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Assemblages chauffants à couche mince

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US-A- 4 843 218	**US-A- 5 508 495**

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to electric heating assemblies comprising a thin resistive film. The present invention assembly finds wide application in cooking appliances and related devices.

BACKGROUND OF THE INVENTION

[0002] Film heating elements comprising a layer of an electrically conductive metal are known such as disclosed in U.S. Patent 2,564,709.

[0003] Such film heating elements have typically been used for defrosting circuits on vehicular window assemblies. Other types of film heating devices are known, such as those disclosed in U.S. Patent 4,536,645.

[0004] Film heating elements have not found acceptance within the appliance industry although several film devices have been disclosed such as in U.S. Patents 4,889,974 and 4,298,789. This is believed to result from a lack of reliability and serviceability associated with most contemplated film heating elements. Thus, there is a need for an assembly utilizing a film heating element that is both reliable and serviceable. Furthermore, it would be desirable to provide a film heating assembly that could be readily adapted and utilized in a wide variety of appliance applications.

[0005] US-A-5 508 495 discloses a domestic cooking apparatus including a layer of ceramic material and a foil heating element disposed to heat at least a portion of the ceramic material. A first insulation layer is disposed between the foil heating element and the layer of ceramic and a second insulation layer is disposed along the other side of the foil heating element.

[0006] US-A-4 843 218 discloses a heating element for thermal household appliances including an inherently stable carrier element having a heating surface in close thermal contact with a substance to be heated, and at least one heating resistor in the form of at least one flat heating conductor strip supported by and closely thermally coupled to the carrier element.

[0007] US-A-4 032 750 discloses a flat plate surface heating unit with a utensil-supporting cover plate provided with a separate, flexible, insulating sheet supporting a resistive foil that is seated on a pad of dielectric material in a reinforced reflector pan.

[0008] GB-A-2 267 421 discloses a hot plate for food, having a heating element assembly comprising a glass sheet coated with an electrically conductive material and adapted to be connected to an electricity supply via electrical contact areas. The resistive layer may be made of tin doped with fluoride.

SUMMARY OF THE INVENTION

[0009] The present invention achieves all of the foregoing objectives and provides in one aspect, a heating assembly comprising a planar substrate, a thin electrically resistive film disposed on the substrate, and a non-stick layer disposed on an opposite side of the substrate. The resistive film may comprise a metal oxide or doped metal oxide. The non-stick layer may comprise polytetrafluoroethylene. One or more electrically insulating layers can be disposed between the resistive film and the substrate or on the top side of the substrate. The heating assembly may also comprise electrically conductive electrodes in electrical association with the resistive film, the electrodes preferably comprising a cermet-based silver thick film material. The substrate may comprise porcelainized carbon steel, porcelainized ferritic stainless steel, aluminum oxide, glass ceramic designated under the trade name Ceran, Si_3N_4-ceramic, or combinations thereof.

[0010] More specifically, the objectives referred to will be achieved in connection with a heating and/or warming assembly which has obtained the characterizing features indicated in the appending claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

FIG. 1 is an exploded view of a first preferred embodiment thin film heating assembly in accordance with the present invention;

FIG. 1A is a partial perspective view of an alternate preferred embodiment thin film heating assembly;

FIG. 2 is a cross-sectional view of the first preferred embodiment thin film heating assembly taken along line 2-2 in FIG. 1 after fabrication;

FIG. 2A is a cross-sectional view of another preferred embodiment thin film heating assembly;

FIG. 3 is a perspective view of a heating device utilizing a thin film heating assembly in accordance with the present invention;

FIG. 4 is a perspective view of a range utilizing a plurality of thin film heating assemblies in accordance with the present invention;

FIG. 4A is a front perspective view of a range illustrating a selectively positionable thin film heating assembly in accordance with the present invention;

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] The present invention provides heating and warming assemblies that utilize a thin electrically resistive film. As referred to herein, the term "thin film" generally refers to films having a thickness from about 0.1 to about 1.0 micrometers. The term "thick film" as used herein, refers to films having a thickness from about 1.0 to about 25 micrometers. In the assemblies described herein, the term "heating assembly" generally refers to an assembly that is capable of providing a temperature of between about 200°C and about 350°C along its heating surface. The heating assemblies described herein may be designed and constructed so that they are operable at temperatures higher than 350°C, such as up to about 400°C. The term "warming assembly" as used herein generally refers to an assembly that is capable of providing a surface temperature between about 40°C and about 200°C along its heating surface.

