April 8, 1947. E. BUEHLER 2,418,460

RESISTOR

Filed Dec. 31, 1943

FIG. 1

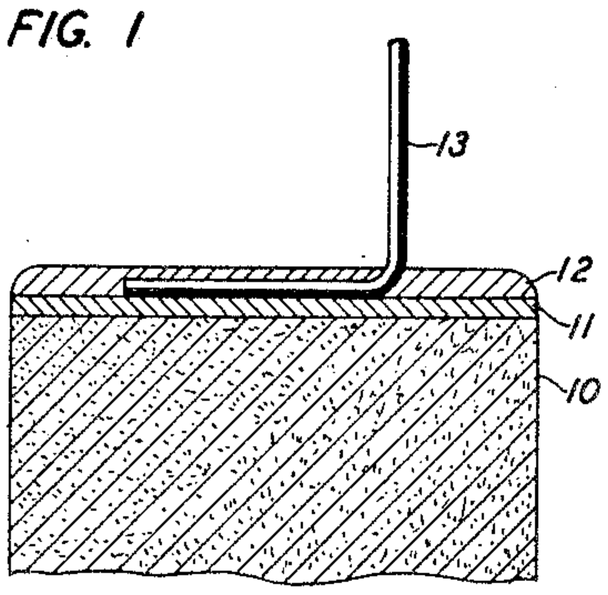
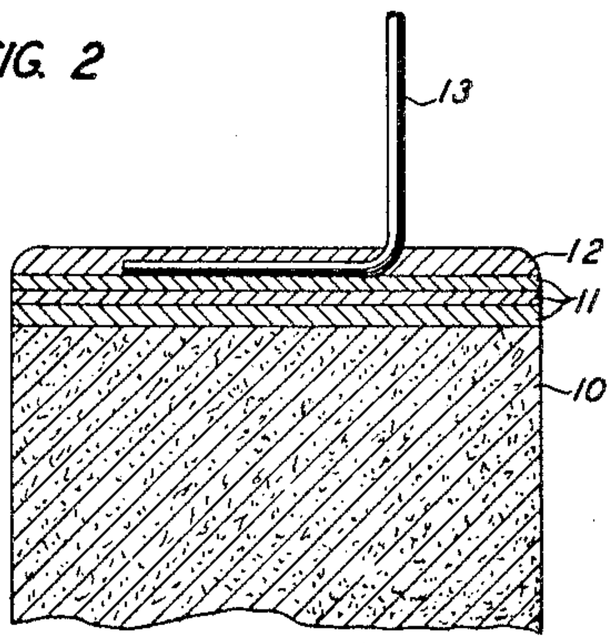


FIG. 2



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RESISTOR

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6 Claims. (Cl. 201—63)

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This invention relates to resistors and more particularly to the making of electrical connections to resistor bodies.

The problem of making connections to resistor bodies has many ramifications, depending, among other things, upon the material of the resistor body and that of the contact or connecting means; the temperature at which the device is to be operated; the particular circuit use to be made of the resistor and other varied factors. The present invention involves making connections to resistor bodies of non-metallic material with suitable metallic material or materials.

In many cases an electrical connection to a resistor is adequate if it will pass current into or out of said resistor in sufficient quantity without overheating. In many instances, however, the current passing through the resistor is variable and the pattern of its variations is of the essence in the circuit, where the resistor is employed. In such cases it is important that no additional variation of the current be caused at the junction between the resistor body and its connecting means. For example, in carrier telephone systems, there are employed resistors, the resistance of which varies greatly with changes in temperature, which resistors have come to be known as "thermistors," which is an abbreviation of "thermally sensitive resistor." These thermistors are often made from bodies of metal oxide material with metallic connectors attached thereto. Unless suitable precautions are taken, unwanted variations of resistance may occur at the junctions between the resistor bodies and the metallic connections. This results in small but detrimental variations in current. These unwanted variations or "noise" may take the form of extraneous modulations or variations such as are made by a granular resistance microphone and which have been called microphonic noise.

It is an object of this invention to so make connections to resistor bodies, that the previously noted unwanted current variations are avoided or greatly inhibited.

A feature of this invention resides in a multiportion connection, one portion of which makes substantially "noiseless" contact with a resistor body and another portion of which ruggedly secures a connecting lead in place.

Another feature of this invention involves a coating of metallic material making intimate contact with a resistor body and having a thermal coefficient of expansion substantially the same as that of said body.

Other and further objects and features of this

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invention will be more fully and clearly understood from the following detailed description of exemplary embodiments thereof taken in connection with the appended drawings in which:

Fig. 1 is a sectional view of a resistor illustrating one embodiment of the invention; and

Fig. 2 is also a sectional view of a resistor disclosing another illustrative embodiment of the invention.

