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Takayasu et al.

[11] **3,836,883**

[45] **Sept. 17, 1974**

[54] **FUSE AND RESISTOR DEVICE**

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[73] Assignee: **Hokuriku Electric Industry Co., Ltd.,** Toyama-Prefecture, Japan

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[21] Appl. No.: **312,500**

[30] **Foreign Application Priority Data**

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June 5, 1972 Japan 47-55135

[52] **U.S. Cl.** **337/163,** 337/159, 337/296
[51] **Int. Cl.** **H01h 85/04**
[58] **Field of Search** 337/159, 160, 163, 296

[56] **References Cited**

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Primary Examiner—J. D. Miller
Assistant Examiner—Fred E. Bell
Attorney, Agent, or Firm—Watson, Leavenworth, Kelton & Taggart

[57] **ABSTRACT**

A fuse and resistor device is disclosed comprising a substrate of insulating material, a resistance film of tin oxide deposited on said substrate, a layer of glass material having a relatively lower melting point and deposited on said resistance film and an insulation layer surrounding both said resistance layer and said glass layer. When overcurrent passes through the device it acts as a fuse resulting from the resistance film partially or wholly migrating into the glass layer now melted on the resistance film thus preventing the current from flowing through the device.

17 Claims, 11 Drawing Figures

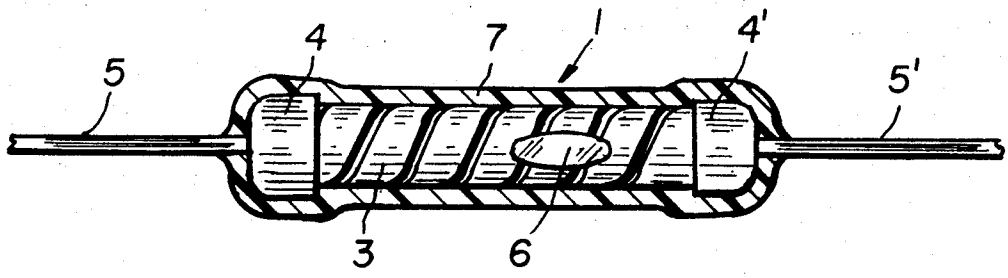


FIG. 2

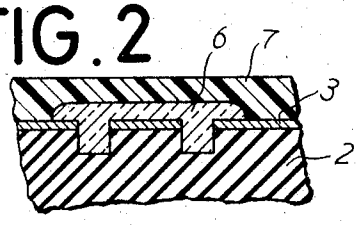


FIG. 3A

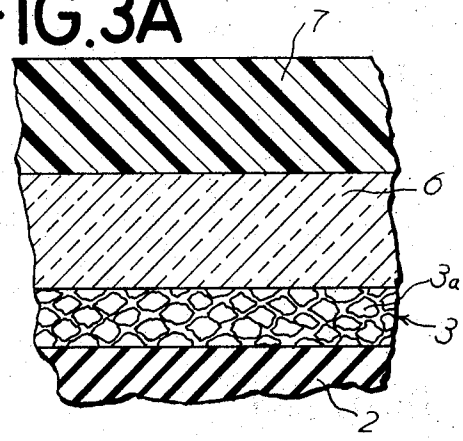


FIG. 3B

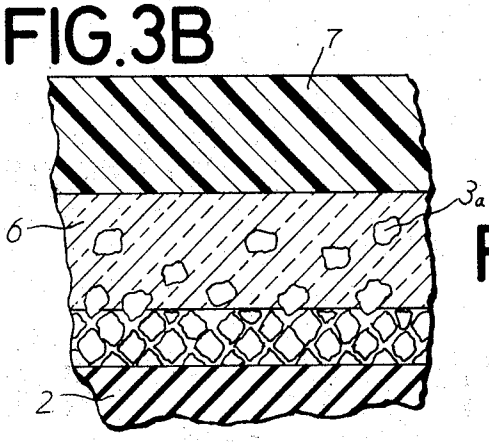


FIG. 3C

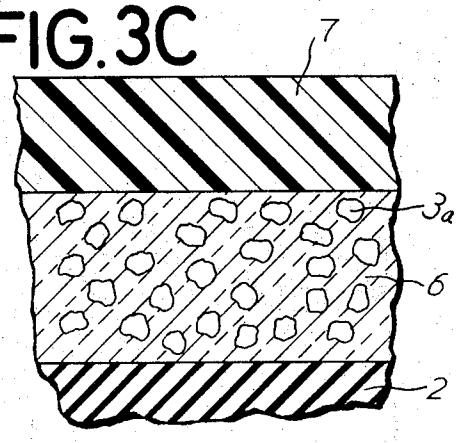


FIG. 5

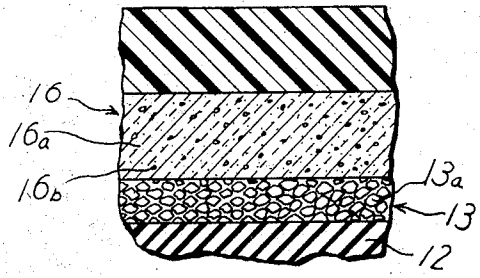


FIG. 6A

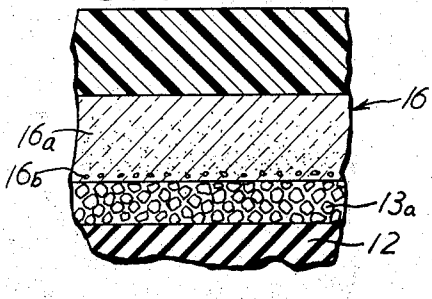
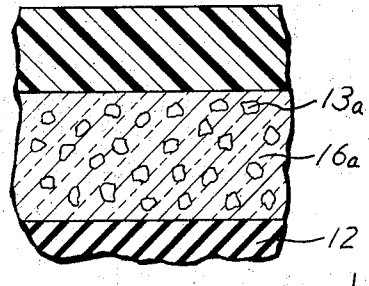


