

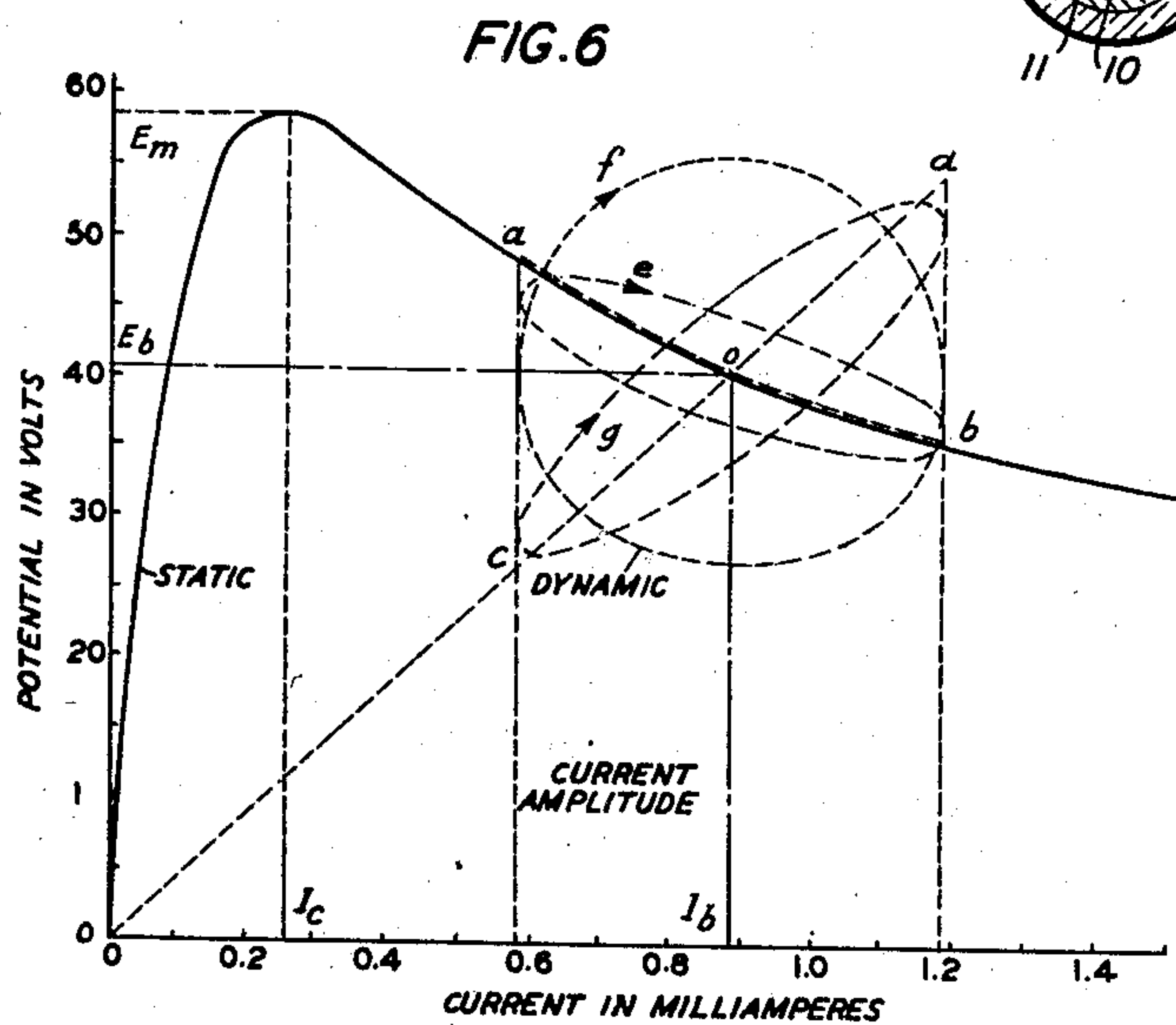
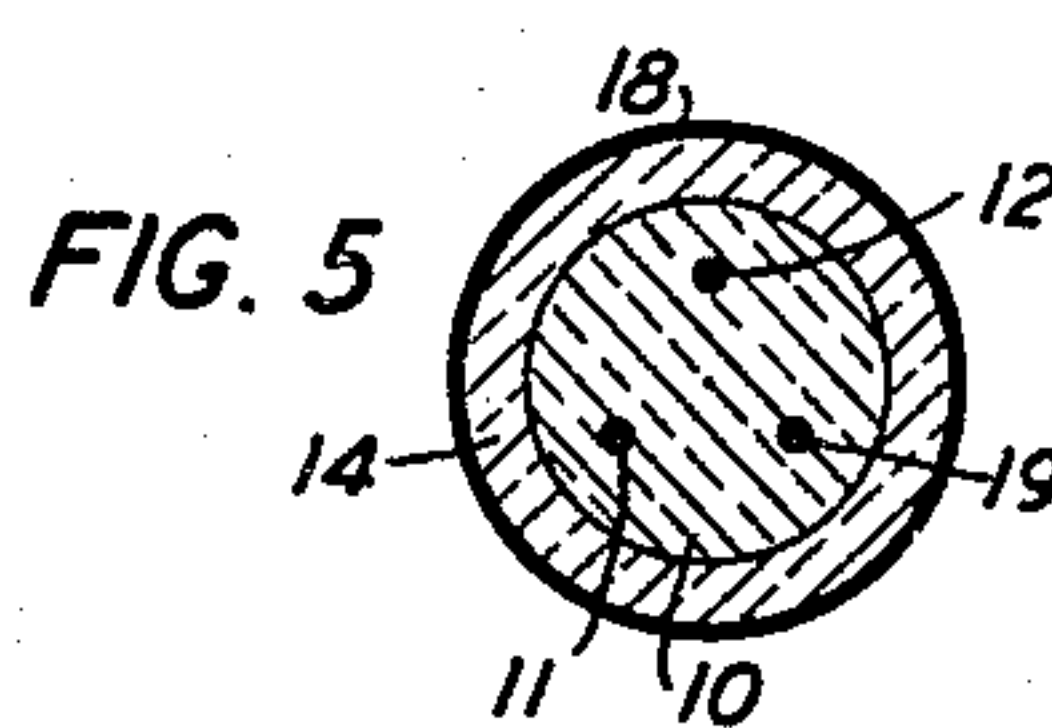
