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3,146,340

HEATING DEVICES

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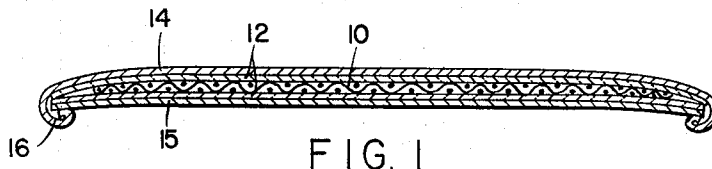


FIG. 1

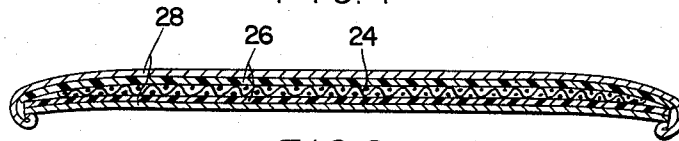


FIG. 2

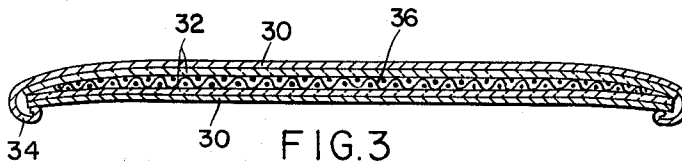


FIG. 3

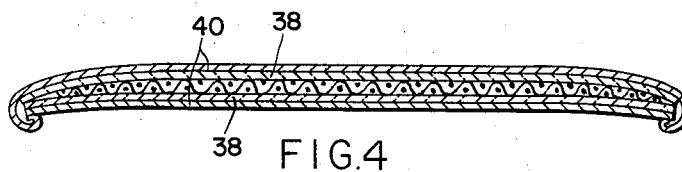


FIG. 4

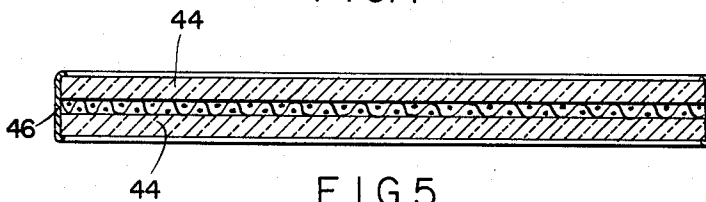


FIG. 5

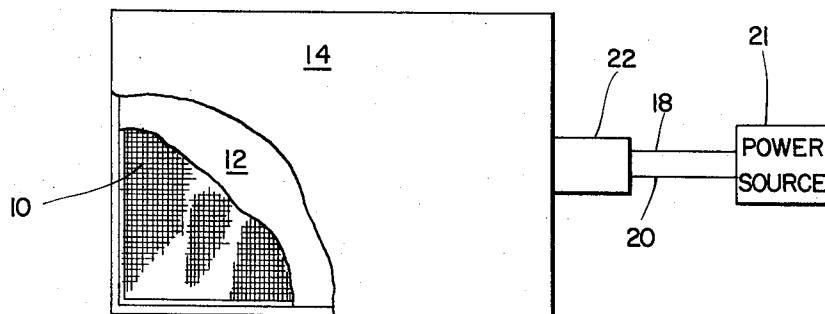


FIG. 6

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HEATING DEVICES

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1 Claim. (Cl. 219—520)

This invention relates in general to electrical heating devices and more particularly is directed towards a new and improved heating apparatus which employs encapsulated graphite cloth as the primary heating element.

Carbon products, particularly those made of graphite, have many uses in the electrical field, frequently being employed as electrodes in electric furnaces, as anodes for electrolytic processes, for motor and generator brushes, as anodes and grids for electric tubes, as well as for numerous other components. In addition to the conventional graphite products which have been available heretofore, there has been added a graphite cloth which is felted or woven from strands of graphite filaments. One of the primary features of this cloth is that when electrically energized, it provides a radiation surface much greater than that of a rod or tube containing the same quantity of graphite. The graphite cloth is therefore extremely useful and possesses the further advantage of having a low thermal mass.