FIG. 6B



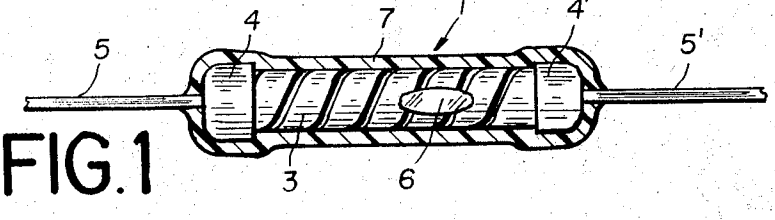


FIG. 1

FIG.4

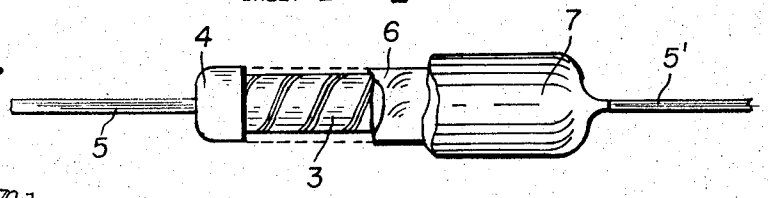


FIG.7

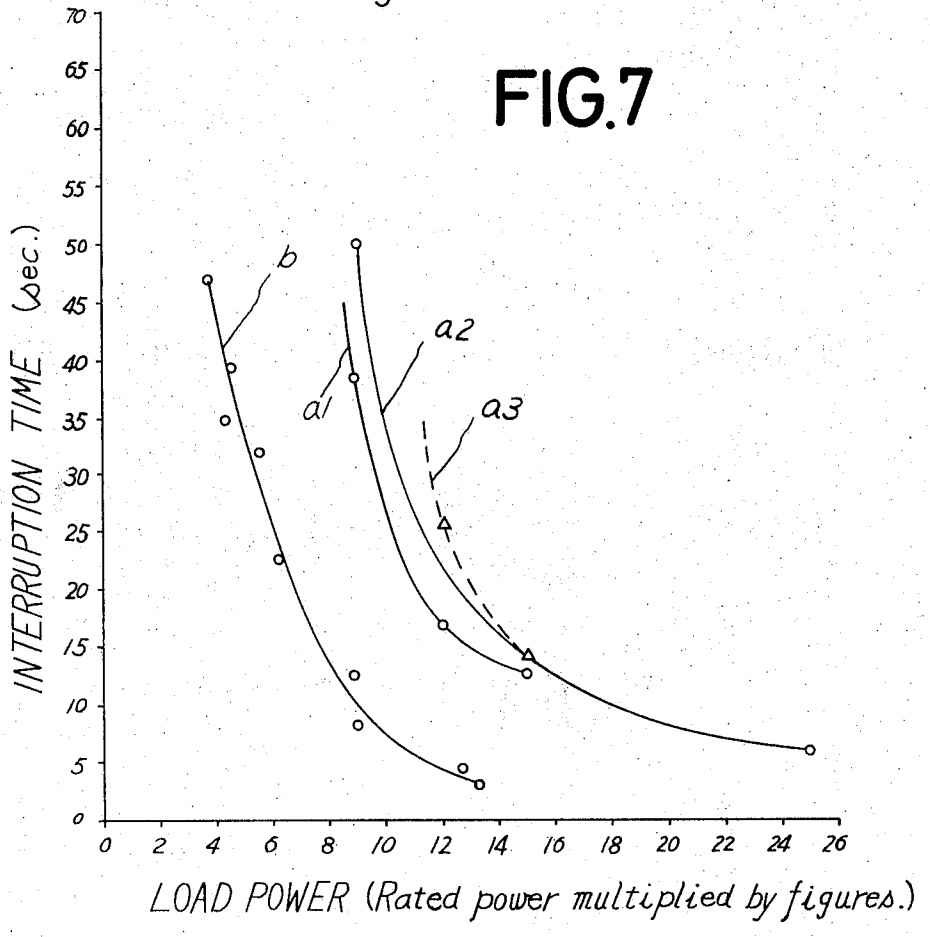
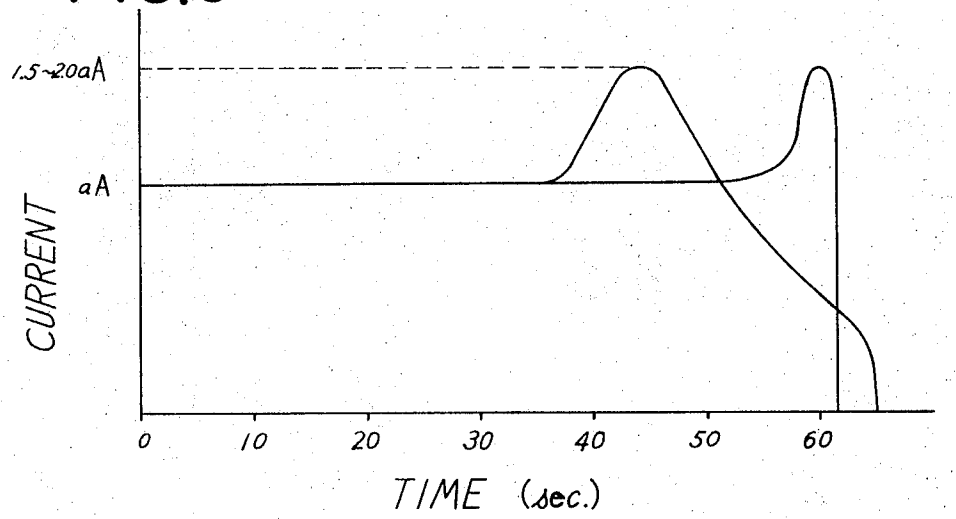


FIG.8



FUSE AND RESISTOR DEVICE

BACKGROUND OF THE INVENTION

This invention relates to a fuse and resistor device for an electrical apparatus and more particularly to a fuse and resistor device employed for incorporation into an electrical circuit in an electronic communication apparatus, such as a television set or the like, and which acts as a normal electrical resistor device during the passage of any rated current through the device while the device acts as a fuse to abruptly interrupt any overcurrent through the device when it passes through the circuit, whereby such overcurrent can be prevented from flowing through the circuit.