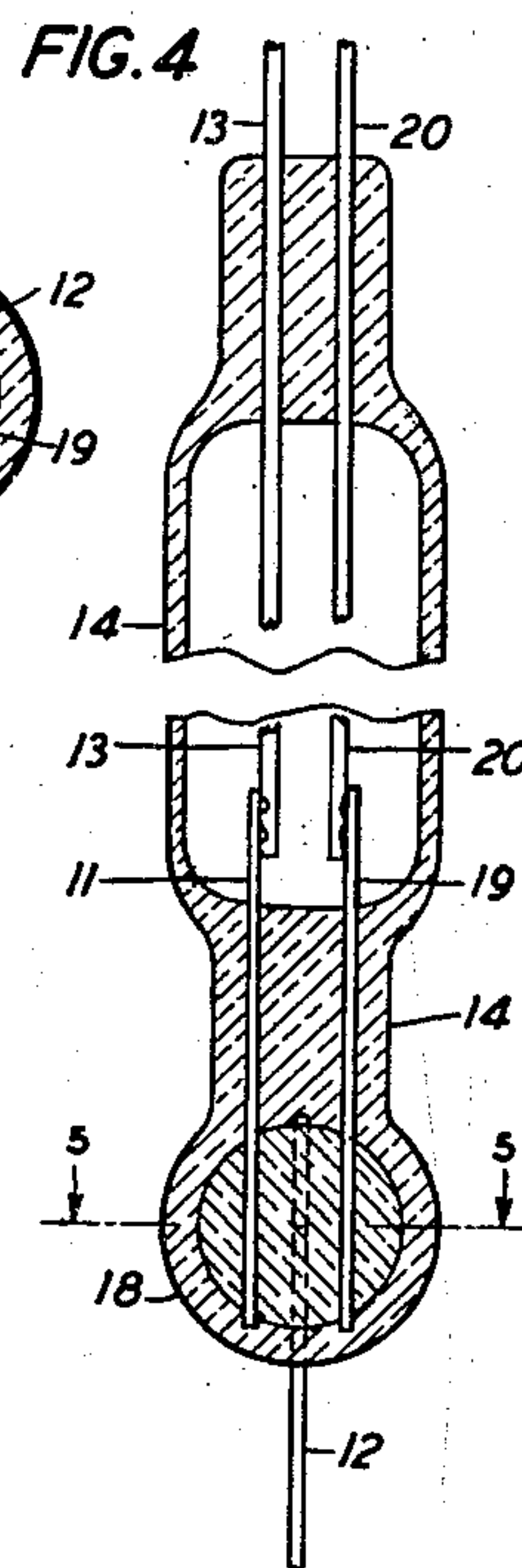
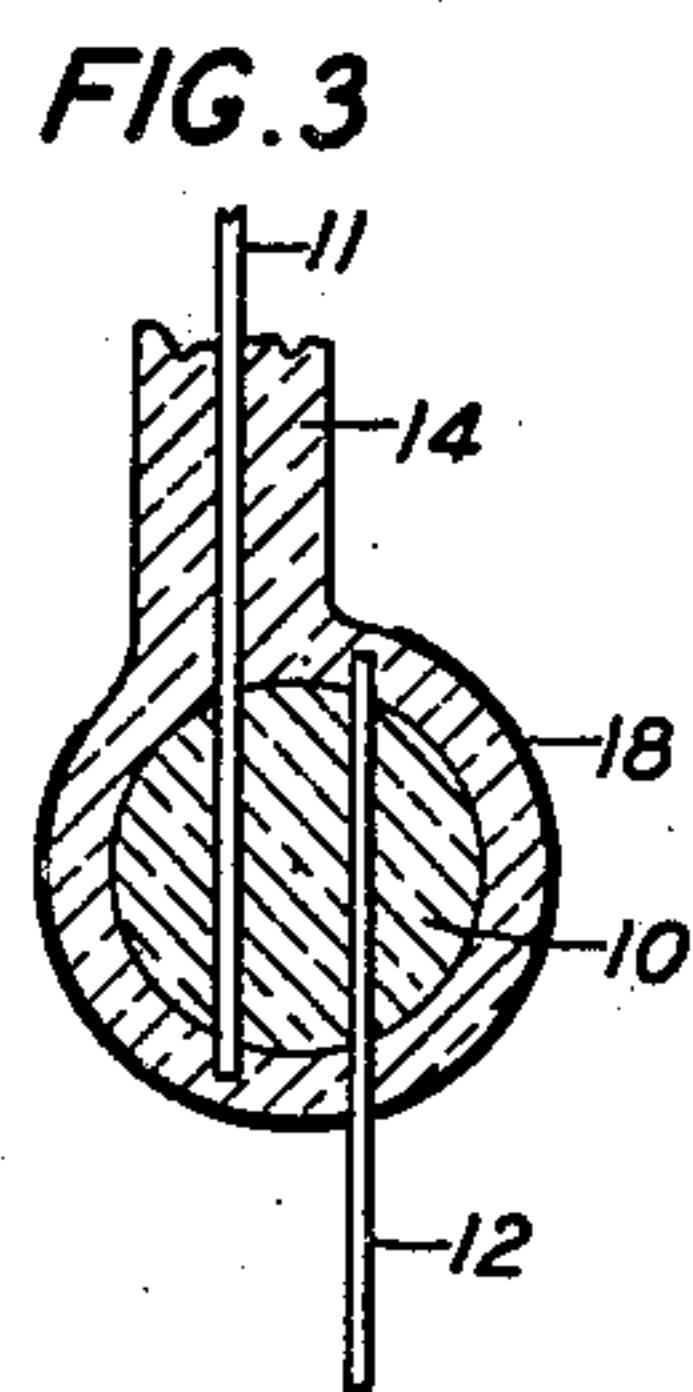
