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ELECTRICAL HEATING UNIT WITH AN INSULATING REFRACTORY SUPPORT

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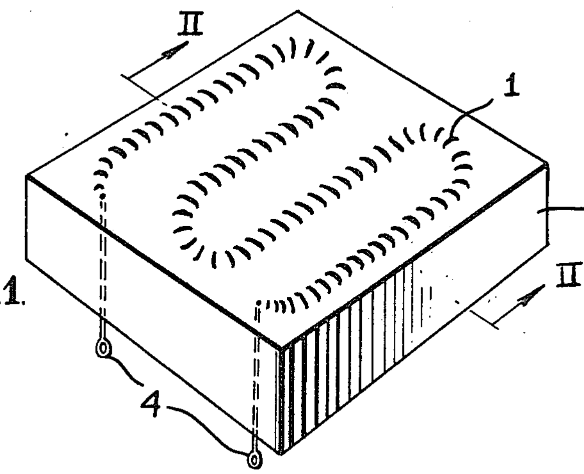

Fig.1.

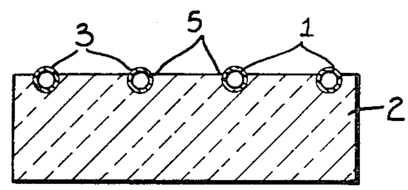

Fig.2.

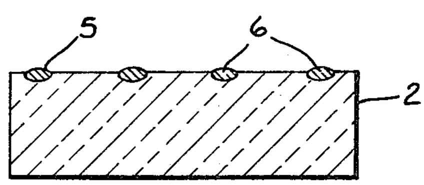

Fig.3.

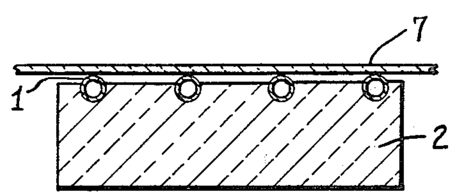

Fig.4.

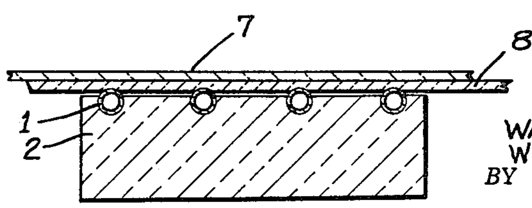

Fig.5.

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ELECTRICAL HEATING UNIT WITH AN INSULATING REFRACTORY SUPPORT

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U.S. Cl. 219—544 7 Claims

ABSTRACT OF THE DISCLOSURE

A composite, thermally insulated electrical heating unit comprising an electrical heating element substantially embedded and secured within an insulating body of filter molded inorganic refractor fiber.

BACKGROUND OF THE INVENTION

This invention relates to an improved composite construction for electrical heating units such as typically employed in electrical cooking stoves and similar domestic and commercial electrical heating appliances such as hot plates, ovens, warmers, toasters, grills, broilers, and commerical, laboratory and hobby furnaces or kilns, and the like providing maximum heating efficiency and direction of heat, and effective support and protection for the electrical heating element.

Electrical heating elements such as the currently common domestic stove units of the type known as Calrod (a General Electric Co. product comprising a resistance heating wire embedded in alumina encased within a metal sheath), or similar rigid self-supporting units are generally fully exposed and thus radiate heat in all directions with an appreciable heat loss whereby present stove constructions normally employ underlying reflective metal bowls to minimize the loss of heat downward or away from the generally superimposed object to be heated. Nevertheless, the heat dissipation is significant and aside from the low efficiency and poor economics of such a system, it results in a stove which is relatively ineffective in rate of heating and capacity in relation to gas fired stoves.