DESCRIPTION OF THE PRIOR ART

Hitherto, any fuse and resistor device is impractical because of its delayed development. In the prior art there has been proposed a fuse and resistor device comprising a resistance or impedance film in the spiral form on a substrate, said resistance film including a portion of higher current density than that of the remaining portions thereof, which portion is adapted to be burnt off upon the flow of any overcurrent through the resistance film.

However due to the possible lack of uniformity in the width of the spiral resistance film along the spiral direction thereof, the fuse and resistor device will be partially overheated even during the passage of the rated current through the device, which causes it to have a worse load-life characteristic than that of a conventional film resistor device and to have a gradually increased resistance value. Thus, such fuse and resistor devices are practically speaking, unutilizable.

SUMMARY OF THE INVENTION

Therefore, it is a principal object of the present invention to provide a fuse and resistor device which is adapted to have a predetermined resistance value maintained during the flow of the rated current through the device and to assure the interruption of overcurrent through the device.

Resistance film or layer of tin oxide, such as SnO_2 has been usually used for a resistor device. The inventor has discovered that the tin oxide resistance film, when heated to high temperature, tends to be compatible with glass material, resulting from the same property of tin oxide to that of glass material, which has been assured by many tests. It should be understood that engagement of the tin oxide resistance film with glass material causes the resistance film to migrate into glass material there adjacent when subject to the high temperature to maximize the resistance value of the film.

In accordance with the present invention, there is provided a fuse and resistor device comprising a substrate of insulating material such as ceramics, a resistance film of tin oxide deposited on said substrate, a layer of glass material having a relatively lower melting point and deposited on said resistance film and an insulation layer surrounding both said resistance layer and said glass layer. During the passage of the rated current through the device, it acts as a normal resistor device and when overcurrent passes through the device, it acts as a fuse resulting from the resistance film partially or wholly penetrating into the glass layer to interrupt the current from flowing through the device.

BRIEF DESCRIPTION OF THE DRAWINGS

The other objects and features of the present invention will be apparent to those skilled in the art from the reading of the following description of the preferred embodiments taken in connection with the accompanying drawings:

FIG. **1** is a side elevational view of a fuse and resistor device in accordance with the present invention with an insulating layer broken away;

FIG. **2** is an enlarged and vertically sectional view of a portion of the device as shown in FIG. **1** with the arrangement of a glass layer shown relative to a substrate and a resistance film;

FIGS. **3A** through **3C** are enlarged and fragmentary views in section showing islet particles of resistance material gradually migrating into the molten glass layer when overcurrent flows through the device as shown in FIG. **1**, with FIG. **3C** illustrating the resistance film interrupted at a point of the resistance film where the islet particles of resistance material migrate into the glass layer;

FIG. **4** is an elevational view of a modified fuse and resistor device in accordance with the present invention with an insulation layer and a glass layer partially broken away;

FIG. **5** is an enlarged and fragmentary sectional view of another embodiment in accordance with the present invention;

FIGS. **6A** and **6B** are similar to FIG. **5**, but showing islet particles of resistance material gradually migrating into a molten glass layer when overcurrent flows through the device as shown in FIG. **5**, with FIG. **6B** illustrating the device interrupted at a point of a resistance film where the resistance film partially migrate into the glass layer;

FIG. **7** is a graph showing time required to interrupt various fuse and resistor devices in accordance with the present invention, relative to electric power applied across the terminals of the devices; and

FIG. **8** is a graph showing the relationship of concentric current through the device as shown in FIG. **5** with time from the begining of the overcurrent to flow through the device.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to FIG. **1**, a fuse and resistor device in accordance with the present invention is generally illustrated at reference numeral **1**. This fuse and resistor device is of a type referred to as a film resistor and comprises a substrate **2** of insulating material such as ceramics, glass or the like and resistance film or layer **3** of tin oxide deposited on the substrate **1** by any conventional and suitable process. The processes for depositing the resistance film include immersing, spraying, vacuum-depositing, sputtering, coating and the like. The resistance film **3** may be preferably formed of tin oxide including Sb_2O_3 in addition to SnO_2. The tin oxide resistance material may preferably include 90 to 99.5 percent by weight of SnO_2 and 0.5 to 10 percent by weight of Sb_2O_3. The resistance material may further include tin polyoxide such as Sn_2O_3 added thereto.

