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2,184,847

RESISTOR AND METHOD OF MAKING IT

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FIG. 1

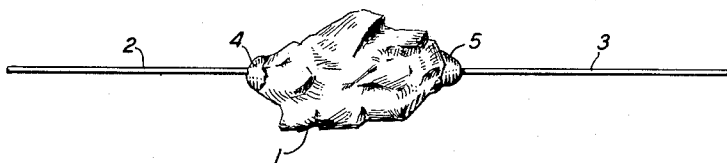


FIG. 2

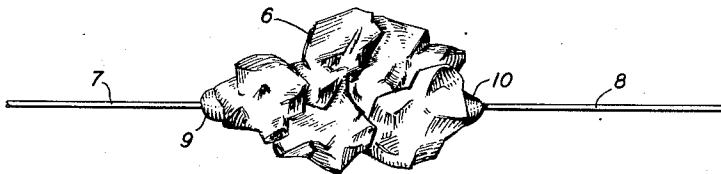


FIG. 3

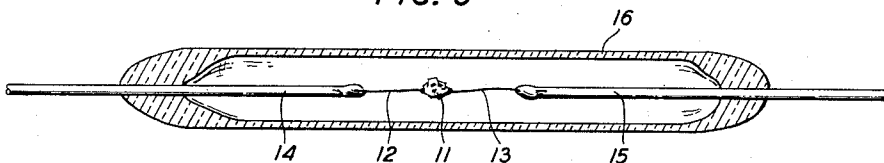
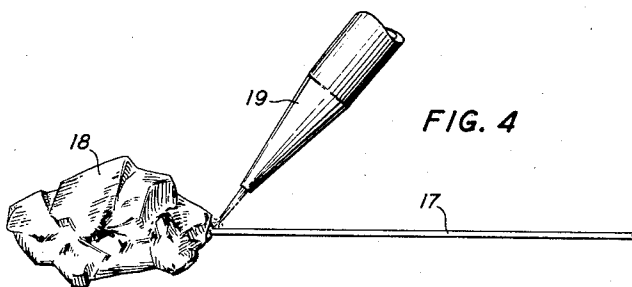


FIG. 4



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RESISTOR AND METHOD OF MAKING IT

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4 Claims. (Cl. 201-63)

This invention relates to electrical resistance elements and methods of making them and particularly to those elements having large temperature coefficients of resistance.

5 The objects of the invention are to obtain greater precision, dependability, and efficiency of operation; to secure improved construction and greater durability; and to improve the methods of making these resistance elements.

10 Suggestions have been made heretofore for the use of different materials in the manufacture of electrical resistors which are required to vary their resistance over wide ranges in response to changes of temperature. For example, silver sulphide and boron are known to have very large temperature coefficients of resistance, and they have been proposed for use in electrical resistors where this characteristic is desirable. It is also known that the element boron is hard and durable and does not deteriorate when used in electrical circuits either with alternating current or with direct current. This element occurs in crystalline form, the individual crystals being quite small in size, having a degree of hardness that approaches that of diamond, and having a melting point in the neighborhood of 2500° C. In my investigation of these materials I have discovered that resistors made of minute boron granules, containing one or several boron crystals, are particularly well suited for use in electrical circuits where large negative temperature coefficients of resistance are required, where a high degree of precision and efficiency are desirable, and where other factors, such as durability and long life and simplicity and compactness of structure are essential. I have also discovered that, notwithstanding the wide separation between the melting point of the boron crystals and the melting points of the metals which are most desirable for use as lead wires, it is possible to make a simple and highly efficient joint between the metallic lead wire and the boron particle, and further that it is also possible by my new method to obtain the desired degree of electrical resistance by controlling the joint between the lead wire and the boron crystals.

Accordingly, the present invention contemplates the making of an electrical resistor by joining metallic lead wires to a granule or crystal of boron by deriving from the boron granule or crystal and from the metal of the lead wires boride particles which serve to secure the wires firmly to the boron and also to determine the resistance of the resistor.

55 A feature of the invention is the method of

making these resistors in which the electrical lead wire is first brought into contact with the boron crystal, following which a minute flame is applied to the point of contact between the lead conductor and the crystal. Although the melting point of the boron crystal is as high as 2500° C. and the melting point of a platinum lead wire is around 1800° C., I find that by applying a minute flame, the temperature of which need not exceed 750° C., to the point of contact between the platinum lead wire and the boron crystal, a small mass of platinum boride is formed which firmly joins the lead wire to the body of the crystal.

A further feature of the invention is the method of making a resistor as above set forth in which the electrical resistance is fixed at any desired value by determining the area of contact between the boride joint and the crystal.

These and other features of the invention will be described more in detail in the following specification.

In the drawing accompanying this specification:

Fig. 1 shows the resistor, largely magnified, comprising a single crystal of boron and lead wires joined at the opposite sides of the crystal by small boride joints;

Fig. 2 shows a resistor, similarly magnified, comprising a granule composed of several unseparated boron crystals;

Fig. 3 shows a resistor in which the boron unit and its fine lead wires are sealed within a small glass tube; and

Fig. 4 illustrates the method of making a joint between the boron crystal and the metallic lead wire.