Also, electrical heating elements which are not rigid or self-supporting such as common resistance wires, wire coils, metal bands or strips, and thus are mounted or supported upon dielectric structures such as mica sheets or common dense refractory bodies are similarly susceptible to wasteful heat losses not only by radiation in ineffective directions, but because of conduction of heat away from the intended object to be heated and its resulting dissipation through the mounting or supporting body which due to its typical density or composition is of poor thermal insulating properties. Moreover, the attempted applications of heat insulations to electrical elements to reduce such uneconomical heat losses have encountered problems in attaching the components due to difference in coefficients of expansion, a deficiency of bonding adhesives in joining such diverse materials and at the high temperatures encountered and with variations in thermal expansion, and the openness or porous nature and the lack of rigidity or flexibility and compressibility and low strength of many of the more effective thermal insulating compositions.

Summary of the invention

This invention consists of electrical heating units comprising an electrical heating element embedded within a surface or surfaces of an inorganic refractory fiber insulating body formed by means of filter molding the inorganic refractory fiber in situ about the electrical heating element

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with at least a portion of the area of said heating element exposed at a surface of the body of inorganic refractory fiber whereby the filter molded in situ resilient inorganic refractory fiber securely embraces the heating element and anchors the same within the body of inorganic refractory fiber.

It is the principal object of this invention to provide a composite electrical heating unit for domestic and commercial stove cooking surfaces and other heating devices which is more economical in operation and fabrication and of improved heating efficiency, as well as embodying a self-containing, practical and effective thermal and electrical insulating mounting or support for electrical elements, and the protection thereof.

Brief description of the drawings

This invention will be more fully understood and further objects and advantages thereof will become apparent when reference is made to the following detailed description of a preferred embodiment of the invention and the accompanying drawings in which:

FIG. 1 is a pictorial view illustrating a preferred composite electrical heating unit of this invention comprising a coiled wire resistant heating element;

FIG. 2 is a cross-sectional view of the preferred composite electrical heating unit of FIG. 1 taken along line II—II;

FIG. 3 is a cross-sectional view similar to FIG. 2 illustrating the composite electrical heating unit of the invention constructed with a typical Calrod type of element embedded within the body of refractory insulating fiber;

FIG. 4 is a cross-sectional view similar to FIG. 2 illustrating the preferred embodiment of the invention provided with a refractory glass cover; and

FIG. 5 is also a cross-sectional view similar to FIG. 2 illustrating the electrical heating unit of the invention provided with an electrical insulating sheet to insulate the exposed electrical resistant coil in combination with a refractory glass cover.

Description of the preferred embodiment

This invention comprises a composite, highly effective, insulated electrical unit, adaptable to a variety of applications as set forth hereinbefore, wherein the electrical heating element is securely and permanently embedded within a thermal insulating body of optimum effectiveness at temperatures and conditions normally encountered with such units, and which also provides support and protection for the element if required, and method of achieving the same. The invention enables the utilization of highly effective insulating materials of low density, flexible and resilient integrated masses of inorganic refractory fiber with conventional electrical heating elements by forming and effectively permanently affixing the body of insulating fibers about the electrical heating element by means of filter molding the fibrous insulating material into a securely embracing integrated mass of fiber about the element surrounding it on all sides except the surface area intended to transfer and precisely direct the generated heat, and obviates such difficulties as cutting of the insulation to accept the element, the use of inadequate bonding adhesives or securing devices and the problems of attempting to effectively unit an element, which may itself be completely flexible such as a resistant wire coil, to a non-rigid and compressible body as well as the subsequently encountered relatively different movement of the components due to unlike coefficients of expansion upon heating.

The formation of the fibrous insulating body about the heating element by means of filter molding in situ causes the individual fibers during filtration to embrace the element over all its surfaces exposed and to uniformly intertwine and knit themselves thereabout while accumulating upon the filter surface and the electrical heating element positioned thereon, and even to enter into an open wire coil such as in common wire electrical resistant heating elements, with the result that the integrated body of fibers uniformly encompass the element over all contacting surfaces. This overall uniformity of contact, together with the cramping effect of the substantially individually and pressure applied resilient fibers uniformly over the surface area of the element embedded within the formed fiber body, firmly and securely anchors the embedded element within the body of fibrous insulation notwithstanding the exposure of at least a portion or area of the heating element at a surface of the insulating body to permit effective transmission and direction of heat. Moreover, the cramping effect of the body formed in situ under pressure from substantially individual fibers through filter molding is not discernibly reduced due to differences in thermal expansion or contraction upon heating or cooling because of the resilient properties of the fibrous body formed by filter molding. Additionally when the electrical heating element is round or eliptical as is typical if not an open coil wherein the fibers usually actually penetrate the element, the forming of the fibrous insulating body in situ about the element by filter molding produces an encompassing body extending about all portions of the element except the limited area exposed at a surface of the insulating body which in most cases includes a lip extending on both sides beyond a 180° of the round or eliptical element thereby providing an additional locking of the embedded element within the insulating body.