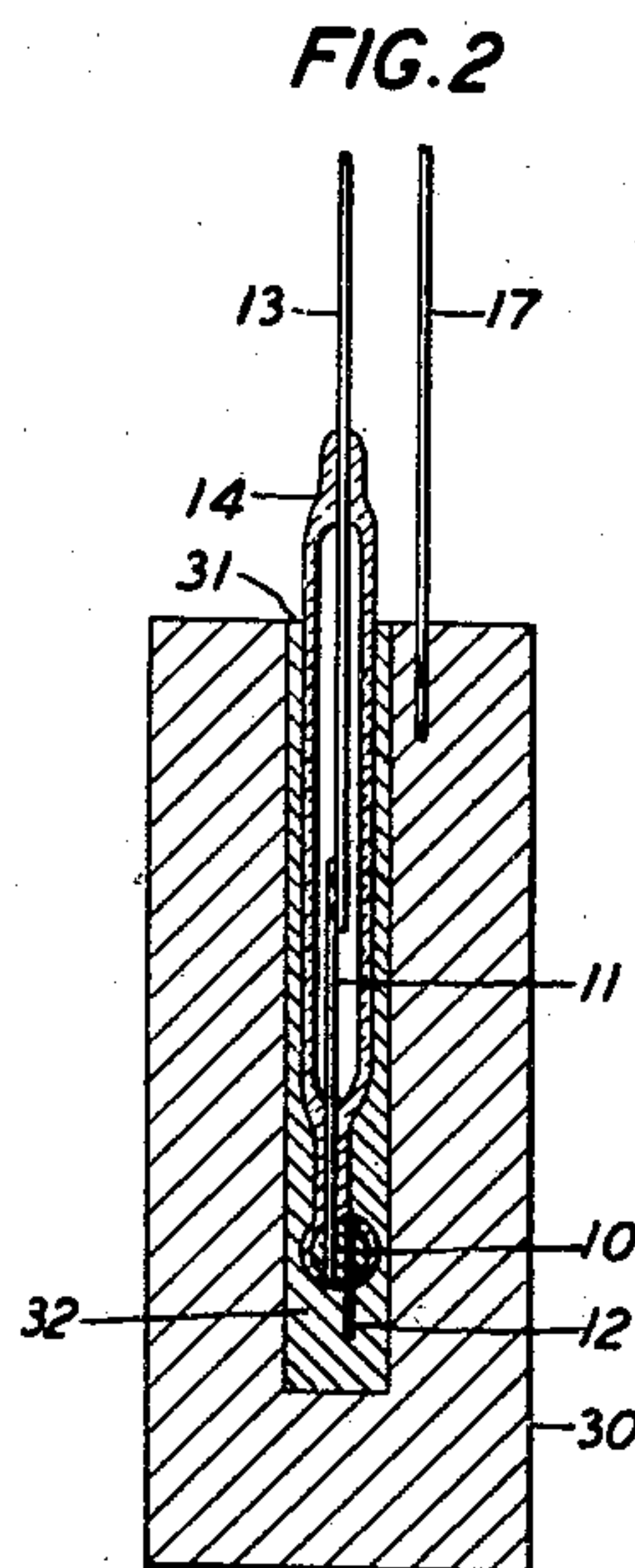
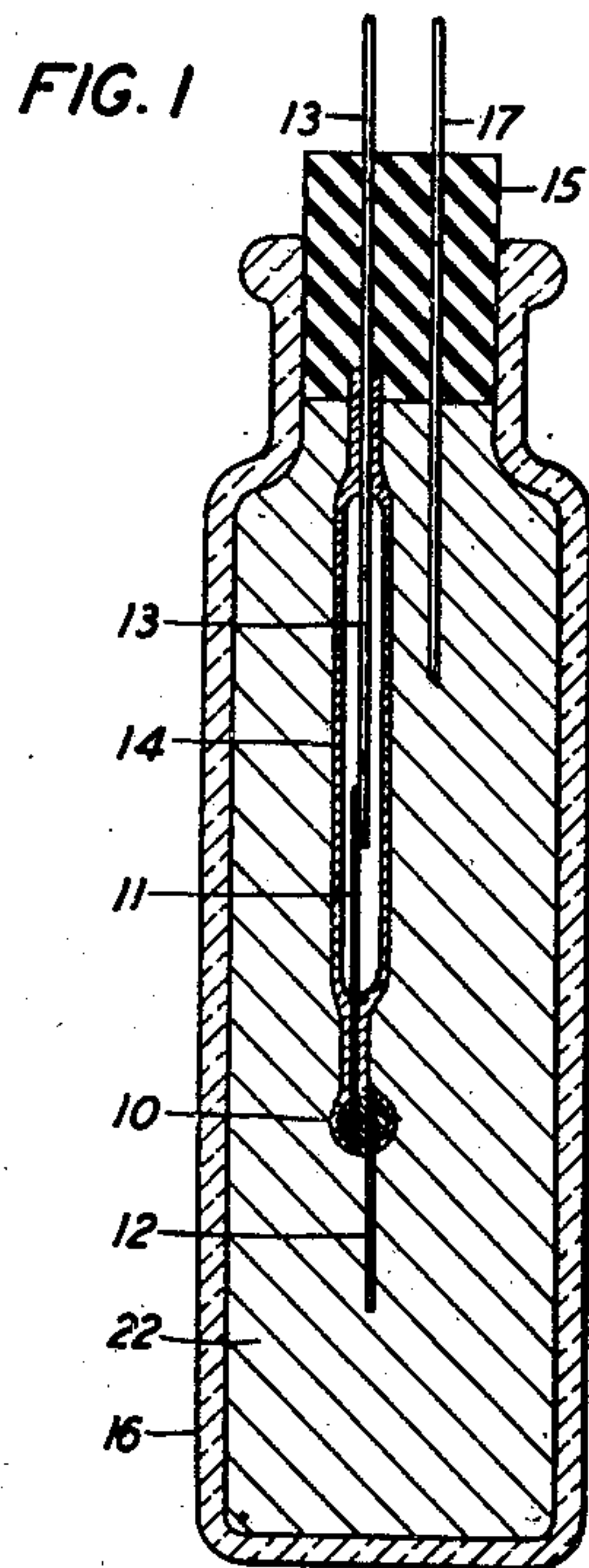
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2,407,288