[0013] The preferred embodiment thin film heating assemblies of the present invention generally comprise (i) a substrate, (ii) a resistive film for heat generation in thermal association with the substrate, (iii) one or more electrically conductive electrodes or bus bars in electrical association with the resistive film, and (iv) a non-stick layer disposed on the exposed surface(s) of the assembly. The preferred embodiment thin film heating assemblies may further comprise (v) one or more dielectric or electrically insulating layers disposed on one or both sides of the resistive film (ii), or on the substrate side that is opposite the substrate side facing the resistive film. In some applications, it may also be preferred to provide an electrically conductive layer on the substrate side opposite the substrate side facing the resistive film. This is described in greater detail below.

[0014] FIG. 1 is an exploded view of a first preferred embodiment thin film heating assembly 110 in accordance with the present invention. Before describing the particulars of the various preferred embodiments, it is to be noted that the accompanying figures are not necessarily to scale. In many of the figures, the thickness of the resistive film and other layers has been exaggerated to better illustrate the structure and relationship of the various components. In actual practice however, the resistive film may be several orders of magnitude thinner than other components of the assemblies such as for instance the substrate. This aspect is described in greater detail below. Referring to FIG. 1, assembly 110 comprises a substrate 120, one or more resistive films 130 disposed on one side of the substrate 120 and in thermal association with the substrate 120, one or more outer electrodes 140 that are in electrical association with the resistive films 130 and disposed on the same side of the substrate 120 as the resistive films 130, one or more inner electrodes 150 that are also in electrical association with the resistive films 130 and disposed on the same side of the substrate 120 as the resistive films 130 and the outer electrodes 140, and a non-stick layer 160 disposed on a side of the substrate 120 opposite the substrate side facing the resistive films 130 and the electrodes 140 and 150.

[0015] The substrate 120 is preferably planar having a first or outer (upper) face 122, an oppositely directed second or inner (lower) face 124, and a peripheral edge 121. Although the substrate 120 is depicted in FIG. 1 as rectangular in shape, it is to be understood that the substrate 120 may have nearly any shape including circular, oval, and elliptical shapes. The thickness of the substrate 120 is generally dictated by the end use requirements for the assembly 110. Typical thicknesses for the substrate 120 range from about 0.5 millimeters up to about 1 centimeter. It is preferred that the thickness of the substrate 120 is generally uniform. Although it is generally preferred that the substrate 120 is flat, it is contemplated that one or both sides of the substrate could be curved or otherwise nonplanar.

[0016] Another preferred configuration for the substrate 120 is generally planar having one finished, relatively smooth face and a second dimpled face. This configuration is typical for substrates of glass ceramic, particularly those available under the designation Ceran. When a substrate having such a configuration is incorporated into the assemblies of the invention and so utilized as substrate 120 in assembly 110 for instance, the smooth face of the substrate serves as the outer or upper face 122 and the dimpled face serves as the inner or lower face 124.

[0017] The resistive films 130 each have a top surface 132 and a bottom surface 134. As noted, multiple resistive films 130 can be utilized in the present invention assemblies. It is preferred that all films 130 be disposed in the same plane. It is also preferred that the top surface 132 of each resistive film 130 be directed toward, and most preferably immediately adjacent and in contact with, the second face 124 of the substrate 120. The configuration promotes thermal conduction between the resistive films 130 and the substrate 120. It is also preferred that the entirety or at least a majority of the surface area of the second face 124 be covered by the resistive films 130. Accordingly, the collective shape resulting from the resistive films 130 is preferably similar to the shape of the substrate 120. The preferred thickness for the resistive films 130 is described below.