A preferred embodiment of this invention comprises a typical wire or ribbon coil resistant heating element embedded within a body of inorganic refractory fiber insulation formed by filter molding the fiber in situ from a liquid suspension about the coil, as illustrated in FIGS. 1 and 2. Coil resistant heating element **1** is substantially embedded, arranged in a common serpentine pattern, just within the surface of the filter molded insulating body of inorganic refractory fiber **2** having only a limited portion of its area **3** exposed at the surface of body **2** and substantially flush therewith. Lead wires **4** from the coil resistant heating element **1** usually pass back through the insulating body **2** as illustrated to provide for connection with a source of electrical current, but may be positioned in any apt location suitable for the designed insulation. As is clearly illustrated in FIG. 2, comprising a cross-sectional view taken along the line II—II of FIG. 1, the filter molded in situ insulating body **2** includes integral lip like portions **5** extending substantially all about coil **1** except for the limited area exposed at the surface of the insulating body, and thus further effectively gripping the element. Due to the high insulating efficiency of low density fibrous insulations the dissipation of heat in downward or lateral, or in other wasteful directions, is substantially completely inhibited and the generated heat is concentrated and directed to the object or area to be heated.

The filter molding operation of this invention comprises positioning the given electrical heating element upon a suitable filter molding screen or filter with the heating element in the desired configuration or pattern, such as the common serpentine or spiral arrangement frequently employed in heating element constructions of domestic electrical cooking stoves. The area of the heating element to be exposed at the surface of the insulating body is placed in direct contact with the screen or filter member. If necessary, the element can be fixed thereon to prohibit movement during filtering and formation of the insulating body thereabout. The screen or filter element may be conventional for such operations with openings or of a mesh sized to substantially retain the fibers or solid constituents of the suspension. And, although the screen or filter element mold may be over sized whereby a larger insulating body than required is formed and thereafter cut to size, in deference to economics it is preferred that the mold screen be designed as to size and configuration to precisely mold the insulating body.

The filter molding slurry comprises the refractory fiber and any other desired ingredients such as binder, fillers, filter aids, coloring pigments, etc., dispersed within the liquid medium in proportions to provide a relatively dilute suspension as, for example, approximately 0.1 to 10% by weight of total solids and preferably about 1% by weight of total solids. The filtering operation can be carried out with conventional apparatus with the filtering action of forcing the liquid phase of the suspension of solids through the mold screen being induced by a pressure differential provided either by the application of subatmospheric pressures downstream of the filler or the application of super atmospheric pressure upstream through any spot means including a hydraulic head or the application of pneumatic, hydraulic or mechanical piston means, and including open or closed filter chambers. A subatmospheric or vacuum activated filtering operation is preferred with the pressure induced by a pump because of the relatively simple equipment requirements and flexibility.

The filtering operation of forcing the liquid component of the suspension through the filter mold or screen and thereby retaining and accumulating or collecting the fiber and any other entrained solids on the screen, forming the body of the insulation about the element positioned thereon, is simply continued until the insulating body has built up to the required or desired thickness, generally at least about 0.25 and preferably about 0.5 inch greater than the depth of the electrical heating element embedded in the body. Densities of the resulting filter molded fibrous insulating bodies for maximum insulating efficiency and ample strength should range from about 4 to about 30 pounds per cubic foot and preferably about 10 to 15 pounds per cubic foot for an optimum balance of insulating efficiency and strength. Product densities can be achieved or controlled through conventional means comprising the kind of fiber, degree of pressure applied, composition of the slurry, etc.