RESISTOR DEVICE

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RESISTOR DEVICE

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8 Claims. (Cl. 201—63)

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This invention relates to resistors and more particularly to resistors having a high temperature coefficient of resistance and a relatively rapid rate of heating and cooling.

The type of resistor to which the present invention applies has been called a thermistor. This term is a contraction of the words "thermal resistor" and has been applied to a resistor, the resistance of which varies greatly with changes in temperature.

Many materials having conductivities lying between the conductive values normally associated with conductors and with insulators, and generally designated as semiconductive materials, have been found useful as thermistor materials. Many of the semiconductive materials that have been investigated up to the present have a high negative temperature coefficient of resistance. For this reason, it is convenient to discuss thermistor action from the viewpoint of such materials. It should be remembered, however, that materials having a high positive temperature coefficient of resistance will behave in a similar manner.

Although the resistance of a thermistor changes greatly with changes in temperature it does not necessarily follow that the resistance will change rapidly with changes in applied power. In order for the latter to occur it is necessary for the thermistor temperature to closely follow the changes in the applied power.

One object of this invention is a thermistor device having its elements so constructed and arranged that the resistance of said device will closely follow changes in applied power.

A feature of this invention resides in a thermistor device having a resistance element which may have a small thermal capacity, surrounded by a body having high thermal capacity and conductivity, whereby a shorter heating and cooling cycle is obtained.

