Feb. 26, 1935. G. F. BENKELMAN 1,992,410

ELECTRICAL CONTROL UNIT AND METHOD OF MAKING SAME

Filed Dec. 23, 1932 2 Sheets-Sheet 1

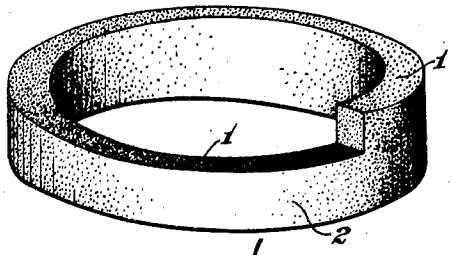


Fig. 1

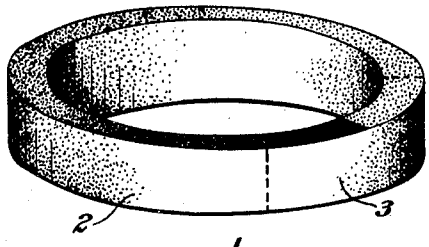


Fig. 2

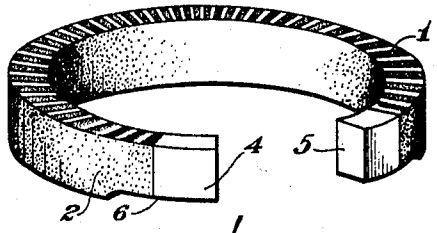


Fig. 3

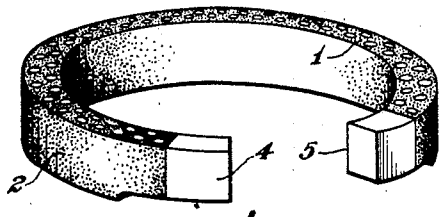


Fig. 4

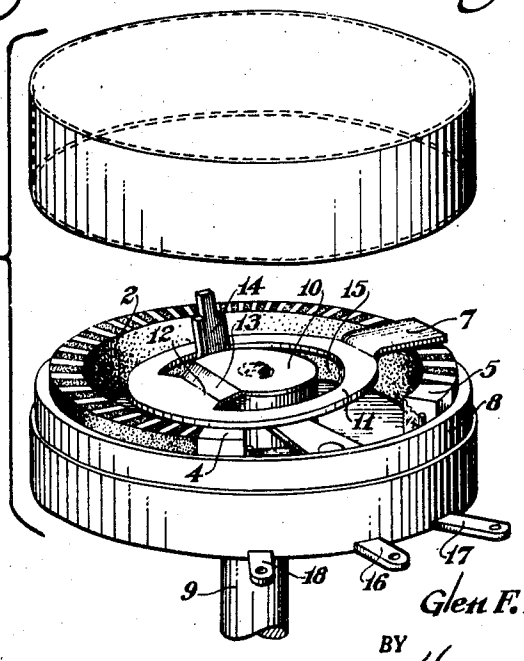


Fig. 5

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ELECTRICAL CONTROL UNIT AND METHOD OF MAKING SAME

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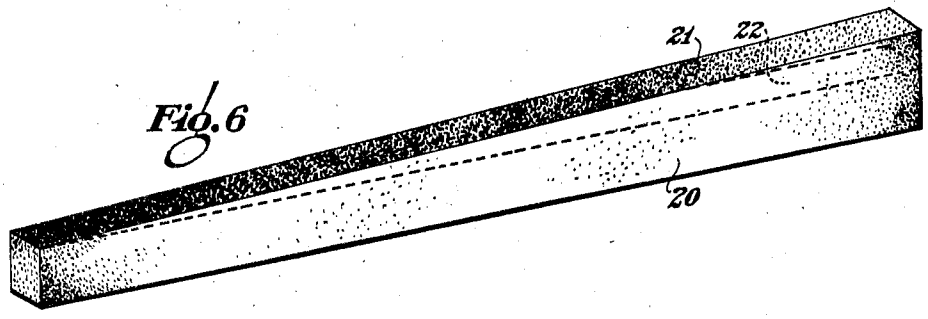


