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RESISTIVE ELEMENT

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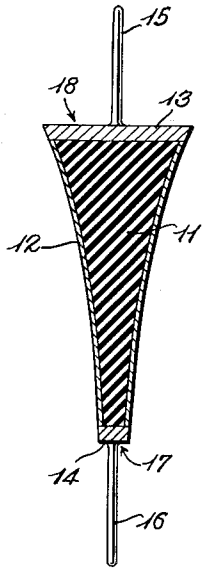

INVENTOR

Geoffrey King Walters

BY Stevens, Davis, Miller & Mosher

ATTORNEYS

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RESISTIVE ELEMENT

Geoffrey King Walters, Dallas, Tex., assignor to Texas Instruments Incorporated, Dallas, Tex., a corporation of Delaware

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This invention relates to novel resistive element which operates partially in the superconducting state and partially in the normal conducting state and which has a resistance equal to any prescribed monotonically increasing function of the current through the resistive element.

Many kinds of non-linear resistive elements, the resistances of which vary in a predetermined manner with the current flowing therethrough, are generally known. But prior to the present invention, there existed no simple circuit element the resistance of which could be prescribed to be any monotonically increasing function. As a result, many functions were not realizable at all by the use of simple circuit elements, but required multi-element complicated electrical circuits.

The element of the present invention comprises an insulating body coated with a film of material which is maintained at a temperature at which the material of the film is superconducting. The diameter of the body of insulating material increases from one end of the element to the other. When operating as a resistive element, the element is connected so that current flows from one end to the other. As the current is increased, the magnetic field associated with the current will increase. As the magnetic field increases, the superconductivity of the film will be destroyed by this magnetic field starting from the end having the smaller diameter and proceeding towards the end having the larger diameter. Thus, by selection of the diameter of the device as a function of the distance from the end having the smaller diameter, any monotonically increasing dependence of resistance on current may be obtained.

Other objects and advantages of the invention will become readily apparaent as the following description of the preferred embodiment unfolds and when taken in conjunction with the single figure of the drawings which shows a cross sectional view of the circuit element of the invention.

As shown in the figure, the device comprises a base or body **11** of insulating material having a coating or film **12**. The coating **12** is made of material which becomes superconducting when the temperature of the material is sufficiently low. Contacts **13** and **14** make electrical contact with the film **12** at each end of the element. The conductors **15** and **16** are electrically connected to the contacts **13** and **14**. The conductors **15** and **16** and the contacts **13** and **14** comprise a means to pass electrical current through the film **12**.

The cross section of the element is circular and the diameter of the circular cross section increases from one end **17** to the other end **18**.

Means are provided, not shown in the figure, to maintain the film **12** at a temperature at which the film would be superconducting. This could be, for example, a container of liquid helium in which the entire element would be immersed. When current flows through the element from one end to the other, a magnetic field will accompany the current. The stronger the current, the more intense will be the magnetic field. When a superconductor is placed in a magnetic field, it loses its superconductivity if the field is strong enough. The strongest magnetic field produced by the current flowing through the film **12** will exist where the current density is the greatest. The current density is a function of the diameter of the element and it will be greatest where the diameter is the smallest. Because the superconducting material is only a thin film of material, a moderate amount of current flowing through this film will be accompanied by a magnetic field which will have sufficient strength to destroy the superconductivity of the film. For relatively low currents, the superconductivity will be destroyed only at the end **17** of the element where the diameter is relatively small and with increasing currents more superconductivity will be destroyed approaching the end **18** having the large diameter. Thus, the distance from the small end of the element to which the superconductivity is destroyed is a function of the current flowing through the element. Therefore, the impedance of the element will be a function of the current. This function can be prescribed to be any monotonically increasing function simply by the choice of the shape of the element.

In a second embodiment of the present invention, the base or body **11** of the device may be of a material which becomes superconducting at low temperatures rather than of an insulator material. Thus, the resistive element disclosed herein may comprise a body of "superconducting" material of the shape shown in Figure 1 with or without a thin coating of a different "superconducting" material. The operation of either of these alternative devices is essentially the same as the preferred embodiment described above.

The above description is a preferred embodiment of the invention and many modifications can be made thereto without departing from the spirit and scope of the invention which is limited only as defined in the appended claims.

What is claimed is:

1. A resistive element comprising a body of insulating material, a thin coating on said body, said coating comprising a material which becomes superconducting below a given temperature, a means to maintain said coating below said given temperature, a first contact at one end of said body making electrical contact with said coating, a second contact at the other end of said body making electrical contact with said coating, said body having a shape such that the diameter of the cross section of said body increases from said one end of said body to said other end of said body.

2. A resistive element comprising a body, a thin coating on said body, said coating comprising a material which becomes superconducting below a given temperature, a first contact at one end of said body making electrical contact with said coating, a second contact at the other end of said body making electrical contact with said coating, said body having a shape such that the diameter of the cross section of said body varies from said one end of said body to said other end of said body.

3. A resistive element comprising a body, a thin coating on said body, said coating comprising a material which becomes superconducting below a given temperature, means to maintain said coating below said given temperature, means for passing current through said coating from one end of said body to the other end of said body, said body having a shape such that the diameter of the cross section of said body varies from said one end of said body to said other end of said body.

4. A resistive element comprising a body, a thin coating on said body, said coating comprising a material which becomes superconducting below a given temperature, means for passing current through said coating from

one end of said body to the other end of said body, said body having a shape such that the diameter of the cross section of said body increases from said one end of said body to said other end of said body.

5. A resistive element comprising a body of insulating material, a thin coating on said body, said coating comprising a material which becomes superconducting below a given temperature, means for passing electrical current through said coating from one end of said body to the other end of said body, said body having a shape such that the diameter of the cross section of said body varies from said one end of said body to said other end of said body.

6. A resistive element comprising a body, a thin coating on said body, said coating comprising a material that becomes superconducting below a given temperature, means for passing current through said coating from one end of said body to the other end of said body, said body having a shape such that the diameter of the cross section of said body varies from said one end of said body to said other end of said body.

7. A resistive element comprising a body of a material which becomes superconducting below a given temperature, a thin coating on said body, said coating comprising a material which becomes superconducting below a given temperature, a means to maintain said coating below said given temperature, a first contact at one end of said body making electrical contact with said coating, a second contact at the other end of said body making electrical contact with said coating, said body having a shape such that the diameter of the cross section of said body increases from said one end of said body to said other end of said body.

8. A resistive element in which the resistance increases with an increase in current passing therethrough, comprising a conical-like shaped body, means on said body to cause the resistance of said element to increase monotonically with an increase in the magnitude of the electrical current passing through said element whenever said element is subjected to a temperature lower than a predetermined value, said means comprising a coating of material capable of superconductivity, and said predetermined value being the critical temperature at which said material becomes superconducting.

9. The combination, comprising a resistive body composed of a material which becomes superconducting below a given temperature, means for maintaining said body below said given temperature thereby rendering said body normally superconducting, discrete portions of said body being characterized by different cross-sectional areas so that the magnetic field produced by current flowing through the discrete portions of said body varies in intensity in a predetermined manner, and means for passing current through the discrete portions of said body to establish a magnetic field surrounding the discrete portions capable of selectively destroying the superconductivity of the discrete portions of said body.

10. The combination according to claim 9 wherein said resistive body defines a thin film.

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