However, the utility of the graphite cloth tends to be restricted in some fields because of the fact that the material deteriorates rather quickly in air at temperatures over 600 degrees centigrade. This characteristic is common to all graphite components to a greater or lesser extent but is a particularly bothersome problem in applying graphite cloth to certain practical applications, such as hot plates and the like, where a heating element having a long, useful life is required.

Accordingly, it is an object of the present invention to increase the useful life of graphite cloth heating elements.

Another object of this invention is to provide a durable, highly efficient heating element having a low thermal mass coupled with high emissivity.

Yet another object of this invention is to provide a simple yet effective encapsulator for graphite cloth.

Still another object of this invention is to provide an improved, variable temperature heating element for use in cooking and similar applications wherein a broad heating surface is required.

More particularly this invention features a heating device in which the primary heating element is a section of graphite cloth encapsulated in a hermetic envelope. In a preferred embodiment the encapsulation comprises two sheets of electrically insulating and thermally conductive material mounted on opposite sides of the graphite cloth and marginally sealed to prevent air from coming into contact with the graphite element. Various switching arrangements may be employed to vary resistance of the element and thus obtain a variety of heating temperatures.

But these and other features of the invention, along with further objects and advantages thereof, will become more readily apparent from the following detailed description with reference being made to the accompanying drawings in which:

FIG. 1 is a cross sectional view in side elevation of a heating device made according to the invention,

FIGS. 2 to 5 are views similar to FIG. 1 but showing modifications of the primary embodiment, and

FIG. 6 is a top plan view of the FIG. 1 device with portions broken away to show details of construction.

In general, the illustrated device comprises a section of sheet carbon material particularly graphite cloth pro-

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vided with suitable leads for connection to an electrical power source and encapsulated within a sealing outer integument of thermally conductive, electrically non-conductive and gas impermeable material. Various switching arrangements may be employed to vary the resistance of the graphite cloth and to provide a wide range of operating temperatures. For normal applications, the graphite fabric may be energized to any temperature from ambient temperature to 1000 degrees F. At temperatures over 600 degrees F., the graphite fabric tends to oxidize in air and by encasing the fabric within a suitable encapsulating material, it is possible to extend greatly the useful life of the fabric.

A preferred fabric is woven in a plain weave from fibers of high purity graphite carbon having a tensile strength in the 50,000 to 100,000 p.s.i. range. These fibers are produced by processing carbonaceous materials at temperatures up to 5400 degrees F. Such graphite fibers display high thermal conductivity and good electrical conductivity. Chemical analysis of the graphite fiber indicates a 99.09% plus carbon content with an ash content of approximately 0.04%. There are no major impurities present in the graphite fibers and the minor impurities are limited to magnesium and aluminum with trace impurities of calcium, iron, manganese, silicon, boron, copper, nickel and sodium. The material sublimates at approximately 6600 degrees F. (3650 degrees C.) without melting. The filaments have an average diameter ranging from 0.00005 to 0.001 inch. The fabric has a thread count per inch ranging from 20 to 30, a thread diameter ranging from 0.01 to 0.04 inch and number of filaments per inch ranging from 1 to 2,000.

Referring now to FIGS. 1 and 6 in the drawings, the reference character 10 indicates a heating element of woven graphite cloth having a generally rectangular configuration and sandwiched between two sheets 12 of electrically insulating but thermally conductive material.

One material which has been found to be particularly well adapted for use as the insulating sheets 12 is an inorganic, vitreous siliceous refractory material such as artificial mica, commercially available under the trademark "Thermica," from the Huse Liberty Mica Co. Thermica does not outgas up to 2000 degrees F., does not deteriorate until well beyond 2300 degrees F. and does not melt until 2500 degrees F. is reached. These limits are well beyond the range for many practical applications of this heating element.

The Thermica sheets 12 are marginally joined to one another to form an air tight seal and thereby prevent air from coming into contact with the graphite cloth 10. Preferably, these sheets are disposed between a pair of stainless steel sheets 14, 15, the marginal edges of which are sealed by rolling the edges of sheet 14 about those of sheet 15. These stainless steel sheets provide excellent wearing surfaces for the insulated heating element. A bead 16 which results from rolling the edges of sheet 14, ensures a rugged, integrated construction.