[0018] The outer electrodes 140 and inner electrodes 150 are preferably straight or linear and oriented parallel with the plane of the substrate 120. The electrodes 140 and 150 are preferably thin strip-like elements having a length dimension significantly greater than their width dimension. The thickness of each electrode 140 and 150 is preferably from about 5 to about 25 micrometers. Each outer electrode 140 includes an electrical lead or termination 142, a top face 144, and a bottom face 146. Each inner electrode 150 includes an electrical lead or termination 152, a top face 154, and a bottom face 156. Although FIG. 1 illustrates the outer electrodes 140 as disposed alongside and adjacent an outer edge of the assembly 110, it is to be understood that one or more, or all of the outer electrodes 140 could be disposed near an intermediate region of the assembly 110. Similarly, other configurations for the inner electrodes 150 and the combination of the inner electrodes 150 and the outer electrodes 140 are contemplated.

[0019] Referring to FIG. 1A, the present invention includes a wide array of configurations and arrangements for the resistive film 130 and the electrodes 140 and 150. For instance, as shown in FIG. 1A, the electrodes 140 and 150 of an alternate assembly 112 can be disposed immediately adjacent the substrate 120, and the resistive film 130 disposed and overlying not only the substrate 120 but also the electrodes 140 and 150. Additional aspects of the preferred embodiment electrodes 140 and 150 are discussed below.

[0020] As shown in FIG. 1, the non-stick layer 160 includes an outwardly facing surface 162 and a second surface 164. The outwardly facing surface 162 preferably constitutes the exposed heating surface of the assembly 110. The second surface 164 is preferably disposed immediately adjacent and in contact with the first face 122 of the substrate 120.

[0021] The assembly 110 is preferably powered by appropriate connection to an electrical power source, such as a three-wire 220 volt supply. Assembly 110 is connected to such a source by connecting the outer electrodes 140 to a respective hot line, e.g. H_1 or H_2, and if desired, an inner electrode 150 can be connected to ground or neutral, e.g. N. The assembly 110 can also be appropriately connected to other three-wire systems, or to two-wire systems.

[0022] FIG. 2 is a cross-sectional view of the first preferred embodiment thin film heating assembly 110 taken along line 2-2 shown in FIG. 1. As illustrated in FIG. 2, it is preferred that the resistive films 130 are disposed underneath and immediately adjacent the substrate 120. The resistive thin films 130 are electrically connected to the electrodes 140 and 150 by disposing the electrodes directly on top, or underneath, the thin films 130.

[0023] FIG. 2A is a cross-sectional view of another preferred embodiment thin film heating assembly 118 in accordance with the present invention. The thin film heating assembly 118 comprises the previously described substrate 120, resistive films 130, one or more outer electrodes 140, one or more inner electrodes 150, and the non-stick layer 160. The assembly 118 further comprises a dielectric or electrically insulating layer 170 disposed between the substrate 120 and the layer of the resistive films 130. Alternatively or in addition, the electrically insulating layer 170 can be disposed on the bottom surface 134 of the resistive films 130. The electrically insulating layer 170 has a size and shape sufficient for it to cover, or substantially so, the components upon which it is disposed. Typically, the components upon which the electrically insulating layer 170 is disposed include the substrate 120, the resistive films 130, the outer electrodes 140, and the inner electrode 150. Alternatively or in addition, the electrically insulating layer 170 may be disposed on the substrate side opposite the substrate side facing the resistive film, i.e. side 122. The thickness of the electrically insulating layer 170 primarily depends upon the electrical insulation properties, i.e. the volume resistivity and dielectric constant, of the material forming the layer 170, and the electrical operating characteristics of the thin film heating assembly 118. The thickness of the layer 170 may also vary depending upon the particular application, but should in all cases, be sufficiently thick to prevent electrical current loss or short circuiting of the resistive films 130, the outer electrodes 140, and the inner electrodes 150. As described in greater detail below, it may in some applications be preferred to provide an electrically conductive layer on the outermost top surface of the assembly. This layer may be in addition to, or replace, the layer 170 when layer 170 is disposed on the substrate side opposite the substrate side facing the resistive film.

