

April 21, 1942.

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2,280,257

RESISTOR DEVICE AND METHOD OF MAKING THE SAME

Filed July 25, 1939

FIG. 1

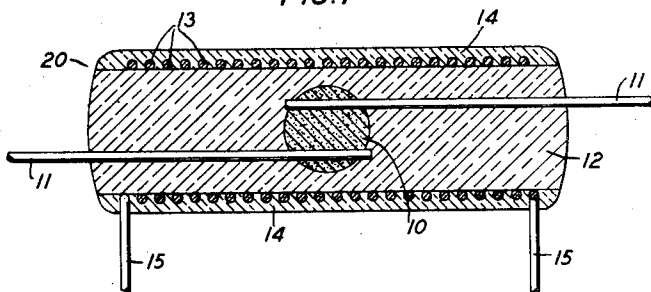


FIG. 2

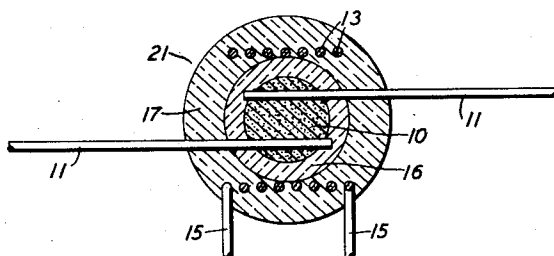
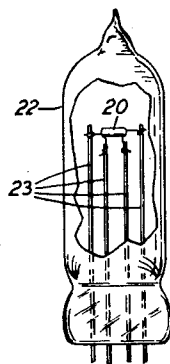


FIG. 3



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2,280,257

RESISTOR DEVICE AND METHOD OF
MAKING THE SAMEGerald L. Pearson, Towaco, N. J., assignor to
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Application July 25, 1939, Serial No. 286,307

12 Claims. (Cl. 201-64)

This invention relates to resistor devices of the type denoted as indirectly heated resistors and to methods of fabrication thereof. More particularly, it relates to such resistors having a resistance element the conductivity of which is highly dependent upon temperatures.

An indirectly heated resistor usually comprises a resistor element, an electrical heater and an insulating barrier between the resistor element and the heater. Ordinarily the outside of the unit is also provided with an insulating covering. One of the chief difficulties encountered in making indirectly heated resistor units has been the production of suitable insulating means, particularly the before-mentioned insulating barrier. The insulating means, besides having good insulating properties at all operating temperatures, must be a reasonably good conductor of heat and remain stable over long periods of time when subjected to repeated heating and cooling cycles.

One object of this invention, therefore, is to produce stable, indirectly heated resistor units having insulating means with good heat conducting properties and whose insulation and heat conducting characteristics are retained at all operating temperatures.

In accordance with one feature of this invention, the resistor element and heater of a resistor unit are embedded in a substantially integral mass of insulating material.

Another feature of this invention resides in a resistor having an insulating portion comprising a glass-like material.

The invention and the foregoing and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing in which:

Fig. 1 is a sectional view of a resistor unit illustrating one form of the invention;

Fig. 2 is a sectional view of a different resistor unit illustrating another form of the invention; and

Fig. 3 is an elevational view of a resistor unit mounted in a protective envelope, a portion of the envelope being broken away to show the internal elements more clearly.

In the fabrication of indirectly heated resistors according to this invention, a resistor element having firmly attached conductive leads or electrodes is first fused into a body of glass or glass-like material. A heater is then applied to the resulting assembly and more glass-like material fused therearound. The unit may take several forms two of which are illustrated in the drawing.

The unit 20 disclosed in Fig. 1 may be made in the following manner: a resistor element, such as a bead 10, of semiconductive material and

having conductors 11 embedded therein, is inserted in a hollow glass body, such as a glass tube, with portions of the conductors 11 projecting from the tube. This assembly is heated sufficiently to soften the glass. Temperatures from 700° to 900° C. may be employed. A suitable method of heating is in a furnace at about 900° C. for thirty seconds in an oxygen atmosphere. The hot glass shrinks around the bead 10 to make good thermal contact therewith. After cooling, the resulting solid glass body or rod 12 has the bead 10 firmly embedded therein. In order to insure good bonding, the glass should have a thermal expansion coefficient as near that of the bead 10 and conductors 11 as possible. A heater coil 13, preferably prewound, is placed over the glass body or rod 12. The coil may comprise wire of a nickel-chromium alloy or other suitable heater wire. An oxide-coated wire is preferred. A glass cement 14 is spread over the coil 13 and rod 12 leaving coil ends 15 projecting. Upon heating to about 700° C. and cooling the cement forms a hard glassy material which holds coil 13 in place, makes good thermal contact with the coil 13 and body or rod 12 and offers good electrical insulation. A preferred cement comprises about 65 per cent of powdered anhydrous sodium borate and about 35 per cent of powdered aluminum oxide, made into a paste by the addition of sufficient water. Another preferred cement comprises approximately 50 per cent each of lithium and potassium borate with water.

Since these units for many purposes are very small, they are preferably mounted in a protective envelope. A glass bulb, such as 22, in Fig. 3 is suitable. The bulb 22 has four supports 23 of conductive material, two of which are attached to heater leads 15 and two to the resistor leads 11 of the unit 20. The bulb is heated, evacuated and sealed off at about 10^{-5} millimeters of mercury. Evacuation is not necessary for stability but serves to increase the sensitivity of the device by decreasing the thermal loss. The enclosed units may be mounted on suitable bases or the like adequate for the purpose for which they are employed.