The graphite cloth 10 may be energized by means of leads 18 and 20 connected to a suitable D.C. or A.C. power source 21 and connected to the cloth through a switching device 22. It will be understood that the electrical connection may be so arranged that only a single predetermined operating temperature or a variety of operating temperatures are available. If a variable temperature control is desired, a multi-position switch may be used in conjunction with various connecting arrangements, which will provide a selection of different resistances, according to the position of the switch. By way of example, the graphite cloth 10 may be provided in a plurality of rectangular strips which may be electrically connected from end to end in series for maximum resistance, or the strip may be electrically connected across

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their center portions. Numerous combinations of series and parallel circuits are possible so that any range of operating temperatures may be provided.

In any event, the graphite cloth heating element, because of its low thermal mass, is able to attain maximum temperature within a very short period, requiring only 30 seconds to reach 1000 degrees F. from room temperature on ordinary house current. Approximately 60 to 90 seconds are required for the element to return to ambient temperature when deenergized.

In FIGS. 2 to 5 there are illustrated several modifications of the invention. In FIG. 2, a section of graphite cloth 24 is mounted between two layers 26 of a thermosetting, heat resistant plastic encapsulator, for example a vinylidene chloride polymer called pyroceram, with stainless steel cover layers 28 fastened over the outer surfaces of the assembled layers as above.

In FIG. 3, two sheets 30 of stainless steel have their inner surfaces coated with a thick layer of vitreous enamel 32 and are marginally connected to one another by a rolled edge 34 which forms an air tight seal to protect a graphite cloth heating element 36 disposed between the enamelled surfaces. In FIG. 4, sheets of a vitreous, heat resistant fabric such as fiberglass 38 are used to encapsulate the graphite cloth heating element with stainless steel sheets 40 providing a wearing surface, as before.

In FIG. 5, a section of graphite cloth 42 is shown mounted between two glass plates 44 held together by a marginal seal 46 which may be of stainless steel or other suitable material. Preferably the plates 44 should be fabricated from a glass that has a high melting point and is resistant to heat and shock. "Vycor", a transparent, high-silica glass, available from Corning Glass Works, has been found particularly satisfactory for the purpose. Vycor possesses exceptional stability, has a very high softening point with a very low coefficient of thermal expansion. The softening point is in the neighborhood of 1500 degrees C. and the linear coefficient of expansion per degrees C. is 0.0000008.

By encapsulating the graphite cloth heating element in the manner described above, its useful life is extended many times over what it would normally be if exposed to the air during energization. While the invention has been described with particular reference to the illustrated embodiments, it will be understood that numerous modifications may be made without departing from the invention. For example, although the encapsulated graphite cloth has been illustrated as embodied in a hot plate, it could equally well be incorporated into toasters, ovens, or similar heating devices. In such case, the heating device would not come into direct contact with the object being heated and the stainless steel cover sheets may be omitted. The marginal portions of the insulating sheets may then be sealed by a variety of suitable means. To eliminate all traces of air from the sealed envelope the several pieces, in one process, are assembled under a vacuum or an inert gas such as nitrogen or argon. It will be understood also that encapsulating materials other

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than those described may be used to good advantage in the device. For example, complete potting of the cloth, as by immersing it in a suspension of alumina gel, has been found effective in extending the life of the cloth. Other materials will appear to those skilled in the art.

Having thus described our invention, what we claim and desire to obtain by Letters Patent of the United States is:

A heating device comprising a section of graphite fabric, said fabric being woven from fibers of high purity graphite carbon having a tensile strength in the 50,000 to the 100,000 p.s.i. range, said fibers being composed of filaments having an average diameter ranging from 0.0005 to 0.001 inch, a strata of gas impermeable, thermally conducting and electrically insulating material overlying opposite sides of said fabric, said strata conforming in outline to said section of fabric but of slightly increased dimensions and being marginally connected to one another to completely encapsulate said fabric, at least one stratum of thermally conducting and laterally stable sheet material conforming in outline to said strata but of slightly increased dimensions and supporting said composite fabric and electrically insulating strata throughout their entire lengths and widths to provide an integrated laterally stable heating device, electrical leads passing through said composite structure and connected to the marginal edges of said fabric at selected locations to define a variety of electrical paths of predetermined electrical resistance values and switching means connecting with said leads for electrically energizing selected portions of said fabric and in selected relationships.

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