Nov. 29, 1932. S. RUBEN 1,889,379

METHOD OF MAKING AN ELECTRICAL RESISTANCE ELEMENT

Filed April 1, 1931

FIG.1.

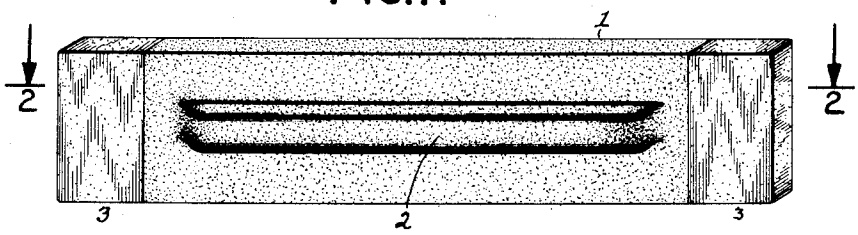


FIG.2.

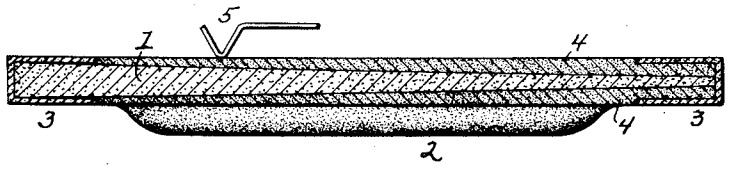
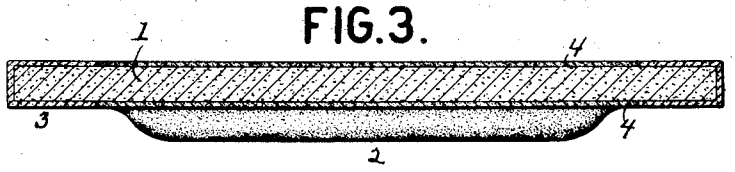


FIG.3.



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UNITED STATES PATENT OFFICE

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METHOD OF MAKING AN ELECTRICAL RESISTANCE ELEMENT

Application filed April 1, 1931. Serial No. 526,894.

This invention relates to a method of making an electrical resistance element. It is an improvement upon the devices and methods described in my prior and co-pending applications 486,698, filed October 6, 1930, and 513,083, filed February 3, 1931. The object of this invention is the provision of a resistance element capable of withstanding overloading and adapted to commercial production according to definite values at low cost.

Broadly, my invention consists of a method of making a resistance element composed of a vitreous mass of cuprous oxide as a base, preferably a ribbed plate, the surface of which is converted into a more conductive copper compound, such as cupric sulphide, with the terminal surface areas re-converted into copper as a surface layer. For fixed resistances the low resistance or cupric sulphide layer is of uniform thickness; but if the unit is to be employed to yield varying resistances by the movement of a contact along the surface, the layer may be of increasing depth.

I have found that cupric sulphide and cupric selenide have temperature resistance coefficients of negligible value. Such a material is employed to advantage in preparing the unit according to the following method: The plate or base is preferably made by heating a copper body to about 1030° C. until completely converted into cuprous oxide, and cleansed in a solution of hydrochloric and nitric acids to remove any cupric oxide or other extraneous coating. The plate is then preferably, though not necessarily, dipped into a two per cent. solution of phosphoric acid to present a very thin surface layer of copper, thereby reducing the surface resistance of the element, after which it is coated with a layer of dry sulphur or coated with sulphur by immersion in a solution of carbon bi-sulphide or potassium sulphide containing free sulphur. When the unit is coated with sulphur directly or after immersion, it is heated, as by the discharge of current, the reaction between the sulphur and the cuprous oxide base yielding the more conductive cupric sulphide layer, until the desired resistance is attained as indicated by a meter in an electric circuit with the element. When the proper resistance value has been reached, the heating is discontinued and the unit cleansed to remove any uncombined or excess sulphur, this being essential to prevent further reaction and reduction of resistance in operation. Because of the negligible temperature resistance co-efficient of cupric sulphide, the resistance reading is substantially the same when the unit is cooled. By so converting the cuprous oxide surface, the change of resistance values is radical, the degree depending upon the thickness of the layer so converted. For instance, the resistance of a unit may be brought in this way from 50,000 ohms to 1 ohm. To obtain a variable resistance unit, various areas or sections of the element may be exposed to increasing temperatures over periods of different lengths, or with varying densities of sulphur on the surface. For terminal contact areas an agent which suitably reacts with the cuprous oxide and cupric sulphide should be applied thereto to yield a surface of copper metal. One method by which this is accomplished is by so applying a solution of zinc dust in sodium hydroxide. In this way any desired degree of thickness of copper metal is quickly obtained.