In Fig. 1, 10 is a part of a body of resistance material, for example, one end of a cylinder or pellet of suitable metal oxide material. An adherent layer of metal 11 is firmly secured to one surface of the resistance material 10. Another adherent metallic layer 12 secures the lead or connecting means 13 to the resistor body. The material of the layer 11 should have a thermal coefficient of expansion approximately the same as that of the resistance material 10.

When the material 10 comprises metallic oxide such as one or more of the oxides of manganese, nickel, cobalt, and copper, a suitable material for the layer 11 is platinum.

In applying this type of contact to a resistor body, for example, to the end of a cylinder of resistance material, comprising oxides of manganese and nickel, the end of the cylinder is ground or otherwise made relatively smooth and plane. A layer of a liquid material containing platinum, or convertible into platinum, is applied to the smooth surface. This material may be platinum chloride mixed with an essential oil such as oil of Rosemary or Lavender and may contain a small amount of a fluxing material such as glass. The material is allowed to dry and then is subjected to a sufficiently elevated temperature to convert the platinum chloride into metallic platinum. This temperature may be between 400° and 800° C. depending upon the resistance material being used. The temperature must not be high enough to cause any change in the resistance material.

The lead or conductor 13 may now be secured to the end of the cylinder by means of the adherent metallic layer 12. The layer 12 may, when applied, comprise a metallic paste such as colloidal silver in a suitable vehicle. The lead 13 may be inserted in the paste or the paste may be applied over the lead and heat applied to form the solid metallic layer 12.

It has been found that the platinum-silver connection above described, although satisfactory for many purposes, does give more "noise" than is desirable for certain installations. This "noise" condition appears to be due to some interaction

between the silver and platinum layers, which apparently pulls portions of the platinum layer a very minute distance away from the surface of the resistor body 10. It has been found that this difficulty may be avoided in necessary situations by applying a plurality of layers 11 of platinum material to the end of the body 10 before applying the silver layer 12, as illustrated in Fig. 2.

In Fig. 2 three layers 11 are shown for illustrative purposes, although two may be sufficient in some cases and more than three may be necessary in others. It appears that in this modification, any interaction between the silver and platinum is limited to the upper layer of platinum and does not affect the layer in contact with the resistance material. If any voids appear between the platinum layers due to the action of the silver layer 12, they do not contribute to the connector "noise." A possible explanation as to why the connection is "noisy" in the one case and not in the other is based on the present generally accepted theory of the dry rectifier. According to this theory if a conductor and a semiconductor are separated by a suitable thin layer of insulation, the conduction across this junction is much greater in one direction than in the other. In the device under consideration, the material 10 is a semiconductor, the adjacent layer 11 is the conductor and the voids therebetween, if any, would be the layer of insulation. Apparently a layer of insulation between two like conductors does not give rectification.

Although this invention has been disclosed by means of illustrative embodiments thereof, it is not intended that the invention be limited thereby; but by the scope of the appended claims only.

What is claimed is:

1. In a resistor including a resistance body and means for making electrical connection thereto, said means including at least one connecting lead, joining means for securing such a lead to said body, whereby microphonic noises at the connection are substantially eliminated, said joining means comprising a coating of platinum, adhering to a portion of said body, and a metallic layer of silver adhering to said coating and thereby securing said lead in electrical and mechanical connection to the body, said coating including a plurality of relatively thin adhering layers of platinum.

2. In a resistor including a resistance body and means for making electrical connection thereto, said means including at least one connecting lead, joining means for securing such a lead to said body, whereby microphonic noises at the connection are substantially eliminated, said joining means comprising a coating of metal having a coefficient of thermal expansion substantially the same as that of said body, adhering to a portion of said body, and a metallic layer of different material than said metal coating adhering to said coating and thereby securing said lead in electrical and mechanical connection to the body, said coating including a plurality of relatively thin adhering layers of the same metal.

3. A resistor comprising a body of metal oxide resistance material, a coating of platinum on one surface of said body, a connecting lead and a layer of silver adhering to said platinum coating and securing the lead in mechanical and electrical connection with said body.

4. A resistor comprising a body of resistance material composed of the mixed oxides of manganese and nickel, a coating of platinum on one surface of said body, a connecting lead, and a layer of silver adhering to said platinum coating and securing the lead in mechanical and electrical connection with said body.

5. The method of making electrical connection to a non-metallic resistor body that comprises smoothing a portion of the surface of said body, applying a metallic coating to said smoothed surface by first spreading over said surface a liquid composition convertible into metal by the application of heat, and then applying heat thereto, and securing a connecting lead to said coating by means of a second metallic layer, said layer being applied as a paste and converted into metal by the application of heat.

6. The method of making electrical connection to a pellet of non-metallic resistance material that comprises smoothing one end of the pellet, applying to the smoothed surface a liquid composition that is convertible into a metal having substantially the same thermal expansion coefficient as that of said pellet, heating to convert the liquid to the metallic state, embedding the end of a connecting lead in a layer of paste convertible into the metallic state by the application of heat, heating and then cooling the assembly to securely attach the lead to the resistor pellet.

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