Fig. 6

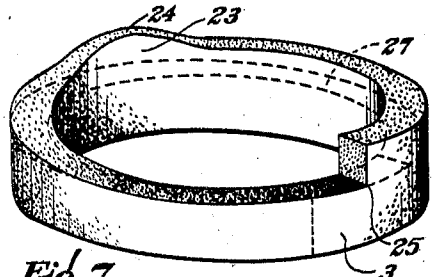


Fig. 7

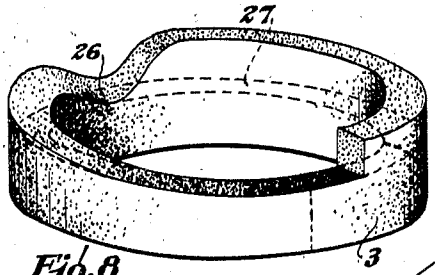


Fig. 8

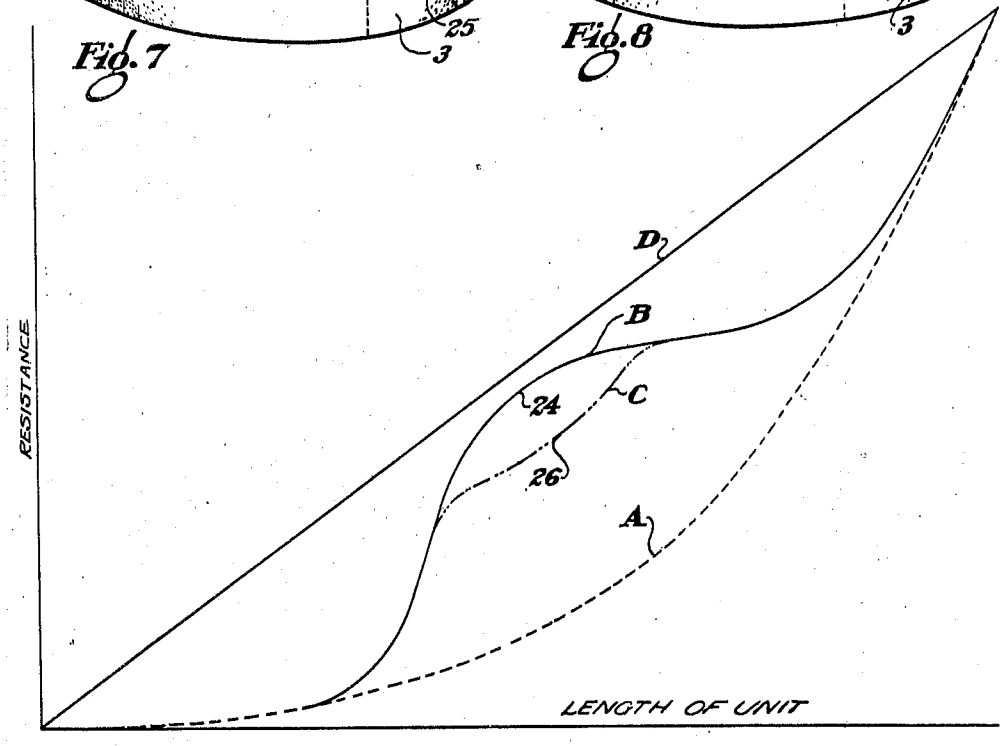


Fig. 9

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Patented Feb. 26, 1935 1,992,410

UNITED STATES PATENT OFFICE

1,992,410

ELECTRICAL CONTROL UNIT AND METHOD OF MAKING SAME

Glen F. Benkelman, Lakewood, Ohio, assignor to Continental Carbon, Inc., Cleveland, Ohio, a corporation of Ohio

Application December 23, 1932, Serial No. 648,543

8 Claims. (Cl. 201—60)

My invention is an improvement in electrical control units and method of making the same, and relates more particularly to variable resistance units.

Heretofore, it has been the common practice to provide rheostats, potentiometers or other similar electrical control devices with a variable resistance unit in the form of a coil of resistance wire helically wound on an insulated ring or other support. In such devices, numerous difficulties have been experienced, such as creating noise in circuits in which they are used, lack of uniform variation in resistance throughout the range of operation of the device, and general poor efficiency in operation.

It is one of the objects of my invention to overcome such difficulties and to produce a control unit which is highly efficient in operation.