Other and further objects and features of this invention will be understood more fully and clearly from the following description of illustrative embodiments thereof taken in connection with the appended drawing in which:

Fig. 1 is a sectional view of one illustrative embodiment of the invention;

Fig. 2 is a sectional view of another illustrative embodiment of the invention;

Fig. 3 is an enlarged fractional portion of Fig. 2 to show details;

Fig. 4 is an enlarged fractional section showing details of still another modification of the invention;

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Fig. 5 is a section taken on line 5—5 of Fig. 4; and

Fig. 6 is a plot showing the electrical characteristics of a thermistor device.

The embodiments of the invention as illustrated in the drawing can be conveniently described in terms of the methods of assembling them.

Referring to Fig. 1, 10 is a thermistor element in the form of a bead having leads 11 and 12 embedded therein. A satisfactory lead material is platinum. The bead may be made of any suitable conducting material having a high resistance-temperature coefficient. One suitable material consists of a mixture of 90 per cent Mn_2O_3 and 10 per cent NiO , heat treated at about 1300° centigrade in oxygen. The resistance of the bead may be controlled by varying the percentage of these oxide components, by adding other oxides such as those of cobalt or copper, or by employing other oxides or oxide combinations.

In this modification the leads 11 and 12 project respectively from opposite sides of the bead. The bead is inserted in the thin walled tube 14 of insulating material such as glass, adjacent one end, with lead 12 projecting from said end. Lead 11 may be made long enough to project from the other end of the tube or a conductor 13 may be secured to the end of lead 11 as by welding. One advantage of using the additional conductor 13 is that it may be made of a material having a thermal expansion coefficient approximating that of the glass or other insulating material used to enclose the bead. An alloy of copper, nickel and iron in proper proportions is suitable when a glass tube is used. The tube is sealed around the bead 10 and in intimate contact therewith. If the tube 14 is of glass, the sealing may be done by the application of sufficient heat to soften the glass. The other end of the tube is sealed around lead 11 or conductor 13 depending on which is employed.

An insulating closure or plug 15 for receptacle 16 supports the thermistor-lead assembly, conductor 13 and the end portion of tube 14 being secured in said plug. Another conductor 17 also projects through the plug 15. The receptacle 16 may be a glass vial. Fluent material 22 having a high thermal capacity and large thermal conductivity, fills the receptacle 16, surrounding the thermistor-lead assembly and conductor 17. A suitable material for this purpose is mercury.

The embodiment of the invention shown in Figs. 2 and 3 is similar to that shown in Fig. 1. An assembly of a bead 10, leads 11 and 12, conductor 13 and tube 14 has, in addition, a thin

coating 18 of metal over that portion of tube 14 adjacent to bead 10, as is shown in Fig. 3. The metal coating should be a material of high thermal conductivity, such as silver. In this modification, a block 30 of metal, such as copper, comprises the body having high thermal capacity and conductivity. The thermistor-lead assembly is secured within a cavity 31 in block 30 by means of a metallic binding material 32. Some suitable binding materials are a low melting point alloy, such as Wood's metal, or other similar bismuth alloys, or a mercury alloy, such as dental amalgam. If a low melting point alloy is used, the cavity 31 is filled with the alloy, the assembly inserted and held in place until the alloy solidifies. When employing amalgam, the assembly is inserted in cavity 31 and the amalgam packed around it. A conductor 17 may be suitably secured to the block 30 as by soldering in an orifice in said block.

For some purposes a thermistor having more than two connecting leads or electrodes is desirable. A thermistor-lead assembly suitable for such a device is shown in Figs. 4 and 5. This assembly is similar to those previously described but includes in addition another thermistor lead 19 which may have a conductor 29 welded or otherwise suitably secured thereto. As may be seen in Fig. 4, the seals at the ends of the tube 14 support the leads and attached conductors in spaced relation. The three leads 11, 12 and 19 may be spaced as indicated in Fig. 5. Although three leads are shown in Figs. 4 and 5, additional leads may be employed in a similar manner where necessary.