While the sulphiding of the cuprous oxide is desirable because of the resulting stability of resistance values and the low cost of production, the cuprous oxide surface may be selenided to yield the lower resistance. For such application the unit is immersed in a solution of selenium in carbon disulphide, or in potassium selenide, the treatment of the unit thereafter being the same as that described above. Reference is made to the accompanying drawing of an embodiment of the invention in which

Fig. 1 is a perspective view of a resistance element, Fig. 2 a sectional view of the element at 2—2, as a variable resistance and Fig. 3 a like sectional view of a fixed resistance element.

Referring more particularly to the drawing 1 represents a resistance element of cuprous oxide base having a rib 2, and two contact areas of copper, 3. The sulphide layer is represented by 4, increasing in thick-

ness along the length in Fig. 2, a movable contact being at 5. The layer 4 is of uniform thickness in Fig. 3.

What I claim is:

1. The method of making a resistance element which consists in heating a copper body in an oxidizing atmosphere until it is converted into a vitreous mass of cuprous oxide, applying to the element a solution of phosphoric acid, coating the surface with sulphur and converting a portion of the cuprous oxide element into cupric sulphide by heat, and cooling said element when a predetermined resistance value is reached.

2. The method of making a resistance element which consists in heating a copper body in an oxidizing atmosphere until it is converted into a vitreous mass of cuprous oxide, applying to the element a solution of phosphoric acid, coating the surface with sulphur and converting a portion of the cuprous oxide element into cupric sulphide by heat, cooling said element when a predetermined resistance value is reached, and reconverting a portion of the surface of said element into copper metal.

3. The method of making a resistance element which consists in heating a copper body in an oxidizing atmosphere until it is converted into a vitreous mass of cuprous oxide, applying to the element a solution of phosphoric acid, coating the surface with sulphur and converting a portion of the cuprous oxide body into cupric sulphide by heat, cooling said element when a predetermined resistance value of the element is reached and reconverting a portion of the surface of the element into copper metal by contact with a solution of sodium hydroxide and zinc.

4. The method of making a resistance element which consists in heating a copper body in an oxidizing atmosphere until it is converted into a vitreous mass of cuprous oxide, applying to the element a solution adapted to reconvert cuprous oxide into copper metal, coating the surface with sulphur and converting a portion of the cuprous oxide element into cupric sulphide by heat, and cooling said body when a predetermined resistance value of the element is reached.

5. The method of making a resistance element which consists in heating a copper body in an oxidizing atmosphere until it is converted into a vitreous mass of cuprous oxide, applying to the element a solution adapted to reconvert cuprous oxide into copper metal, coating the surface with sulphur and converting a portion of the cuprous oxide element into cupric sulphide by heat, cooling said element when a predetermined resistance value of the element is reached, and reconverting a portion of the surface of said element into copper metal.

6. The method of making a resistance element which consists in heating a copper body in an oxidizing atmosphere until it is converted into a vitreous mass of cuprous oxide, applying to the element a solution adapted to reconvert the cuprous oxide into copper metal, coating the surface with sulphur and converting a portion of the cuprous oxide element into cupric sulphide by heat, cooling said element when a predetermined fixed resistance value of the element is reached, and reconverting a portion of the surface of said element into copper metal by contact with a solution of sodium hydroxide and zinc.

7. The method of making a resistance element which consists in heating a copper body in an oxidizing atmosphere until it is converted into a vitreous mass of cuprous oxide, applying to the element a solution of phosphoric acid, coating the surface with sulphur by immersing said body in a solution of free sulphur in carbon bi-sulphide, converting a portion of the cuprous oxide element into cupric sulphide by heat, and cooling said element when a predetermined resistance value of the element is reached.

8. The method of making a resistance element which consists in heating a copper body in an oxidizing atmosphere until it is converted into a vitreous mass of cuprous oxide, applying to the element a solution of phosphoric acid, coating the surface with sulphur by immersing said element in a solution of free sulphur in carbon bi-sulphide, converting a portion of the cuprous oxide element into cupric sulphide by heat, cooling said element when a predetermined resistance value of the element is reached, and reconverting a portion of the surface of said element into copper metal.

Signed at New York in the county of New York and State of New York this 25th day of March A. D. 1931.

SAMUEL RUBEN.