The resistor shown in Fig. 1 includes the single boron crystal 1 and the two lead wires 2 and 3. The lead wires 2 and 3 are joined to opposite sides of the crystal 1 by means of minute particles of boride 4 and 5, respectively. Where platinum is used for the leads 2 and 3, the joints 4 and 5 are, of course, of platinum boride. Other metals, however, such as palladium and iron, may be used for the lead wires, in which case the boride joints vary according to the metal used.

The resistor shown in Fig. 2 is similar to the one in Fig. 1. It differs therefrom in that the boron granule or particle 6 comprises a cluster of unseparated boron crystals. In a similar manner the lead wires 7 and 8 are joined to opposite sides of the granule 6 by means of the boron joints 9 and 10, respectively.

The boron resistance units are preferably small in size, being of the order of one-fiftieth of an inch in diameter. Correspondingly the lead wires, 2 and 3 and 7 and 8, joining the boron unit are of small diameters, in the order of one or two thousandths of an inch.

Since the boron unit and its lead wires are necessarily fragile because of their minute sizes, it is desirable in some cases to mount them within small protective containers. One of these is illustrated in Fig. 3. Here the boron unit 11 has its lead wires 12 and 13 welded or otherwise secured to supporting wires 14 and 15, respectively, and these supporting wires are sealed in the small glass tube 16. Thus the tube 16 serves as a housing and protective casing for the resistance unit. The housing 16 not only protects the boron resistor from mechanical injury but also guards it against wide fluctuations of the ambient temperature. The tube 16 may be evacuated or it may contain any suitable gas at any desired pressure.

The novel method of joining the lead wires to the surface of the boron particle is illustrated in Fig. 4. Here the lead wire 17, which may be of platinum, is first brought into contact with the surface of the boron crystal 18. A pin-point flame of some suitable burning gas is then applied by means of a burning nozzle 19 to the region of contact between the wire 17 and the crystal 18. The presence of this flame causes the formation of platinum boride at the point of contact which constitutes a strong mechanical joint holding the lead wire 17 firmly to the body of the crystal 18. Moreover, the platinum boride has good electrical conducting properties and thereby furnishes a good electrical contact between the lead wire and the crystal. The magnitude of the electrical resistance at the joint formed between the lead wire and the crystal by the pin-point flame may be selected at any desired value by controlling the size of the boride particle and consequently the area between it and the crystal. To do this, the heat produced by the nozzle 19 is controlled so that the temperature at the point where the joint is to be formed is in the neighborhood of 750° C. At temperatures much less than this value the action, by which the boride is formed, will not take place. On the other hand if the temperature is too high the boride is formed at a rate so rapid that it is not possible to control accurately the amount of boride necessary to give the desired resistance. Thus the electrical characteristic of the resistor is fixed by controlling the size of the lead wire joints.

These resistors have utility in many electrical circuit arrangements. They have an extremely large negative temperature coefficient of resistance. Their resistance at normal temperature is high. When, however, current is passed through them by way of the lead wires, their temperature increases due to the heating effect of the current,

and their resistance drops very rapidly in response to increasing temperature. By constructing them of small particles in accordance with the method herein described, the quick response and the precise relation between current and resistance, often required in the control of electrical circuits, are made possible. The small diameters of the lead wires also add to the efficiency and precision of the unit in that they prevent the loss of heat from the boron crystal by conduction to the metal of the lead wires.

What is claimed is:

1. The method of joining a metallic conductor to a body comprised of boron to form an electrical resistance element which comprises bringing the conductor into contact with said body, applying heat at the point of contact to raise the temperature thereof to a value substantially less than the melting point of said conductor to form at said point a joint comprising a compound of boron and of the metal of said conductor, and controlling the temperature at said point of contact to determine the size of the joint formed and the resistance of the element.

2. The method of joining a metallic conductor to a body including boron to form a resistance element which comprises bringing the conductor into contact with said body, applying heat at the point of contact to raise the temperature thereof to a value substantially less than the melting point of either said conductor or said body to form at said point of contact a compound of boron and of the metal of said conductor, and controlling the temperature at said point of contact at a given value to control the amount of the compound formed and the resistance of the element.

3. The method of making an electrical resistance element which comprises bringing a platinum lead wire into contact with the surface of a body containing boron, applying heat at the point of contact to raise the temperature thereof to a value less than the melting point of platinum to form a particle of platinum boride joining said lead wire to said body, and controlling the temperature at said point of contact to control the size of said particle and the resistance of said element.

4. The method of making an electrical resistance element which comprises bringing a platinum lead wire into contact with the surface of a body containing boron, applying a pin-point flame at said point of contact to raise the temperature thereof to a value less than the melting point of either said body or said lead wire to form at said point of contact a particle of platinum boride joining the lead wire physically and electrically to said body, and controlling the temperature at said point of contact to control accurately the size of said particle and the resistance of said element.

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