Suitable inorganic refractory fibrous material for the insulating body of this invention comprises those known manufactured fibrous products which are of a temperature resistance and composition to effectively resists thermal deterioration at the contemplated or designed temperature levels of use of the particular burner and additionally provide a reasonable safety margin over maximum operating temperatures. Fibrous materials include semi-refractory wools or mineral fibers formed of relatively pure rock or argillaceous matter, or metallurgical slags which normally provide, depending upon composition or purity thereof, thermal resistance up to about 1200 to 1500° F., but preferably high refractory compositions such as silica or quartz, magnesia, alumina-silica compositions including those alumina-silica compositions containing titania and/or zirconia in wide ranges of proportions as known in the art, etc., and assorted combinations of such synthetically produced inorganic fibers which exhibit resistance to reterioration at temperatures up to in the order of 2000 to 2500° F. Such heat resistant synthetic fibers and compositions therefor are more fully discussed in an article entitled "Critical Evaluation of the Inorganic Fibers" in Product Engineering Aug. 3, 1964, pages 96 to 100. The relatively stiff but resilient characteristic typical of these synthetically produced inorganic fibers provides, upon formnig by filter molding in situ, the gripping or cramping effect which more securely embraces the electrical element.

Preferably, the inorganic fibrous insulating body includes a binder dispersed throughout the fibers to enhance the adherence of the fibers to each other and in turn the integrity and strength of the resultant insulating body. Among apt high temperature binders are for example clays such as bentonite or hectorite, alkali metal silicates such as sodium and potassium silicates, frit, borax, aluminum phosphate, colloidal silica, colloidal alumina, etc. and combinations thereof in finely divided particulate, liquid suspension or solution form. Suitable proportions of refractory fiber to inorganic binder comprise approximately 60 to 100 parts by weight of fiber to approximately 0 to 35 parts by weight of binder with a typical optimum of about 75 to 90 parts by weight of fiber per 25 to 10 parts by weight of binder. Binder may be applied either by dispersing the same in the stock suspension of fiber in the liquid and collected upon the fiber during the filter molding operation, and/or by means of a subsequent application or impregnation of the formed insulating body if inorganic refractory fiber.

In addition to the inorganic refractory fiber and inorganic binders, small proportions of various other additives or components may be included to improve or augment the manufacturing process or contribute specific properties. For example, organic or fugitive binders which burn out such as common starch based binder materials and synthetic or natural resins may be appropriate to contribute green or pre-dried strength to facilitate handling or other manufacturing operations. Also, small proportions of non-refractory fibrous materials such as cellulosic fibers as exemplified by news or kraft pulp also may be effective in enhancing filtering or contributing to pre-dried strength or coherence in the green or unifired product.

Typical fibers of the amorphous or glassy, anhydrous inorganic oxides such as those referred to above, are dielectrics and constitute effective electrical insulating materials whereby, when employed with a dielectric binder such as a clay, sodium silicate, colloidal silica and others given, provide effective electrical insulations for the electrical heating elements such as common wire resistant coils over extended temperature ranges as well as comprising highly effective thermal insulations in low density masses. Accordingly, the insulating bodies of refractory inorganic fiber of this invention provide adequate electrical insulation in addition to their other attributes and thus frequently obviate the necessity for any additional electrical insulation in many applications.

Further significant embodiments of this invention are shown in FIGS. 3, 4 and 5. FIG. 3 illustrates a composite product of this invention comprising an enclosed or Calrod type of heating element **6** which is flattened to an elliptical or oval cross-section configuration to expand the effective heating surface area. When element **6** is embedded in the body of fibrous insulation **2** to a depth beyond its transverse center, a lip-like portion **5** integral with the body **2**, adds to the gripping power of the filter molded in situ fibers embracing the electrical heating element and further securely anchoring the same therein.