Although the foregoing illustrative modifications of the invention have been shown with one lead connected to the high thermal capacity and conductivity enveloping material, obviously all of the leads may be insulated from said material.

The materials so far disclosed as suitable for rapidly carrying heat away from the thermistor body are all electrical conductors. Since electrical and heat conduction generally go hand in hand, such materials are particularly suitable for this purpose. However, insulating materials having relatively high heat capacity and conductivity may also be employed.

Where insulating materials having suitable thermal characteristics to meet certain thermistor requirements are employed, the construction of the devices may be modified by omission of the insulating layer on the thermistor and leads. In such devices it will, of course, be necessary to bring out all of the leads through this insulating material. In devices of the type shown in Fig. 1, fluent insulating material, such as alcohol, glycerin, oil or a mixture of oil and sand could be used. Various self-sustaining insulating materials having reasonably high heat conductivity may be employed for the Fig. 2 type of device. Some such materials are aluminum oxide; a silicon, zircon, phosphoric acid composition and like materials.

The operation of these devices depends upon the fundamental characteristic of thermistors, that the resistance varies greatly with changes in thermistor temperature and upon the additional fact that the temperature change as a function of power input may be controlled.

If a negative resistance-temperature coefficient thermistor is subjected to a direct current of increasing magnitude, the voltage drop across it is found to increase to a maximum and then decrease. The static voltage-current curve of a

typical thermistor is shown in Fig. 6. Dynamically, the alternating current resistance is negative in the region beyond the voltage maximum E_m for sufficiently low frequencies. The dynamic characteristics of a thermistor are shown for several frequencies in Fig. 6. If a direct current of value I_b greater than I_c (that current corresponding to E_m) be applied to the thermistor, a superposed alternating current of frequency approaching zero will trace out a curve aob approximating the static characteristic. If the superposed current has a very high frequency, the thermal lag of the thermistor will prevent any change in temperature, and hence in resistance, from taking place. The voltage current trace, therefore, will be along the ohmic resistance line cod . At intermediate frequencies the superimposed current will produce traces as shown at e , f and g in the order of increasing frequencies. At low frequencies the effective alternating current resistance is negative, at high frequencies it is positive and at intermediate frequencies it may be either positive or negative; thus for some critical frequency it becomes equal to zero. This latter is the maximum frequency at which the thermistor can be made to act as an oscillator. If the thermistor has a positive resistance-temperature coefficient its characteristic may be illustrated by a current-voltage curve similar to the voltage-current curve of Fig. 6. Such a curve will have a current maximum similar to the voltage maximum E_m of Fig. 6.

A thermistor, the temperature of which will increase and decrease with sufficient rapidity to follow currents varying at audio frequency, has been called a high speed thermistor. The temperature will increase rapidly if (1) the increase in current or power is large, (2) the thermal capacity is small, and (3) the rate at which heat can get away from the thermistor is small. When the current or power is decreased, the temperature will decrease rapidly if (4) the decrease in power is large, (5) the thermal capacity is small, and (6) the rate at which heat can get away from the thermistor is large. A thermistor comprising a relatively small body of thermistor material having a pair of leads embedded therein and mounted in an evacuated vessel will satisfy the first five conditions but the sixth condition is not satisfied and consequently the thermistor does not cool rapidly enough when the power is decreased. The speed of this thermistor, however, can be increased by covering the thermistor body with a mass of material having high heat conductivity and large heat capacity, as is pointed out in the description of the devices illustrative of this invention. It is true that this procedure tends to violate condition (3) above, so that the body will not heat up as rapidly as it would without the added thermal material, however, this decrease in the rate of temperature rise can be compensated by using larger power. The net result is a decrease in the time taken for a complete heating and cooling cycle.

Although this invention has been described by reference to illustrative embodiments thereof, it is to be understood that it is not limited thereby but by the scope of the appended claims only.

What is claimed is:

1. A resistor having a declining voltage-current characteristic comprising a small bead of high negative resistance-temperature coefficient material, having a plurality of electrically conductive leads embedded therein, a tube of glass

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enclosing said leads and sealed around said bead, a container, a closure for said container, said closure supporting said glass tube within the container, and a body of mercury in said container and surrounding the glass tube.