Another object of my invention is to construct a variable resistance unit in which the density of the material of the unit is varied from one extreme to the other throughout the greatest dimension of the unit.

A further object of my invention resides in producing a variable resistance unit by varying the density of the material of the unit in the process of manufacture, whereby the greatest dimension of the unit will be less per ratio of resistance than a corresponding unit of substantially the same ratio of resistance in which the density of the material is substantially uniform throughout.

A still further object of my invention resides in constructing a variable resistance unit of the above-named character, in which the material of the unit comprises an intimate mixture of an electrical conducting material and a non-conductor and binder molded to suitable form and in which the density of the mixture may progress to a predetermined maximum throughout the greatest dimension of the unit.

Another object of the invention consists in the simplicity of construction, ease of manufacture and inexpensiveness of the device, and in the method of making the same.

Other objects and advantages of my invention will more clearly appear from the following description of several embodiments thereof, reference being made to the accompanying drawings in which like reference characters are employed to designate like parts throughout the same.

In the drawings:

Fig. 1 is a perspective view of one embodiment of my invention, illustrating the resistance unit as it comes from the mold, and before the contact face is reduced to lie in a single plane.

Fig. 2 is a view similar to that shown in Fig. 1, and shows the second step in the method of manufacture, wherein the contact face is reduced.

Fig. 3 is a view similar to those in Figs. 1 and 2 and illustrates another step in the process of manufacture, that is, wherein the unit is severed and adapted to be suitably mounted in a support.

Fig. 4 is a view similar to that shown in Fig. 3 and illustrates a second embodiment of my invention.

Fig. 5 illustrates either embodiment mounted in its support and ready for use. In this figure, I have shown a cover for the device which may be applied in use.

Fig. 6 is a perspective view of another embodiment of my invention in which the resistance unit is illustrated as being in the form of a bar or rod and shows the same before the contacting surface has been reduced.

Fig. 7 is a perspective view of still another embodiment of my invention which is similar in many respects to that form shown in Fig. 1, except that the variation in density of the material in the present embodiment is not uniformly varied throughout the greatest dimension of the unit.

Fig. 8 is a view similar to that shown in connection with the embodiment in Fig. 7, but shows a slight variation in the densities of the material throughout the greatest dimension of the unit, and

Fig. 9 is a graphic view of the resistance curves of the units shown in Figs. 1 to 6 inclusive, represented by the curve A; Fig. 7 is represented by the curve B; and Fig. 8 is represented by the curve C.

In carrying out my invention, I will first describe a simple method or process of its manufacture. The embodiments of my invention illustrated in the drawings are ring-like in form, although it is to be understood that my invention is equally well applied to resistance units in other forms if desired, such as rods, bars or tubes extending more or less along a single longitudinal axis.

One method of constructing my invention consists in first intimately mixing together proper predetermined proportions of conductor and non-conductor materials with a suitable binder. A typical resistance composition may consist of 3% graphite, 22%phenol formaldehyde resin and 75% fine silica in approximately those propor-

tions. The mixture is then subjected to pressure and heat, if necessary, so that in molding the unit in ring-like form, the density of the particles of the mixture throughout the extent of the ring is progressively varied from a given starting point on the annulus. One way of accomplishing this which I have found highly satisfactory, is to employ a male die having a helically arranged material pressing face. It will be seen that when such a die is pressed against the material in the mold it will press the particles into intimate contact at one point of the unit and will gradually diminish the density thereof in cross sectional area along the ring at progressive points throughout the remainder of the ring. In other words, the density of the particles will be gradually varied from a maximum to a minimum, or vice versa, about the complete periphery of the ring or unit.

The next step consists in reducing the helically disposed face 1 of the ring 2 so that the said face will lie in a substantially single plane throughout its extent, as illustrated in Fig. 2. This may be done in any suitable manner, as by grinding the upper surface 1 down to a uniform ring thickness.

The next step in carrying out this method of manufacture consists in removing a section, 3, of the ring located at and including the maximum and minimum densities of the compressed mixture. This step is illustrated in Figs. 3, 4 and 5.

