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2,382,024

RESISTORS AND METHODS OF MAKING THEM

Filed April 24, 1943

FIG. 1

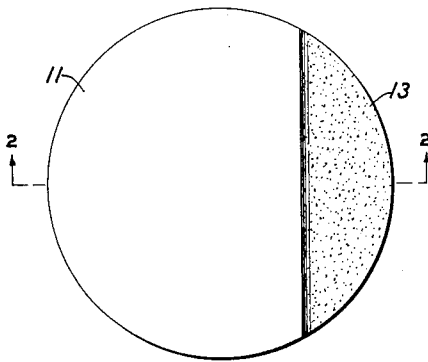


FIG. 3

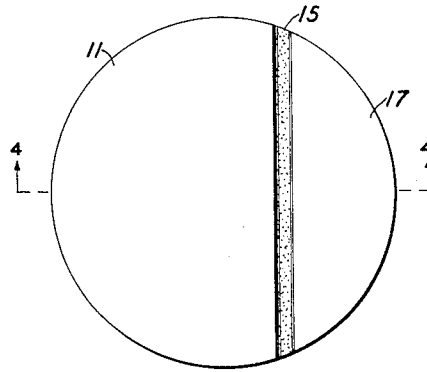


FIG. 2

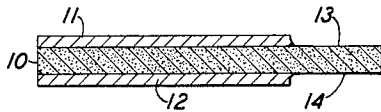


FIG. 4

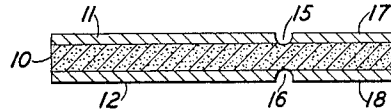


FIG. 5

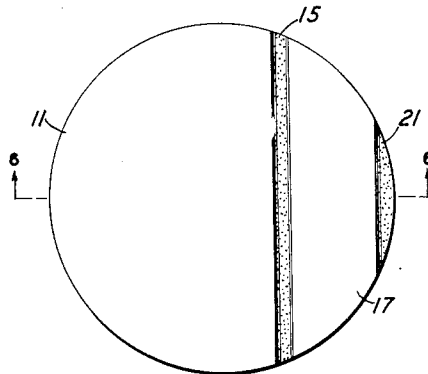
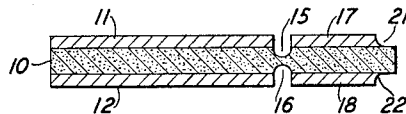


FIG. 6



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RESISTOR AND METHOD OF MAKING IT

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6 Claims. (Cl. 201—63)

The invention herein disclosed pertains to resistors and more particularly to a method of initially adjusting the resistances thereof to desired values, with a high degree of accuracy.

In the making of resistors, particularly those of the disc or plate type, having adherent contacts on opposite faces, difficulties have been encountered in obtaining prescribed values of resistance to the desired degree of accuracy. In an attempt to overcome the foregoing difficulty, it has been the practice to make a resistor of a size and shape so that its resistance between adherent electrodes on opposite faces thereof is somewhat lower than that desired. Then the over-all resistance is increased by segregating corresponding portions of each electrode so that the resistance between the remaining portions is substantially that desired. This may be done by grinding off a segmental portion of the electrode on each face or by separating segmental portions from the main electrodes by grinding a groove across each face of the resistor. This technique is capable of producing resistors with reasonably accurate resistance values. It has been found, however, that very careful and accurate grinding is necessary to secure the requisite resistance within a reasonable per cent of the value desired. Such accurate grinding requires both time and skill.

It is an object of this invention to produce resistors, having highly accurate values of resistance, by an electrode removal or segregating technique similar to that previously described but including additional novel steps, whereby the exercise of a high degree of skill or the consumption of a great deal of time in the grinding operation are avoided.

A feature of this invention resides in adjusting the resistance of a disc or plate type resistor by first segregating like portions of each electrode from the main portion to obtain a resistance only slightly lower than the required resistance, and then removing a small amount of material from the segregated portion of each electrode to bring the resistance to substantially the desired value.