It is frequently desirable due to the porous nature of the low density fibrous insulation to provide an overlying protection against its contact with or penetration by dirt or liquids, especially in applications of the composite product of this invention to, for example, the surface cooking elements of domestic or commercial electric ranges which are especially subject to spilling of or other contact with foods, cooking oils and greases, cleaning preparations, etc. which not only degrade the effectiveness of the thermal and electrical insulating properties of the body of fibrous material but present a highly disagreeable condition and potential hazard. Accordingly it is within the concept of this invention to provide an overlying heat transmitting and fluid impervious cover such as a thermally shock resistant ceramic or glass appropriately secured to the surface of the insulating body of refractory inorganic fiber containing the exposed portion of the electrical heating element. This embodiment is illustrated in FIG. 4 wherein the protective heat transmitting, fluid impervious cover **7** is shown spanning the upper surface of insulating body **2** and electrical heating element comprising resistant wire coil **1**. Securing of the protective covering in position overlying the insulating body may be mechanical to obviate the necessity of bonding agents although this latter means may be utilized if appropriate.

Because of the hazards of the relatively high voltage electrical current of exposed resistant coils and other electrical heating elements in certain applications or constructions, including for instance the fact that at high temperatures certain of the thermally shock resistant glasses are somewhat electrically conductive, it may be expedient or even necessary and within the scope of this invention to superimpose an electrical insulation over the portion of the electrical heating elements exposed at the surface of the filter molded insulating body of inorganic refractory fiber. A preferred electrical insulation for use in this invention consists of a sheet of an inorganic refractory fiber material, of compositions disclosed hereinbefore, superimposed over the portion of the electrical heating elements exposed at the surface of the filter molded body of inorganic refractory fiber, notwithstanding the inherent thermal insulating qualities of fibrous materials because the relatively low thermal resistance of common dielectric materials or electrical insulations, or the rigid inflexibility and difficult to cope with thermal expansion and other difficult attributes of conventional ceramic electrical insulation frequently renders them wanting or unsuitable. However, to preserve economical and effective heating capacity, the electrical insulating sheet of inorganic refractory fiber superimposed over the portion of the electrical heating elements exposed at the surface of the filter molded body of inorganic refractory fiber should be of a thickness substantially less than the thickness of the body of inorganic refractory fiber filter molded about the electrical heating element which succeeds the depth of the said electrical heating element embedded therein. Thus, the greater thickness of the body of the inorganic refractory fiber filter molded about the electrical heating element except at the portion exposed at the surface of said molded body, will cause a majority of the heat generated by the embedded electrical heating element to be transmitted through the considerably thinner superimposed sheet of electrical insulating inorganic refractory fiber. The electrical insulating sheet of inorganic refractory fiber superimposed over the insulating body of inorganic refractory fiber and exposed area of the electrical heating elements being of a non-rigid or resilient construction and composition like that of the body of filter molded inorganic refractory fiber, these components can be united to each other effectively through conventional high temperature bonding agents since they are of like or similar composition and construction providing like or similar coefficients of expansion or if of different coefficients of expansion are sufficiently resilient and possess sufficient give as not to disrupt the bond therebetween whereby they may become effectively and permanently united through available bonding agents, or may be simply secured into positions through mechanical means. FIG. 5 illustrates the foregoing aspect of this invention wherein a relatively thin sheet of electrically insulating inorganic refractory fiber **8** is superimposed over the surface of the filter molded insulating body of inorganic refractory fiber exposing a portion of the electrical heating element and thereby providing an effective electrical insulation encompassing the electrical heating element **1**. Also as shown in FIG. 5 this embodiment may be optionally provided with a protective heat transmitting fluid impervious covering **7** to impede the penetration of fluids or other possible contaminates.

Additional means of protecting the surface of the body of inorganic refractory fiber, and/or increasing its strength and resistance to abuse, is to impregnate or treat the surface or entire body with an appropriate indurating agent such as sodium silicate, colloidal silica, colloidal alumina, aluminum phosphate, zirconium pyrophosphate, etc.