Units 21 of the type shown in Fig. 2 may be constructed as follows: a bead-type resistor 10 having conductors 11 is wetted with a suitable liquid, such as water, and dipped in finely pulverized metal borate. Zinc or potassium borate is preferred. The borate is then fused into a glassy mass 16 surrounding the bead, by the application of heat at from 700° to 900° C. The heat may be applied by a flame, oven or other suitable means. The glass enclosed bead is then inserted into a coil 13 of heater wire, the assembly again wetted and more metal borate powder applied. Heat is again applied as before, to fuse

the borate into a glass. The whole assembly is thereby enclosed in a glass bead with the resistor leads 11 and heater leads 15 projecting therefrom. Units made in this manner are ordinarily smaller than those of Fig. 1 for the same size resistor element 10. The wetting steps comprise a simple and convenient method of making the borate powder stick until fused and in the case of assembly with the coil the surface tension centers the inner element in the heater coil. The unit 21 may be mounted in an envelope in a similar manner to that employed for unit 20.

The resistor element 10 may comprise any resistance material having desired resistance characteristics. Semiconductive materials which have been found suitable for many applications comprise heat-treated combinations of metal oxides such as disclosed in application Serial No. 274,144 of R. O. Grisdale, filed May 17, 1939, now Patent 2,258,646, issued October 14, 1941, and Serial No. 280,692 of E. F. Dearborn, filed June 23, 1939.

Although the invention has been disclosed by illustrative embodiments thereof, it is to be understood that various modifications may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. An indirectly-heated resistor unit comprising a bead of semiconductive material having conductive leads attached thereto, a hollow glass rod fused around and in intimate contact with said bead and a portion of said leads, and a heater coil around said glass rod and held in contact therewith by a glass-like cementing material fused around said coil and rod.
2. An indirectly-heated resistor unit comprising a bead of semiconductive material having conductive leads attached thereto, a layer of metal borate fused around and in intimate contact with said bead and a portion of said leads, a heater coil over said layer, and another layer of metal borate fused over said first layer and coil.
3. An indirectly-heated resistor unit comprising a bead of semiconductive material having conductive leads attached thereto, a layer of zinc borate fused around and in intimate contact with said bead and a portion of said leads, a heater coil over said layer, and another layer of zinc borate fused over said first layer and coil.
4. An indirectly-heated resistor unit comprising a bead of semiconductive material having conductive leads attached thereto, a layer of potassium borate fused around and in intimate contact with said bead and a portion of said leads, a heater coil over said layer, and another layer of potassium borate fused over said first layer and coil.
5. An indirectly-heated resistor unit comprising a bead of high resistance-temperature coefficient semiconductive material having conductive leads attached thereto, a fused glass-like mass enclosing and in intimate contact with said bead and a portion of said leads, and a heater coil around said glass-like mass and held in contact therewith by a layer of fused material comprising sodium borate and aluminum oxide.
6. An indirectly-heated resistor unit comprising a bead of high resistance-temperature coefficient semiconductive material having conductive leads attached thereto, a fused glass rod enclosing and in intimate contact with said bead and a portion of said leads, and a heater coil around said glass rod, and held in contact therewith by a layer of fused material comprising sodium borate and 35 per cent aluminum oxide.
7. The method of making a resistor unit that comprises fusing a layer of glass-like material over a high resistance-temperature coefficient semiconductive body and a portion of its attached conducting leads, applying an electrically conductive heater means to said layer, and securing said heater means in place by fusing a second layer of glass-like material over the first layer and the heater means.
8. The method of making a resistor unit that comprises inserting into a glass tube a body of high resistance-temperature coefficient semiconductive material having conductive leads attached thereto, said leads being of sufficient length to project from the tube, heating the assembly to fuse the glass tubing and then cooling to tightly enclose said body and leads in the resulting glass body, inserting said glass body into a coil of heater wire, applying a cementing material thereto, and heating to fuse the cement into a glass-like mass enclosing the coil and attaching it to the glass body.
9. The method of making a resistor unit that comprises inserting into a glass tube a body of high resistance-temperature coefficient semiconductive material having conductive leads attached thereto, said leads being of sufficient length to project from the tube, heating the assembly at about 900° C. to fuse the glass tubing and then cooling to tightly enclose the body and leads in the resulting glass body, inserting said glass body into a coil of heater wire, applying a cementing material thereto, and heating at about 700° C. to fuse the cement into a glass-like mass enclosing the coil and attaching it to the glass body.
10. The method of making a resistor unit that comprises wetting a semiconductive body, applying powdered metal borate thereto, heating to fuse the borate into a glass-like layer, applying a heater coil over said layer, wetting the assembly, applying more powdered metal borate over the first layer and coil, and heating to fuse the borate into a glass-like outer layer.
11. The method of making a resistor unit that comprises wetting a semiconductive body, applying powdered metal borate thereto, heating at a temperature between 700° and 900° C. to fuse the borate into a glass-like layer, applying a heater coil over said layer, wetting the assembly, applying more powdered metal borate over the first layer and coil, and heating to a temperature of between 700° and 900° C. to fuse the borate into a glass-like outer layer.
12. An indirectly-heated resistor unit comprising a body of semiconductive material having conductive leads attached thereto, a mass of glass-like material fused around and in intimate contact with said body and a portion of said leads, and a heater coil around said glass-like mass and held in contact therewith by a glass-like cementing material fused around said coil and mass.

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