The ring-like unit is then ready for properly forming its terminals 4 and 5, as shown in Fig. 3. The terminal ends of the ring may be under cut at 6, if desired. The unit is now ready to be mounted in any suitable support or housing, a movable contact 7 being provided for purposes which will be more fully described hereinafter.

It will thus be seen that by my invention I have not only produced an inexpensive and efficient method of manufacturing variable resistance units, but that the unit itself has many novel features which eliminate many of the difficulties heretofore encountered with such devices.

It has been the common practice in making variable resistance units or controls to helically wind a wire having desirable resistance characteristics upon an annular core of insulating material. The convolutions, while being close together, must of necessity be spaced from each other on the core. In such devices employing a contact arm movable over the convolutions, it becomes necessary to cut out one or more convolutions at a time as the contact is moved. It is therefore evident that the resistance control in a circuit in which the device is connected cannot be as finely adjusted as where the contact moves over a continuous conducting surface, as distinguished from an interrupted conductor surface. Circuits employing these prior art devices are necessarily noisy due to the make and break operation of the contact over the wound resistance element.

In my invention I have produced a resistance element which presents a continuous conductor surface to the movable contact, although the conductivity of the surface throughout the extent thereof is uniformly varied from a maximum to a minimum, or vice versa. As I have stated hereinbefore, I accomplish this desired condition by progressively varying the density of the mixture comprising the element.

In Fig. 3 I have illustrated one type of unit having a number of relatively highly conductive portions along the contact surface of the unit. These portions can be in the form of inserts or may be applied by spraying metal thereon over a stencil, the portions being arranged to lie at an angle to the radii of the ring so that the movable contact will at all times engage at least two adjacent contact portions. In Fig. 4 I have shown a still different arrangement wherein these portions may be in the form of small discs arranged in a somewhat staggered relationship.

In assembling the unit, it may be seated in a suitable housing or support 8 composed of insulating material. This housing is provided with an axial opening for receiving the shaft 9 which carries an operating knob (not shown) on one end and the movable contact on its other end. In the embodiment shown in Fig. 5, the contact member 7 includes a hub 10 secured to the shaft 9. The contact arm 7, however, is carried primarily by a ring-like member 11 spaced from the hub, except at a point defined by the web or stop 12. This web may be bent, as shown at 13, to impart a slight tension to the arm 7. A stop 14 projects through the opening 15 between the members 10 and 11 and is engageable by opposite sides of the web 12 as the contact 7 is moved from one extreme position to the other. Suitable lugs 16 and 17 connecting with the movable contact 7 and with one end 5 of the resistance unit, respectively, may be used when the device is used as a rheostat, and a lug 18 may be connected to the other end of the unit when the device is to be used as a potentiometer.

Although I have illustrated in the drawings resistance units of ring-like form, it is to be understood that my invention may be equally well employed in making resistance units in straight bar or rod form in which the density of the material of the unit is uniformly varied from one extreme to the other throughout the length of the bar or rod.

In Fig. 6 I have illustrated an embodiment of my invention in which the unit is in the form of a bar or rod 20, in which the density of the material thereof progresses or is graduated throughout the length of the rod or bar. In constructing this type of resistance unit, the upper surface of the portion represented at 21 lies in a plane inclined to that in which the longitudinal axis of the unit lies. The portion 21 is removed, as by grinding, to present a contact face 22 which lies in a plane substantially parallel to the axis of the rod or bar. In this form of the invention, a movable contact may be caused to engage the upper finished surface 22 and moved therealong as desired, and the portions of the rod to the right in Fig. 6, being less dense in composition, will be of a higher resistance than corresponding portions to the left in Fig. 6 where the material of the rod is more dense, and therefore the particles composing the material are in more intimate contact with each other.

In Figures 7 and 8 I have illustrated still another embodiment of my invention, in which the unit is shown as being substantially ring-like in form and in which the density of the material of the unit is non-uniformly varied throughout the annulus. For instance, in Figure 7, a portion of the ring at 23 represents a section in which the density of the material is suddenly decreased to a point 24 in either direction. I have shown this portion 23 in relation to other portions of the ring in Figure 7 substantially opposite the point on the ring identified at 25, although it is to be understood that any irregularity in the

density of the material, such as the section 23, may be provided at any point desired on the unit, and that a plurality of these irregularities may be employed if desired.