The resistance film **3** is shown to be conventionally cut into the spiral form to adjust the resistance value

thereof to provide a predetermined one. The device also comprises a pair of cap type terminals 4 and 4' surrounding and securely mounted on both ends of the resistance film 3 on the substrate 1 by conventional means, said terminals each having a lead secured thereto at their centers by soldering or any other means.

The device comprises a layer 6 of glass material in the particle form having a relatively lower melting point and deposited on the resistance film 3, which should be understood to be the most important feature of the present invention. Commercial glass material may be used which consists of the following components, for example:

Component	I	II	III	IV
PbO_2	64.1	72.0	80.0	72.5
B_2O_3	11.9	18.0	13.0	12.5
SiO_2	5.0	2.5	3.5	—
ZnO	19.0	5.0	—	15.0
Al_2O_3	—	2.5	3.5	—

(Figures in this table indicate the extents of the components at percent by weight.)

The glass layer 6 may be partially applied on the spiral resistance film 3 across one or two turns thereof as shown in FIGS. 1 and 2 because the device is sufficiently interrupted only at a portion of the resistance film 3. However, in view of the ease of its manufacture, it may be preferably provided on the resistance film 3 over all the areas thereof. It should be noted that the time required to interrupt the device from the begining of the overcurrent flow through the device depends upon the area of the glass layer 6 in contact with the resistance film 3 which will be described in detail hereinafter. The glass layer 6 may be bonded onto the resistance film 3 by any suitable adhesive added to glass material of the layer 6.

An insulation layer 7 formed of material such as silicone is provided to cover the resistance film 3 and the glass layer 6 for retention of the latter. The insulation layer may be preferably formed of non-combustible material such as inorganic material and silicone resin when it is subject to high temperature, 300° to 800°C, for example to which the device will reach as overcurrent passes therethrough.

The resistance film 3 of the present device, as shown in FIG. 3A, comprises a plurality of islet particles 3*a* superimposed one on another, said islet particles formed of aggregate crystals with the crystals being bonded to each other by Van der Waals' force which they have. When overcurrent passes through the tin oxide resistance film to cause the surface thereof to reach the temperature of 300° to 800°C, the glass layer 6 on the film melts into fluid so that the islet particles 3*a* of the film 3 are absorbed or scattered into the molten glass layer in a short time as shown in FIG. 3B until all the islet particles 3*a* in contact with the glass layer 6 are transferred into the latter as shown in FIG. 3C. Thus, the spiral resistance layer 3 discontinues at a portion thereof to interrupt the passage of the overcurrent.

As previously mentioned, the time required to interrupt the passage of the overcurrent depends on the contact area of the tin oxide resistance film 3 with the glass layer 6. In case of the deposition of the glass layer 6 on the resistance film 3 at a smaller area as shown in FIGS. 1 and 2, upon flow of the overcurrent through the film 3, the islet particles 3*a* of the layer 3 in contact with the glass layer 6 are shortly transferred into the latter to abruptly increase the resistance value of the device so that the film 3 provides an acceleratedly increased resistance value to enhance the interruption of the overcurrent through the device. On the other hand, in case of the deposition of the glass layer 6 on the resistance film 3 at a larger area as shown in FIG. 4 the islet particles 3*a* over the larger area migrate into the glass layer 6 so that the film never provides a locally increased resistance value along the length thereof to tend to retard the interruption of the overcurrent through the device. The interruption time depends also upon the thickness of the insulation layer 7 because the thickened layer prevents the heat from the resistance film 6 from readily dissipating thus increasing the temperature within the device. Thus, it will be found that a shorter interruption time can be provided by depositing the glass layer 6 on the tin oxide resistance film 3 substantially at its middle portion and thickening the insulation layer 7.