An exemplary preferred means of producing the electrical heating units of this invention comprises filter molding from a dilute water suspension, in percent by weight of 12% (0.42 lb.) binder of Baymal solids, Du Pont's colloidal alumina product described in U.S. Patent No. 2,915,475; 4% (0.14 lb.) papermakers alum (aluminum sulfate) coagulant; and, 84% (2.94 lbs.) inorganic refractory fiber Cerafiber, Johns-Manville Corp.'s refractory fiber of substantially equal pats of alumina and silica, dispersed in 100 gallons of water. The papermakers alum is included to flocculate the Baymal binder to increase its retention upon the fiber and thus minimize loss of the colloidal material during filtering.

Upon positioning the electrical heating element directly upon the filtering element, arranged in the desired pattern, the filtering element, connected with a suitable vacuum system, is submerged into the above suspension and a sub-atmospheric pressure of about 20 inches of mercury applied thereto. The fibrous material is thereupon uniformly and firmly deposited and fixed over the exposed surface of the heating element and accumulated to a depth of about 1 inch and dry density of approximately 12 p.c.f. on the mold screen measuring 5 inches square in about 25 seconds time.

An optional procedure is to filter mold the insulating body about the heating element from a suspension of fibers without binder, and if appropriate apply the binder subsequent to formation through impregnation or other apt means.

It will be understood that the foregoing details are given for purposes of illustration, not restriction, and that the variations within the spirit of this invention are intended to be included within the scope of the appended claims.

What we claim is:

1. An electrical heating unit comprising an elongated electrical heating element securely embedded in gripping embrace within the surface of an insulating body of a resilient mass of integrated inorganic refractory fiber filter molded in situ about the elongated electrical heating element with at least a portion of said elongated heating element substantially along its length exposed at a surface of the embracing insulating body of inorganic refractory fiber, the electrical heating element being securely held embedded in gripping embrace within the surface of the insulating body of resilient mass of integrated inorganic refractory fiber resulting from the cramping effect of the mass of integrated fibers produced by filtering molding of the inorganic refractory fiber in situ about the electrical heating element.

2. The electrical heating unit of claim 1 wherein the insulating body of inorganic refractory fibers is bonded into an integrated, shape retaining structure with an inorganic binder.

3. The electrical heating unit of claim 1 wherein the insulating body of inorganic refractory fiber is at least about 0.25 of an inch thicker than the depth of the electrical

heating element embedded therein and thus provides an effective thermal insulation about the electrical heating element except the exposed surface.

4. The electrical heating unit of claim 1 wherein the surface of the filter molded inorganic refractory body having a portion of the embedded electrical heating element exposed therein is provided with a heat transmitting, fluid impervious cover.

5. The electrical heating unit of claim 1 wherein a protective layer of material providing the property of insulating electricity is superimposed over the portion of the electrical heating element exposed at the surface of the filter molded body of inorganic refractory fiber to electrically insulate the exposed electrical heating element.

6. The electrical heating unit of claim 5 wherein the protective layer of electrical insulating material superimposed over the exposed portion of the electrical heating element is a sheet of inorganic refractory fiber of a thickness substantially less than the thickness of the body of inorganic refractory fiber filter molded about the electrical heating element which exceeds the depth of the said electrical heating element embedded therein whereby the greater thickness of the body of the inorganic refractory fiber filter molded about the said electrical heating element except at the portion exposed at the surface of said molded body and having superimposed thereon the thinner sheet of electrical insulating inorganic refractory fiber will cause a majority of the heat generated by the said embedded electrical heating element to be transmitted through the said superimposed thinner sheet of electrical insulating inorganic refractory fiber.

7. The electrical heating unit of claim 6 wherein the major heat transmitting surface consists of the surface of the body of filter molded inorganic refractory fiber having a portion of the electrical heating element exposed therein with the superimposed protective layer of electrical insulating inorganic refractory fiber thereon is provided with a heat transmitting, fluid impervious cover.

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VOLODYMYR Y. MAYEWSKY, Primary Examiner

U.S. Cl. X.R.

219—548, 464, 354, 345; 252—312; 338—275