Other and further objects and features of this invention will appear more clearly and fully from the following description of an exemplary embodiment thereof taken in connection with the appended drawing in which:

Figs. 1 and 2 show respectively on an enlarged scale, a plan and sectional view of a disc resistor with segmental portions of the electrodes re-

moved in accordance with the known method previously described;

Figs. 3 and 4 show respectively also on an enlarged scale, similar views in which segmental portions of the electrodes are separated by means of grooves, also in accordance with the known method; and

Figs. 5 and 6 show respectively likewise on an enlarged scale, a plan and sectional view of a disc resistor which has been processed in accordance with the new method of this invention.

Referring first to Figs. 1 and 2, 10 is a disc of resistance material such as metal oxide, for example, one or more of the oxides of manganese, nickel, cobalt or copper. On each face of the disc are adherent electrodes 11 and 12 which may be of any suitable material having a relatively high conductivity, such as for example, silver. The electrodes are assumed to have originally extended over the portions of the disc designated by 13 and 14, these portions having been ground away or otherwise removed to adjust the resistance as near as possible to the proper value.

As depicted in Figs. 3 and 4, the resistance adjustment can also be made by grinding or otherwise forming grooves 15 and 16 across the faces of the disc to segregate respectively segment 17 from main electrode 11 and segment 18 from main electrode 12. By this expedient substantially similar results can be obtained to those obtained by the method which was applied to the device of Figs. 1 and 2.

As is obvious from an inspection of Figs. 1 and 2, the exterior electrical connections are made to the electrodes 11 and 12. In the device shown in Figs. 3 and 4, it is intended that the exterior connections also be made to the larger electrodes 11 and 12, since the disc 10 is ordinarily proportioned to have, before the grinding operation, a resistance only slightly lower than that required.

An inspection of Fig. 4 will reveal that with the connections made to electrodes 11 and 12, the over-all resistance of the device is made up of several increments. This over-all resistance comprises the resistance between the electrodes 11 and 12 shunted by the series combination of the resistances between 11 and 17, 17 and 18, 18 and 12. Because of the configuration of the device, the resistance in series is much higher than that between the electrodes 11 and 12 so that the over-all resistance is only slightly lower than that between said electrodes. As previously indicated considerable care and time is required to grind or otherwise remove portions of the elec-

trodes to obtain an over-all resistance that is within a relatively few per cent of that required. However, in accordance with this invention, the difficulty may be obviated by grinding small portions at 21 and 22 (Fig. 6) from the electrodes 17 and 18.

In order to attain a high degree of accuracy, the grooves 15 and 16 are adjusted as to orientation and depth so that the resistance between electrodes 11 and 17 and between 12 and 18 is in the order of several times that between the electrodes 17 and 18. Then when a small portion of the electrodes 17 and 18 is removed as at 21 and 22, the resistance between 17 and 18 is increased slightly. Because of the relative resistance values in the main and shunt circuits, this small change in resistance appears as a very small change in the overall resistance. A very high degree of accuracy of resistance adjustment can therefore be obtained by making the disc originally somewhat too low in resistance, then grinding grooves such as 15 and 16 to bring the resistance nearly up to the value desired and then by grinding at 21 and 22 to further increase the resistance in very small increments until the required resistance is very closely attained.

The method is not limited to grinding at the regions 21 and 22 but may be done on other portions of the electrodes 17 and 18. For example, if a higher degree of accuracy than is attainable by the old method is required, but the allowable accuracy is less than that attainable by the present method in its preferred form, the grinding may be done on 17 and 18 alongside of the grooves 15 and 16. Since it is desirable in the interest of accurate grinding to remove the material along the full length of the groove, the accuracy is obviously not as great as where the grinding is done on the outer periphery because more material is removed. By grinding at two places along parallel lines, it is a relatively simple matter to set up tables or charts of dimensions for grinding of a given size disc to a required resistance value.

This method is furthermore not limited to resistors of circular configuration, since other shapes may be employed and orientation of the areas of material removal adjusted accordingly.

For example, a plate comprising a rectangular center section with semicircular ends may be treated in about the same manner as the circular disc, the second grinding being made at the semicircular ends. If the resistors are in the form of rectangular plates, the second grinding might be made at the corners of the segregated electrodes preferably at an angle of 45 degrees for ease of calculation.