Referring now to FIG. 5 there is illustrated in enlarged section a portion of a more preferable fuse and resistor device 11 wherein a blend layer 16 is deposited either partially or wholly on a tin oxide resistance film or layer 13 in the spiral form on an insulating substrate 12, said blend layer being formed of a blend consisting of glass frits 16*a* and metal powder 16*b*, both of which are required to have lower melting points. The glass frits 16*a* may be of that composition described in connection with the previous embodiments as shown in FIGS. 1, 2 and 4. Metal material in the form of powder 16*b* includes indium, tin, cadmium, bismuth, lead, zinc and eutectic alloy thereof. The metal powder may be preferably of the grain size in diameter less than 500 microne. The metal powder may be preferably blended within a range between 5 and 200 parts relative to 100 parts of glass frits. Glass frit 16*a* and metal powder 16*b* may be bonded to one another by a binder, an organic resin such as epoxy resin, melamine resin, phenol resin or an inorganic resin such as silicone, for example.

Such metal powder 16*b* serves to enhance the interruption time of the fuse and resistor device for the reason as described hereinafter. When overcurrent passes through the device as shown in FIG. 5 to reach higher temperature within the device, metal powder 16*b* in the blend layer 16 are initially melted to be absorbed into the resistance film 13, as shown in FIG. 6A, so that a spark is established across the groove defined by the spiral resistance film 13 to cause the concentric current to flow thereacross. Thus, the concentric current flows through the resistance film 13 already heated by the overcurrent therethrough to raise the film to higher temperature than that it reaches when only overcurrent flows through the film as done in the previous embodiments as shown in FIGS. 1, 2 and 4. Metal powder 16 (*b*) may most preferably consist of eutectic alloy of 74 percent by weight of indium and 26 percent by weight of cadmium or that of 67.75 percent by weight of cadmium and 32.25 percent by weight of tin.

FIG. 7 shows the relationship of the interruption time (the period from the begining of the passage of the overcurrent to the interruption thereof) with the load power (rated power multiplied by the figures indicated in this figure) in connection with specified examples in accordance with the present invention, which were tested by the inventors. In this test there were used the

devices in each of which the glass layer was of that listed in the first column (I) of the above-indicated table and the insulation layer of silicone had the thickness of 1 mm. The devices used each had the resistance value of 50 ohm per square, but it was found that other fuse and resistor devices of different resistance value had the same tendency to those of the examples in this test. The characteristics indicated at the curves *a*1, *a*2 and *a*3 in FIG. 7 were those of the devices in each of which the layer of only glass material was provided on the spiral resistance film of tin oxide as shown in FIGS. 1, 2 and 4, while the characteristic indicated at the curve *b* in FIG. 7 was that of the device in which the blend layer of glass material and metal powder was provided on the spiral resistance film identical to those of the devices having the characteristics *a*1, *a*2 and *a*3. The resistance films used were each formed of material including 95 percent by weight of SnO_2 and 5 percent by weight of Pb_2O_3. In this figure, the curve *a* 1 shows the characteristic of the device in which the glass layer was deposited on the spiral resistance layer across one turn thereof as shown in FIG. 1, the curve *a*2 the characteristic of the device in which the glass layer was provided in the straight line on the resistance film along the longitudinal axis of the device, and the curve *a*3 the characteristic of the device in which the glass layer was provided on the resistance film over all the area thereof as shown in FIG. 4. As apparent from these curves, the smaller contact area the glass layer has with the resistance layer, the shorter the interruption time is. The curve shows the characteristic of the device in which the blend layer of 100 parts of glass frits and 100 parts of commercially available lead-zinc alloy powder bonded by 10 parts of epoxy binder was provided on the spiral resistance film across one turn thereof as arranged similarly to the glass layer as shown in FIG. 1. As compared with the characteristic indicated at the curve *a*2 which corresponds to the curve *b* in the arrangement, the interruption time according to the characteristic indicated at the curve *b* will be found to be substantially half of that of the former. It will be understood from FIG. 8 that the current flows through the resistance film as shown in FIG. 5 within the range of 20 to 40 seconds from the begining of the passage of the overcurrent, about twice of that through the resistance film of the device as shown in FIG. 1 because of the concentric current flowing through the former film.