[0024] The preferred materials for the various components of preferred heating assemblies in accordance with the present invention are as follows. The substrate (i) can be nearly any heat resistant, relatively rigid material. The material selected for the substrate (i) should also exhibit electrical insulating properties or be coated or otherwise treated to have such property. The material selected for the substrate (i) should have a relatively low coefficient of thermal expansion. Examples of materials suitable for use as the substrate (i) include, but are not limited to, porcelainized carbon steel, porcelainized ferritic stainless steel, aluminum oxide, glass ceramic commonly referred to as Ceran, Si_3N_4-ceramic, and combinations of the foregoing. A particularly preferred material for the substrate is glass ceramic. A preferred glass ceramic is $Li_2Al_2Si_2O_6$ beta-quartz (LAS), such as available from Eurokera or Schott. If a porcelainized steel is selected for use as the substrate (i), it should be free of alkali and alkali earth metals so as to maintain good electrical insulating properties at temperatures above 150° C. A supplier of such porcelainized steel substrates is Ferro. Glass ceramic is generally preferred since as compared to other substrates, glass ceramic exhibits a relatively low thermal shear stress. The coefficient of thermal expansion of glass ceramic is essentially zero as compared to steel having a coefficient of thermal expansion of about 11 ppm. The use of near zero thermal expansion glass ceramic significantly reduces the tendency of crazing and cracking of other layers or films deposited on the glass substrate such as tin dioxide.

[0025] The electrically resistive film (ii) can be a thin film of metal oxide such as for instance tin dioxide, a cermet-based thick film material, a polymer-based thick film material, or any type of electrically resistive film or coating. It is preferred that the resistive film (ii) is a thin film of metal oxide, and most preferred that the metal oxide thin film be a doped tin dioxide thin film. A preferred dopant for tin dioxide is 0.1 to 0.5 weight percent fluorine. It is also preferred that the metal oxide thin film be deposited on a face of the substrate (i) by an atmospheric chemical vapor deposition (ACVD) process. One preferred metal oxide for example, is tin dioxide thin film doped with approximately 0.4 weight percent fluorine, and applied by an atmospheric chemical vapor deposition process at approximately 550°C. It is contemplated that other techniques for depositing the resistive film (ii) could be utilized. For instance, liquid materials or resistive film precursors could be applied by spraying and if necessary followed by additional spray coatings, exposure to heat or radiation, or other operations depending upon the end use application.

[0026] The material utilized for forming the resistive film (ii) has a positive temperature coefficient (PTC) with respect to its electrical resistance. When utilizing a metal oxide such as tin oxide, the temperature coefficient of resistance may be adjusted by adding appropriate amounts of oxides of iron, cobalt, nickel, niobium, tantalum, zirconium, and hafnium. It is important that the resistive film (ii) exhibit a PTC so that electrical resistance of the film increases with temperature. This property prevents temperature runaway during application of electrical power to the heating assembly. It is preferable to utilize a resistive film that has a linear PTC in the range of 25° to 400°C. Doped tin dioxide exhibits this property. The resistive film (ii) should be able to accommodate a power density of between about 1.0 to about 20 W/cm^2 and a current density of between about 11,000 to 90,000 A/cm^2.

[0027] The thickness of the resistive film (ii) varies depending upon the materials utilized for the resistive film (ii) and the particular application. The preferred thickness of such films generally ranges from about 0.1 to about 0.5 micrometers for most metal oxides or doped metal oxides, including tin dioxide. The thickness of the resistive film when formed from a thick-film material, for instance a cermet-based thick film material or a polymer-based thick film material, is between about 1 and about 25 micrometers.