2. A resistor having a declining voltage-current characteristic and comprising a small bead of high negative resistance-temperature coefficient material, having a plurality of electrically conductive leads embedded therein, a tube of glass having one end thereof sealed around said bead, one of said leads projecting outside of said tube through the glass seal and the others enclosed in said tube and projecting from the other end thereof, a container, a closure for said container, said closure supporting said glass tube within the container, and a body of mercury in said container and surrounding the glass tube, said one lead being in contact with said mercury and a conductor secured through said closure and making contact with the mercury.

3. A resistor having a declining voltage-current characteristic and comprising a small body of negative resistance-temperature coefficient material sealed in one end of a tube of insulating material, a plurality of electrical conductors secured to said body, one of said conductors projecting from the sealed end of the tube and the others extending through said tube and projecting from the opposite end thereof, a layer of metal on the sealed end of said tube, a body of metal having high thermal conductivity and large thermal capacity having a cavity containing the previously named elements, and a mass of metallic binding material filling the remainder of the cavity and securing said elements in place within said metal body, said one conductor being in electrical connection with said metal body and said other conductors and tube projecting from said metal body.

4. A declining voltage-current characteristic resistor comprising a small bead of oxidic material having a high negative temperature coefficient of resistance, a pair of substantially parallel wires embedded in said bead and projecting therefrom, a thin layer of glass sealed over said bead, a glass tube comprising an extension of said layer surrounding one of said wires, the other wire projecting sealably through said layer, a layer of silver over said glass layer, a body of copper having a cavity containing the previously named elements, and a mass of mercury alloy filling the remainder of the cavity and securing said elements in place within said copper body.

5. A resistor having a declining voltage-current characteristic and comprising a small body of negative resistance-temperature coefficient material, a pair of electrical conductors secured to said body, a tube of insulating material enclosing said body and one of said conductors, that portion of said tube adjacent the body being sealed around said body and covered with a thin

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layer of silver, a body of copper containing a cavity, the major portion of said tube including the sealed portion being in said cavity, and an alloy of bismuth having a melting point below 100° centigrade filling the remainder of the cavity, said enclosed conductor projecting from said tube outside of the copper body and the other conductor projecting from the sealed portion of the tube and in electrical contact with said alloy.

6. A declining voltage-current characteristic resistor comprising a small bead of oxidic material having a high negative temperature coefficient of resistance, a pair of wires embedded in said bead and projecting therefrom in opposite directions, a thin layer of glass sealed over said bead, a glass tube comprising an extension of said layer surrounding one of said wires, the other wire projecting sealably through said layer, a layer of silver over said glass layer, a body of copper having a cavity containing the previously named elements, and a mass of low melting point metal filling the remainder of the cavity and securing said elements in place within said copper body.

7. A resistor having a declining voltage-current characteristic and comprising a small body of negative resistance-temperature coefficient material sealed in one end of a tube of insulating material, a pair of electrical conductors secured to said body, one of said conductors extending through said tube and projecting from the opposite end of said tube and the other conductor projecting from the sealed end of the tube, a layer of metal on the sealed end of said tube, a body of metal having high thermal conductivity and large thermal capacity having a cavity containing the previously named elements, and a mass of metallic binding material filling the remainder of the cavity and securing said elements in place within said metal body, said one conductor and tube projecting from said metal body and said other conductor in electrical connection with said metal body through the binding material.

8. A resistor device comprising a small body of material having a high temperature coefficient of resistance, a plurality of electrically conductive leads embedded in said body and projecting therefrom, a tube of insulating material enclosing said body and a portion of each of said leads, the remaining portion of each lead projecting from the tube to serve as electrical connectors from said body to an external circuit, said tube being sealed around said body and the adjacent portion of said leads, and a mass of high thermal conductivity, large thermal capacity material enclosing and in intimate thermal contact with the major portion of said tube including the part containing said body.

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