It should be noted that the insulation layer not shown on the blend layer and on the resistance film of the device as shown in FIG. 5 serves to prevent the explosion upon the establishment of the spark across the groove defined by the adjacent turns of the spiral resistance film in addition to protect the device from the circumferences thereof.

Some preferred embodiments of the present invention having been described by way of example, it is anticipated that certain modifications or changes in arrangement and construction may occur to those skilled in the art, and it is anticipated that such alterations and modifications may be made without departing from the spirit of the invention or the scope of the appended claims.

What is claimed:

1. A fuse and resistor device comprising a substrate of insulating material, a resistance film of tin oxide deposited on the substrate, a glass layer having a relatively lower melting point deposited on the resistance film and an insulation layer surrounding both the resistance film and the glass layer, said resistance film being composed of tin oxide comprising a small amount of Sb_2O_3 in addition to SnO_2.

2. A fuse and resistor device as set forth in claim 1, wherein said glass layer is in contact with said resistance film at a portion thereof.

3. A fuse and resistor device as set forth in claim 1, wherein said glass layer is in contact with said resistance film over all the areas thereof.

4. A fuse and resistor device as set forth in claim 1, wherein SnO_2 is ranged from 90 to 99.5 percent by weight and Sb_2O_3 is ranged from 0.5 to 10 percent by weight.

5. A fuse and resistor device as set forth in claim 1, wherein said resistance film is composed substantially of Sn_2O_3.

6. A fuse and resistor device as set forth in claim 4, wherein the thickness of said insulation layer is predetermined to provide a reduced rate of dissipation of the internal heat of the device and an increase in the internal temperature of the device.

7. A fuse and resistor device comprising a substrate of insulating material, a resistance film of tin oxide deposited on said substrate, a layer of blend comprising glass material and metal material in the form of powder, both having a relatively lower melting point, said blend layer deposited on said resistance film, and an insulation layer surrounding both of said resistance film and said blend layer.

8. A fuse and resistor device as set forth in claim 7, wherein said metal material is selected from the group consisting of indium, tin, cadmium, bismuth, lead, zinc and eutectic alloy thereof.

9. A fuse and resistor device as set forth in claim 8, wherein said metal material is eutectic alloy of 74 percent by weight of indium and 26 percent by weight of cadmium.

10. A fuse and resistor device as set forth in claim 8, wherein said metal material is eutectic alloy of 67.75 percent by weight of cadmium and 32.25 percent by weight of tin.

11. A fuse and resistor device as set forth in claim 7, wherein said blend layer is in contact with said resistance film at a portion thereof.

12. A fuse and resistor device as set forth in claim 7, wherein said blend layer is in contact with said resistance film over all the areas thereof.

13. A fuse and resistor device as set forth in claim 7, wherein said resistance film is composed of tin oxide comprising a small amount of Sb_2O_3 in addition to SnO_2.

14. A fuse and resistor device as set forth in claim 13, wherein SnO_2 is ranged from 90 to 99.5 percent by weight and Sb_2O_3 is ranged from 0.5 to 10 percent by weight.

15. A fuse and resistor device as set forth in claim 7, wherein said resistance film is comprised substantially of Sn_2O_3.

16. A fuse and resistor device as set forth in claim 8, wherein the thickness of said insulation layer is predetermined to provide a reduced rate of dissipation of the internal heat of the device and an increase in the internal temperature of the device.

17. A fuse and resistor device as set forth in claim 7, wherein said metal material is blended within the range between 5 and 200 parts relative to 100 parts of glass material.

* * * * *