[0028] A tin dioxide thin film may be applied to the dimpled underside of a Ceran type glass ceramic substrate. Although not wishing to be bound to any particular theory, it is believed that superior adhesion is achieved between a thin film and a dimpled or irregular surface substrate as compared to a substrate having a smooth surface. A dimpled surface has a greater amount of surface area available for bonding than a relatively smooth surface. The increased surface area decreases the wattage or power density carried by the thin film and so, promotes reliability of the thin film. The dimpled surface also prevents or minimizes fractures of the substrate. By depositing a thin film directly on the dimpled face of a substrate, the occurrence of scratches or fissures in the thin film is reduced. Since there is essentially no tensile stress at the peaks or high points of the dimples, the propagation of cracks in the substrate and adjacent films, is significantly minimized. Depositing a thin film directly upon a dimpled surface is preferred as compared to applying a thick film cermet material or adhesive material on the dimpled surface, since deposition of a thin film does not produce differential stresses on the glass ceramic and resulting shear and fracture. Furthermore, the dimpled surface promotes gripping for an electrical edge connector used for transmission of electrical power to the thin film layer. Moreover, direct deposition of a thin film on a dimpled substrate surface avoids having to smooth or otherwise finish the dimpled surface. This will in many applications provide significant economic advantage. It may in some instances be desirable to apply an intermediate dielectric layer between the underside of the Ceran substrate and the tin dioxide film.

[0029] It is preferred that a dimpled substrate have a particular configuration as follows. For a substrate having a thickness from about 4 to about 5 millimeters, the dimpled surface preferably comprises a plurality of closely arranged dimples that project outward a distance of from about 40 to about 200 micrometers from the substrate surface. Each dimple is preferably oval shaped and oriented so that its major diameter is parallel with the longitudinal axis of the substrate. It is most preferred that all of the dimples, or at least a majority, be oriented parallel to one another and with the longitudinal axis of the substrate. The preferred major diameter for each oval is about 2.1 millimeters. The preferred minor diameter of each oval is about 1.75 millimeters. The ovals are preferably spaced from each other by about 3.4 millimeters between centerpoints of adjacent dimples as measured along their width or minor diameter, and about 2.5 millimeters between centerpoints of adjacent dimples as measured along their length or major diameter.

[0030] The electrodes or bus bars (iii) are preferably formed from a cermet-based silver thick film material. It is contemplated that other electrically conductive materials could be utilized for the electrodes (iii). The selected materials should be compatible with other materials utilized in the resulting heating assembly. A preferred material for the electrodes is a silver cermet. This preferred material is applied by screen printing. In its printable state, it comprises a carrier or solvent, glass frit, and silver particles. When deposited on a glass substrate and fired at approximately 550°C, it forms a blend with the glass substrate as a continuous phase with the silver particles dispersed therein. Silver cermet materials are available from DuPont, ESL, and Ferro for example.

[0031] The non-stick layer (iv) is preferably formed from crosslinked silicone or polytetrafluoroethylene (PTFE) impregnating a porous scratch resistant structure like flame sprayed stainless steel. Various crosslinked silicone compositions may be utilized for the non-stick layer (iv).

[0032] The optional dielectric layer (v) is preferably any electrically insulating material that is suitable for exposure to relatively high temperatures, such as generated by the heating assemblies described herein. Examples of such materials include silicone dioxide, titanium dioxide, inorganic high temperature cements, sealing glasses, sol gel applied ceramics such as zirconia applied as a sol gel, high temperature paint, plasma or flame sprayed ceramics, or combinations thereof. The dielectric material selected preferably has a coefficient of thermal expansion as close to the substrate (i) as possible. A specific example of a preferred material for the dielectric layer is a glass layer fused to a glass ceramic substrate. Such fusing can be performed at temperatures in the range of 600°C to 850°C. Another specific example of a preferred material for the dielectric layer is a thin film of titanium dioxide TiO_2. This can be applied via atmospheric chemical vapor deposition. A further specific example of a preferred material for the dielectric layer is a ceramic material, for instance an alumina-based ceramic material, that is plasma sprayed or HVOF sprayed. Another specific example of a preferred material is zirconium dioxide (ZrO_2) that is applied as a sol gel.

