a number of different forms, dependent upon the type of resistive element employed in the potentiometer. By way of example, the bridge may comprise a mechanical device, located adjacent to the resistive element, which during rotation of the wiper causes the wiper to be lifted from the resistive element proper during passage over the resistance element dead space. Another type of bridge commonly used comprises a dielectric material, such as a thermosetting plastic, which is applied to the void left by the removal of the end turns of the resistive element. The dielectric material must be applied in either a single coat or successive coats as needed until the void is filled to the level of the windings on the resistive element.

Numerous disadvantages are experienced in the use of the prior art bridges, the most objectionable of which are the difference in wear rates between the resistance wire of the element and the bridging material, and the migration of abraded dielectric material from the bridge to the electrically active area of the resistance element causing, in some instances, high contact resistance between the

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movable wiper and the resistance element. Such high contact resistance produces what is commonly referred to as potentiometer "noise." Other disadvantages include the cost of constructing the void filling bridges, wherein an operator is required to insert the resistive element within the housing member, mark the desired dead space or void upon the resistive element, remove the element and unwind the turns, reinstall the element in the housing and, working under a microscope, fill the void with a dielectric material.

Accordingly, it is the principal object of the present invention to provide a variable resistance bridge and method for constructing such bridge which does not require the removal of turns of resistance wire nor the addition of material to the resistance element dead space.

Another object of the present invention is to provide a variable resistance bridge which has a wear rate identical to that of the resistance wire of the element.

A further object of the present invention is to provide a variable resistance bridge constructed of the same material as that used in the electrically conductive area of the resistance element, thus eliminating the hazard of migration of abraded dielectric particles from the bridge to the conductive areas.

Other and further objects, features and advantages of the invention will become apparent as the description proceeds.

Briefly, in accordance with a preferred form of the present invention, a single-turn variable resistor incorporates a resistance element comprising a length of mandrel formed into an annulus and fitted into the body of the variable resistor. The mandrel is wound with a plurality of turns of resistance wire to a predetermined pitch, the resistance wire being wound completely to the edges of the mandrel. The mandrel is then fitted within the body of the variable resistor so that the ends thereof are juxtaposed with a minimum amount of space therebetween, preferably less than the pitch of the resistance wire. The arcuate extent of the active resistance element between the end terminal connections is determined and appropriate end terminals attached to the resistance wire. The remainder of the resistance element must then be rendered electrically inactive in order to prevent a short circuit by the variable resistor wiper when it traverses the ends of the resistance element. As heretofore noted, a procedure utilized by the prior art was to physically remove the resistance element from the housing and unwind the resistance wire from the mandrel up to the end terminal connections, after which the element was replaced in the housing and the void was filled with a suitable dielectric material.

According to a preferred aspect of the present invention, the electrical dead space is obtained by severing the turns of resistance wires located between the end terminal connections and the ends of the mandrel. The severing of the resistance wires may be accomplished by open-circuiting or "blowing" the individual turns by applying an excess of electrical current to the area to be severed, or by mechanically cutting the individual turns with a sharp-edged instrument. By severing each turn in some portion of the resistance element other than that which is contacted by the movable wiper, the wiper will smoothly traverse the dead space by passing over the electrically inert but otherwise intact turns of resistance wire. Thus, there is provided between the terminal wires a bridge which is identical in construction and material to the re-

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mainder of the resistance element, thereby obviating the undesirable features of the prior art variable resistance bridges.

A more thorough understanding of the present invention may be obtained from the following detailed description taken in connection with the accompanying drawing in which:

FIG. 1 is a sectional view of a representative single-turn potentiometer;

FIG. 2 is a sectional view taken along the line 2—2 of FIG. 1;

FIG. 3 is a sectional view of a representative resistance element;

FIG. 4 is a view in perspective of a potentiometer bridge constructed in accordance with this invention; and

FIG. 5 is a perspective view showing two methods of constructing the wire bridge in accordance with this invention.