Although generally speaking the removal of the electrode and resistance material has been referred to in terms of grinding, it is believed obvious that other methods and means of removal may be used, for example, some cutting or scraping operation. Although grinding is ordinarily considered to be a more accurate method of removal, the new technique in accordance with this invention allows accurate adjustment with the use of less accurate methods of material removal.

Although this invention has been described by means of certain illustrative embodiments thereof, it is to be understood as not limited thereby but by the scope of the appended claims only.

What is claimed is:

1. A method of adjusting the resistance of a plate or disc type resistor having adherent conductive coatings substantially covering each face,

that comprises proportioning the resistor so that its resistance between coatings is somewhat lower than that required, separating each conductive coating into two portions, a portion of each coating corresponding in area, shape and orientation to the portion of the other coating directly opposite thereto, to provide two pairs of electrodes, whereby the effective resistance of the resistor, when connection is made to one of said pairs of electrodes, comprises the resistance between the electrodes of said pair, in parallel with the series combination of the resistance between the electrodes of the other pair and the resistance between the pairs, the separation being made so that the resistance between pairs is several times the resistance between the electrodes of said other pair, said effective resistance being slightly lower than that required, and then increasing the effective resistance slightly by removing a portion of each of said other electrodes.

2. The method of accurately obtaining a desired value of resistance in a disc or plate type resistor having adherent conductive electrodes substantially covering each face, that comprises proportioning the resistor to have a slightly lower resistance than is desired, dividing each conductive coating into corresponding pairs of main and auxiliary electrodes, the relative size and shape of each pair of electrodes being such that when connection is made to the main electrodes the resistance is slightly lower than that desired, and then removing small portions from the auxiliary electrodes to raise the resistance to substantially that desired, the resistance between the main and auxiliary electrodes being several times higher than the resistance between the auxiliary electrodes.

3. The method of accurately adjusting the initial resistance of a disc type resistor having adherent conductive coatings covering opposite faces thereof that comprises initially proportioning the resistor to have a slightly lower resistance than that desired, segregating a corresponding, small segment of each coating from the main portion thereof, to which electrical connection is to be made, the size of the segmental portion being such that the over-all resistance of the device when connection is made to the main electrodes is still slightly lower than that desired, and then removing corresponding small portions from the segregated segments adjacent the edge of the disc until the over-all resistance is substantially that desired.

4. A resistor comprising a disc of resistance material, adherent conductive coatings on opposite faces of said disc, a pair of corresponding grooves extending across each face of the disc and dividing the adherent conductive coatings into a pair of main and a pair of auxiliary electrodes, the effective resistance of the resistor when connection is made to said main electrodes comprising the resistance between said electrodes in parallel with the series combination of the resistance between the auxiliary electrodes and the resistance between the electrode pairs, the resistance between the pairs of electrodes being several times the resistance between the electrodes of the auxiliary pair.

5. A resistor comprising a disc of resistance material having adherent conductive coatings substantially covering each face thereof, a pair of corresponding grooves across each face of said disc separating each conductive coating into two portions, a portion of each coating corresponding in area, shape and orientation to the portion of

the other coating directly opposite thereto, to provide two pairs of electrodes, whereby the effective resistance of the resistor when connection is made to one of said pairs of electrodes comprises the resistance between the electrodes of said pair, in parallel with the series combination of the resistance between the electrodes of the other pair and the resistance between the pairs, the resistance between the pairs being in the order of several times the resistance between the electrodes of said other pair.

6. The method of adjusting the resistance of a disc type resistor having adherent conductive coatings substantially covering each face, that comprises proportioning the resistor so that its resistance is lower than that required, grinding a groove across each face of the resistor to separate each conductive coating into two portions, a por-

tion of each coating corresponding in area, shape and orientation to the portion of the other coating directly opposite thereto, to provide two pairs of electrodes whereby the effective resistance of the resistor when connection is made to one of said pairs of electrodes comprises the resistance between the electrodes of said pair, in parallel with the series combination of the resistance between the electrodes of the other pair and the resistance between the pairs, the resistance between pairs being several times the resistance between the electrodes of said other pair, said effective resistance being slightly lower than that required, and then increasing the effective resistance slightly by grinding off a small portion of each of said other electrodes.

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