In Figure 8 I have illustrated a section 26 which represents a portion in which the density of the material is suddenly increased. This portion of the ring may likewise be located at any point about the periphery of the ring and, if desired, a plurality of these increased density portions may be employed. In connection with Figure 8, however, where a decidedly increased density of the material is desired in any portion of the ring, it may be necessary to make the overall depth of the ring greater than that shown in Figure 7.

It is to be understood that in carrying out my invention, various arrangements of densities of the material may be employed, it simply being necessary to apply pressure to the material during its process of manufacture, and in degree according to the predetermined requirements of variation in resistance desired in the unit.

In each instance, the upper surface of the ring, which of necessity does not lie in a single plane, may be reduced to present a uniform contacting surface lying in a single plane, as illustrated at 27. When the unit is finished to this extent, a section 3 may be removed to permit the ring to be mounted in a suitable support.

In Figure 9 the curve A represents the resistance curve of a unit such as is illustrated in Figures 1 to 6, wherein the density of the material of the unit diminishes and the resistance of the unit increases uniformly throughout the greatest dimension of the unit. Curve B represents the resistance curve of a unit in which the density of the material is gradually decreased from a maximum for a given distance along the unit and is then suddenly further decreased to a point indicated at 24, whereupon the density again is suddenly increased and proceeds from that point on gradually to a minimum density. Curve C in Figure 9 represents the resistance curve of a unit similar to that shown in Figure 8, whereas curve D represents the resistance characteristic in a unit having a uniform density throughout its length.

In the graph, Figure 9, the ordinate represents resistance in ohms, while the abscissa represents the total distance traveled by the contact 7.

Various changes may be made in the details of construction and arrangement of parts without departing from the spirit of my invention or the scope of the appended claims.

Having thus described my invention, I claim:

1. The method of making an electrical resistance unit for control devices which consists in forming the unit to shape and simultaneously applying a pressure to the material of the unit in which said pressure is varied from one point throughout the extent of the unit to impart a continuously varied cross sectional density to the unit material, whereby the electrical resistance of the unit is varied throughout the extent of the unit.

2. The method of making an electrical resistance unit for control devices which consists in shaping the unit into a ring-like form and simultaneously applying pressure to the material of the unit in a progressive manner from one point and throughout the extent of the ring-like form to impart a continuous and uniform progressively varied density to the material of the unit, whereby the electrical resistance of the unit is gradually varied from a maximum to a minimum throughout its extent.

3. As a new article of manufacture, a variable resistance unit formed of a mixture of materials in which the ratio of the ingredients is constant, said unit characterized by the fact that the density of the material of the unit is uniformly and continuously varied throughout the extent thereof.

4. As a new article of manufacture, a variable resistance unit formed of a mixture of materials in which the ratio of the ingredients is constant, said unit characterized by the fact that the density of the material of the unit is continuously and progressively varied throughout the extent thereof.

5. As a new article of manufacture, a variable resistance unit formed of a mixture of materials in which the ratio of the ingredients is constant, said unit characterized by the fact that the density of the material of the unit is uniformly and progressively varied continuously from a minimum at one point of the unit to a maximum at another point thereof.

6. A resistance unit including an intimate mixture of conducting and non-conducting materials in constant ratio, the density of the said mixture being progressively and uniformly varied from one point on the unit to another point on said unit.

7. The method of making an electrical resistance unit for control devices which consists in shaping the unit into a continuous ring-like form and simultaneously applying pressure to the material of the unit in a progressive manner from one point and throughout the extent of the ring-like form to impart a continuous and uniform progressively varied density to the material of the unit, whereby the electrical resistance of the unit is varied from a maximum to a minimum throughout its extent.

8. The method of making an electrical resistance unit for control devices which consists in shaping the unit into a ring-like form and simultaneously applying pressure to the material of the unit in a progressive manner from one point and throughout the extent of the ring-like form to impart a continuous and uniform progressively varied density to the material of the unit, whereby the electrical resistance of the unit is gradually varied from a maximum to a minimum throughout its extent, and subsequently removing a portion of the ring-like form to provide an open circuit conductor.

GLEN F. BENKELMAN.