The potentiometer shown in FIGS. 1 and 2 includes a housing 10 comprising a cylindrical shell portion 11 and a back plate 12. A front lid 13, having a shoulder 14 which registers with an internal wall 15 of the case 10, is fixed to the case by a clamp 16. The front lid 13 includes a shoulder 17 and a threaded boss 18 for mounting the potentiometer in an instrument panel or the like.

A resistance element 19, which may comprise an annular core or mandrel 20 having a plurality of turns or convolutions of resistance wire 30 wound thereon, is positioned within the housing 10. A shaft 31 is rotatably mounted in the front lid 13 and in a bearing 32 which is mounted in the back plate 12 of the housing 10. A block 33, which is preferably made of nonconducting material, is mounted on the shaft 31 by suitable means such as a setscrew 34 inserted in a threaded opening 35 in the block 33. Spacing washers 36 may be placed on the shaft 31 between the front plate 13 and the block 33 to eliminate axial movement of the shaft relative to the housing.

Block 33 has a shoulder 37 and a cylindrical surface 38, the axis of which is collinear with the axis of rotation of the shaft 31. A contact carrier arm 39 is provided with a circular opening 40 in one end thereof, the contact carrier being positioned on the block 33 so as to abut the shoulder 37. A bushing 50 is mounted on the surface 38 of the block 33 and serves to attach the contact arm 39 to the block 33, the bushing being fixed to the block 33 by suitable means, such as by a press fit thereon.

A spring element 51 having an end bent to form an arcuate contact 52 is mounted on the end of the arm 39 opposite the circular opening 40, the contact portion 52 being urged into engagement with the inside diameter of the resistance element 19 by the action of the spring 51.

Terminals 53, 54 and 55 are mounted in the cylindrical shell portion 11 of the housing 10, the terminals providing electrical connections to the resistance wire 30 and to the contact 52. A circuit is completed from the terminal 55 to the contact 52 through a brush 56 mounted in the terminal 55 and riding on the bushing 50, the brush, bushing and contact carrier arm being formed from electrically conductive material.

A cross-sectional view of a representative resistance element 19 is shown in FIG. 3. The mandrel 20 is preferably a round copper wire which has been coated with an appropriate insulating enamel 57, such as a polyvinyl formal polyester or phenolic-epoxy resin. It will be apparent that if the mandrel is constructed of a nonconductive material, the dielectric layer 57 may be deleted. The mandrel is normally straight when wound with the resistance wire 30 to a predetermined pitch and then formed into a helical configuration, these operations preferably being performed according to the apparatus and methods taught and claimed by D. G. Marlow in U.S. Patent No. 2,334,880, entitled "Apparatus for Winding Cores" and H. H. Cary et al. in U.S. Patent No. 2,620,790, entitled "Method and Apparatus for Winding Resistance Ele-

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ments," each of which is assigned to Beckman Instruments, Inc. The helixed resistive element is then cut or sawed to produce one or more single-turn resistive elements of the appropriate length. After winding, a coating 58 of insulation similar to that used for the mandrel insulation is applied to approximately 270° of the surface of the wound mandrel to prevent displacement of coil turns of the resistance wire during subsequent processing. Approximately 90° of the mandrel surface is left uncoated as shown in FIG. 3 to provide good electrical contact with the potentiometer wiper contact 52. In the embodiment herein shown, the inner portion of the resistance element 19 is not coated, and wiper 52 traverses this uncoated inner portion of the resistance element. Optionally, the entire circumference of the resistance element may be coated and the wiper track cleaned by buffing or the like in accordance with the method and apparatus described by H. H. Houdyshell in U.S. Patent No. 2,860,455, entitled "Coil Buffing Process and Apparatus" and assigned to Beckman Instruments, Inc., assignee of the present invention. It will be obvious to those skilled in the art that certain design considerations may dictate that the outer surface or either side surface of the resistance element 19 be left exposed for the wiper to traverse without departing from the spirit of the invention.

