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ELECTRICAL RESISTANCE DEVICE

Filed Jan. 16, 1961

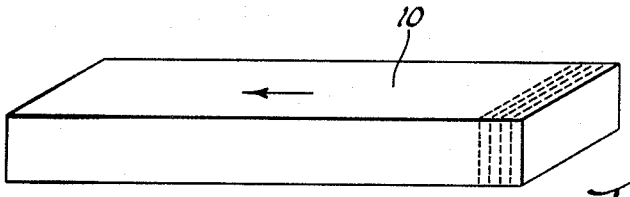


Fig. 1

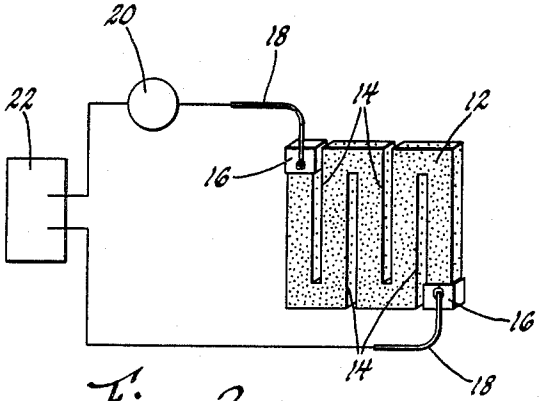


Fig. 2

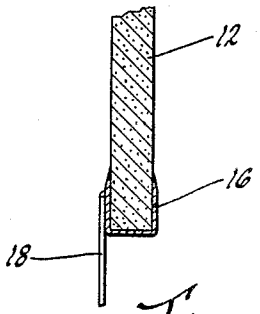


Fig. 3

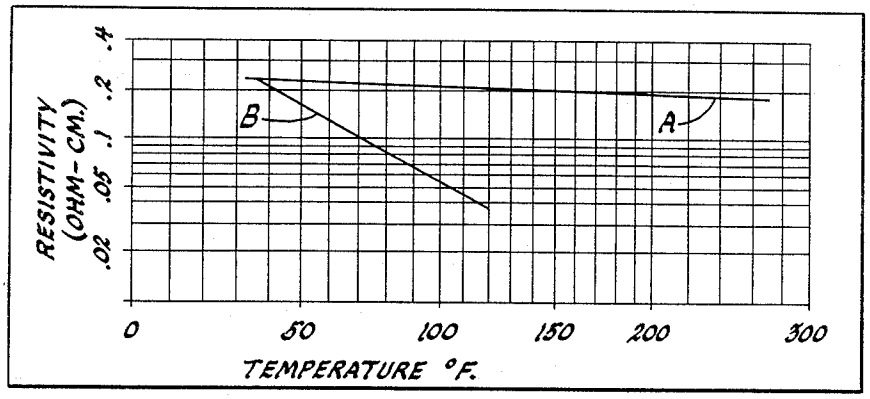


Fig. 4

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ELECTRICAL RESISTANCE DEVICE

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This invention relates to the composition and manufacture of a device for utilizing a pyrolitic graphite or the like as a thermistor for sensing temperature changes.

In conventional thermistors the thermistor material has a low coefficient of thermal conductivity and therefore only very small thermistors are practical for rapid and accurate temperature measurement. These small thermistors are incapable of carrying currents large enough to be useful without amplification of the current.

It is an object of this invention to provide a thermistor using pyrolitic graphite as the sensing element. In forming pyrolitic graphite a nucleus of heated commercial graphite is placed in a hydrocarbon-gas stream whereby as the graphite picks up carbon from the gas, crystals of oriented graphite form with their flat surfaces parallel to the existing surface. Crystals then join each other with strong bonds along the flat planes but bonds between the layers are weak. Heat travels hundreds of times more easily along the layers than through them. The pyrolitic graphite material has an extremely high coefficient of thermal conductivity in the direction of the layer plane and allows the carrying of more current with easy dissipation of the internal resistance losses and therefore can be used satisfactorily as thermistors without the need for utilizing amplifying devices. The good heat transfer characteristics of pyrolitic graphite lengthwise of the crystals makes this material very quickly responsive to temperature changes and the heat stability of the material is excellent.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawing wherein a preferred embodiment of the present invention is clearly shown.

In the drawing:

FIGURE 1 is a perspective view showing a blank wafer of pyrolitic graphite from which the thermistor elements are cut.

FIGURE 2 schematically shows a thermistor connected in a circuit for measuring temperature changes.

FIGURE 3 is an enlarged sectional view showing the arrangement for attaching an electrical conductor to the pyrolitic graphite shown in FIGURE 2.

FIGURE 4 is a graph showing the relationship between resistivity and temperature in representative pyrolitic graphite materials.

Referring now to the drawings wherein a preferred embodiment of the invention has been illustrated, FIGURE 1 shows a blank **10** of pyrolitic graphite from which thermally sensitive resistors are cut. The layer plane of the blank **10** is in the direction of the arrow shown thereon and as is well known, the thermal conductivity in this direction is at least one hundred times the conductivity perpendicular to the layer plane. The crystallites of the material have their basal planes aligned substantially parallel to the top surface of the blank **10**.

Pyrolitic graphite has been known since at least 1883 as indicated in the magazine entitled Machine Design for May 26, 1960, to which reference may be made for information on a recent technique for making pyrolitic

graphite. Pyrocarbides such as silicon carbide and tungsten carbide may also be used and made in the same manner as one would use and make thermally sensitive resistors of pyrolitic graphite material.

In making thermally sensitive resistors, commonly called thermistors, a blank, such as the blank **10** shown in FIGURE 1, is sliced along the dotted lines shown therein so as to obtain blanks which can then be slit as indicated at **14** in FIGURE 2 of the drawing so as to form a substantially serpentine thermistor element having the shape shown in FIGURE 2. In order to make connections to the ends of the thermistor element the ends of the pyrolitic graphite material are first copper plated by electroplating copper on the pyrolitic graphite so as to form copper caps **16**, as shown in FIGURES 2 and 3. A conductor **18** can then be soldered to each copper cap **16** so as to make a good electrical connection to the thermistor element.

FIGURE 4 shows the relationship between resistivity and temperature of pyrolitic graphite material. The upper line A shows the relationship in a relatively coarse grain thermistor element whereas the lower line B shows the relationship in a relatively fine grain thermistor element.

It will be noted that the negative temperature coefficient is greater in a fine grain thermistor than in a coarse grain thermistor. The grain structure of the material is controlled in the manufacture of the material in accordance with known principles. Thus, when the thermistor material is made by the process involving high temperature pyrolysis of carbon containing vapors, the higher the temperature, the finer is the grain structure produced.

By connecting the thermistor element **12** in series with a galvanometer or other current flow responsive device **20** and then supplying current to the circuit from a power source **22**, the device can be used as a controlling device or a device for very accurately detecting and indicating temperature changes without the need for using any amplifying equipment and with a minimum of deviation resulting from internal resistance losses.

While the embodiment of the present invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. A thermally sensitive resistor element comprising, a fine grain polycrystalline form of graphite in which the layer planes of the graphite crystals are perpendicular to the direction of current flow, said element comprising a serpentine member having terminals secured to its ends.

2. A thermally sensitive resistor comprising, a polycarbide selected from the class consisting of silicon carbide and tungsten carbide and having oriented elongated crystals, and means for passing a current through said resistor in the general direction perpendicular to the layer planes of said crystals.

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