The enlarged perspective view of FIG. 4 shows, in detail, a preferred embodiment of a potentiometer bridge constructed in accordance with this invention. As shown, the single-turn resistance element 19 is desirably formed so that when it is located within the potentiometer housing 10, the ends 59, 60 thereof are juxtaposed with a minimum amount of space therebetween, preferably less than the pitch of the resistance wire 30. A preferred method and apparatus for so forming the resistance element is described and claimed by V. J. Abrams in the copending application, Serial No. 91,080 entitled "Method and Apparatus for Forming Resistance Elements," filed on even date herewith and assigned to Beckman Instruments, Inc., now Patent No. 3,157,081. Terminal wires or leads 70 and 71 extending to terminals 53 and 54 (FIG. 2) are preferably attached to the resistance wire 30 at respective points 72 and 73 by scraping away the coating enamel and capacitor discharge welding to a single-turn of a resistance wire according to a desired one of the methods described and claimed by R. E. Semple in U.S. Patent No. 2,710,328, entitled "Welding Process" and U.S. Patent No. 2,783,361, entitled "Welding Process and Apparatus," each of which is assigned to Beckman Instruments, Inc.

The positions of connection points 72, 73 determine the arcuate extent of the active winding. A predetermined dead space must be provided between these points since the radius of the arcuate wiper contact 52 is usually of such magnitude that the wiper may be in simultaneous electrical contact with several turns of resistance wire. In representative potentiometers, a newly constructed wiper contacts two to four turns simultaneously and, after some use, tends to flatten out and contact additional turns. Thus, the dead space is required to prevent the contact 52 from shorting the ends of the resistance element 19 in those potentiometers permitting continuous movement of the wiper in either or both directions.

Potentiometer specifications usually require that the resistance element have an arcuate length of 354° to 356°; accordingly, a dead space usually has a length of 4° to 6°. As heretofore noted, a void of this length cannot be tolerated because of the variable torque required in moving the wiper over this area, and the resultant damage to the end turns of the resistance element due to impact of the wiper as it is lifted out of the dead space. The bridge of this invention as shown in FIG. 4 includes the resistance element between the end terminals after being modified by severing each of the resistance coils or convolutions 74 in this region at a point 75, thereby electrically disconnecting each of said several coils from the remainder of the resistance element. It will, of course,

be understood that not every turn in the dead space need be severed since severing the first turns or convolutions 74a adjacent the end terminals will suffice to electrically disconnect the remainder of the turns within the dead space. Preferably, the turns are severed under the layer 58 of striping enamel, thereby preventing the severed coils from unwinding. Also, by severing the coils under the enamel, the coil remaining exposed to the wiper presents a uniform structure to the wiper as it is rotated through the dead space. The torque required to rotate the potentiometer shaft 31 thus remains constant, and wear of the resistance element at or around the dead space is obviated.

Two methods of severing the resistance coils 74 are illustrated in FIG. 5. The mechanical separation of the wires under the enamel may be obtained with a sharp-edged instrument 76. It may also be obtained by contacting electrical leads 77, 78 to closely adjacent regions of a single turn of resistance wire and "blowing" the section between the leads with an excess current applied through switch 79, when closed, from a power source 80.

Although exemplary embodiments of the invention have been disclosed and discussed, it will be understood that other applications of the invention are possible and that the embodiments disclosed may be subjected to various changes, modifications and substitutions without necessarily departing from the spirit of the invention.

I claim:

1. A bridge for a single-turn variable resistance device including a resistance element formed of a length of helically coiled resistance wire having its axis disposed in a substantially closed loop with the ends of said coiled wire in closely spaced juxtaposition, a movable electrical wiper mounted to traverse a closed path around said resistance element thereby to successively engage adjacent turns of said resistance wire, electrically conductive members connected to said resistance wire at electrical contact points a predetermined distance from the ends thereof, said bridge comprising a plurality of turns of resistance wire between each electrical contact and the respective end of said resistance wire, at least one of said turns being severed in a region out of the path of engagement between said resistance wire and said wiper, said severed turns forming a non-conductive coiled section having an arcuate length greater than the contact length of said wiper.

2. A bridge for a single-turn variable resistance device including a resistance element formed of a non-conductive mandrel and resistance wire helically coiled therearound at a predetermined pitch, said resistance element being contained within the variable resistance device with the ends of the mandrel juxtaposed and spaced not greater than the pitch of said resistance wire coils, a movable wiper mounted to traverse a closed path around said helically coiled resistance wire thereby to successively engage adjacent coils of said resistance wire, terminal leads connected to said resistance wire a predetermined distance from each end of said mandrel, said bridge comprising a plurality of coils of resistance wire between each connection of a terminal lead and the respective end of said mandrel, at least one of said coils being severed in a region out of the path of engagement between said resistance wire and said wiper, said severed turns forming a non-conductive coil section having an arcuate length greater than the contact length of said wiper.

3. A bridge for a single-turn variable resistance device including a resistance element formed of a non-conductive mandrel and a resistance wire coiled therearound at a predetermined pitch, said resistance element being contained within the variable resistance device with the ends of the mandrel juxtaposed and spaced not greater than the pitch of said resistance wire coils, a movable wiper mounted to traverse a closed path around said coiled resistance wire thereby to successively engage adjacent coils of said resistance wire, insulation covering a substantial portion of said coiled resistance wire with the

exception of said path traversed by said wiper, terminal leads connected to said resistance wire a predetermined distance from each end of said mandrel, said bridge comprising means for providing a dead space in said coiled resistance wire between the connection of each terminal lead and said respective ends of said mandrel comprising a plurality of coils of resistance wire in said space severed in a region covered by said insulation, said insulation retaining said severed coils in position.

4. A variable resistance device comprising a resistance element having closely spaced juxtaposed ends, a plurality of helically wound coils of resistance wire located in the portions of the resistance element adjacent said ends, an electrically conductive wiper mounted to traverse a closed path around said resistance element and said coils of said resistance wire located in the portions of the element adjacent said ends, terminal leads electrically connected to said resistance element, means for providing a dead space in the resistance element between the points of connection of said terminal leads comprising respective open circuited coils of said resistance wire between the points of connection of said terminal leads, said open circuited coils being of an arcuate length greater than the contact length of said wiper and forming a path for said electrical wiper between the points of connection of said terminal leads.

5. A bridge for a variable resistance device comprising a resistance element having closely spaced juxtaposed ends, a movable electrical wiper mounted to contact said electrical resistance element and to traverse a closed path therearound, electrical contacts connected to the resistance elements at points a predetermined distance from the ends thereof, and a plurality of helically wound coils of resistance wire between each electrical contact and the respective end of the resistance element, a plurality of said turns being severed in a region out of the path of engagement between said resistance wire and said wiper, said severed turns forming a non-conductive coiled section having an arcuate length between each electrical contact greater than the contact length of said wiper.

6. In a variable resistance device, a resistance element comprising a coil of resistance wire wound along essentially the entire length of a mandrel which extends in circular circumference through substantially 360°, terminal members electrically connected to said coiled resistance wire for connecting said resistance element into an electrical circuit and a wiper adapted to engage said coil of resistance wire, said coil having sufficient adjacent turns thereof severed between said terminal members to provide a section of said coil of arcuate length greater than the contact length of said wiper disconnected from the remainder of said coil.

7. In a potentiometer of the continuous rotation type: an electrical resistance coil having a plurality of turns; a toroidal insulating member for supporting said coil; two terminals electrically connected to said coil at two respective points thereof; said coil having a first portion having turns which are cut out over a part of their length and a second portion having complete turns, said first portion being located in the space between said two points, the cut-out turns individually adhering on said insulating member, whereas the complete turns are spirally wound on said insulating member; a contact member in sliding relationship with each of said cut-out and complete turns successively, whereby an electrical connection is established between said contact member and said complete turns, while the cut-out turns cooperate with said contact member for ensuring the mechanical passage thereof.

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