[0033] The optional dielectric layer (v) can be incorporated into any of the heating or warming assemblies described herein. Multiple dielectric layers may be utilized where necessary. A preferred location for incorporating one or more electrically insulating layers in the assemblies described herein is between the electrically resistive film (ii) and the substrate (i) and on the upper substrate side.

[0034] As noted, the present invention includes assemblies comprising a top or outermost layer of an electrically conductive material. It may in some applications, be desirable to provide an electrical connection between that top electrically conductive material and an electrical ground. A preferred material for this top electrically conductive grounding layer is ACVD fluorine doped tin dioxide (SnO_2) thin film having a thickness of from about 0.1 to about 0.5 micrometers, or an Invar-alloy film, for example Fe-Ni, having a thickness of from about 0.1 to about 10 micrometers.

[0035] Any or all of the electrode or bus bars (iii), the non-stick layer (iv), and/or the dielectric layer (v), and the optional safety ground layer can be formed by screen printing techniques, spray coating operations, or other suitable techniques depending upon the characteristics of the starting materials. For applications in which the electrodes or bus bars (iii) are formed from an initially flowable material, such as thick film paste materials, it is preferred to screen print the electrode material directly onto the surface of interest. This enables formation of any desired arrangement or pattern of electrodes or bus bars in a simple and economical fashion.

[0036] The coefficient of thermal expansion (CTE) of components (i) - (iv) and optional dielectric layer (v) and safety ground layer is preferably closely matched. Careful selection of the materials utilized for components (i) - (iv) and the noted optional layers, and appropriate matching of their respective thermal expansion characteristics ensure that the resulting assembly will exhibit high durability and minimal failure occurrences.

[0037] A preferred combination of materials for the various components is as follows. The substrate (i) preferably comprises a glass ceramic. The resistive film (ii) is preferably formed from doped ACVD tin dioxide. A cermet-based silver thick film is utilized for the electrodes or bus bars (iii). The non-stick layer (iv) consists of crosslinked silicone or PTFE impregnating a porous scratch resistant structure like flame sprayed stainless steel or plasma sprayed ceramic.

[0038] Heating by the thin film heating assemblies, such as assembly 110, is performed by passing electrical current through the resistive film 130. This is preferably achieved by electrically connecting the electrical leads 142 to a voltage source. A controller can be used to regulate the flow of electric current to control the temperature of the resistive film or the heating assembly. If utilizing doped tin oxide for the resistive film (ii), the linear PTC characteristic of that material enables direct temperature control by monitoring the change in current versus temperature change.

[0039] The present invention also provides appliances that employ the previously described thin film heating assemblies. FIG. 3 illustrates a griddle 200 comprising a thin film heating assembly 210, one or more controls 220, and an enclosure 230. The thin film heating assembly 210 is preferably similar to the previously described heating assemblies. The heating assembly 210 is incorporated within the enclosure 230 by techniques known to those skilled in the art.

[0040] FIG. 4 illustrates a domestic range 300 comprising a plurality of thin film heating assemblies in accordance with the present invention. The range 300 comprises a planar, relatively large surface area griddle 310 utilizing a thin film heating assembly such as the previously described heating assembly 210. Moreover, the range 300 may comprise one or more oven heating panels 330 disposed in the lower portion of the range 300 that employ the thin film heating assembly of the present invention. These oven heating panels 330 are described in greater detail below. The range 300 may utilize any combination of the griddle 310 and the oven heating panels 330. The range 300 may further comprise one or more heating element elements 348 in the form of conventional electrical resistance elements known in the art, or in accordance with the present invention thin film heating assemblies. The range 300 generally comprises an enclosure 340, a door 346 pivotally attached thereto, and indicators and electronic controls 342 and 344 respectively, for monitoring and controlling the operation of the griddle 310, the oven heating panels 330, and the heating element elements 348.

[0041] The thin film heating assembly of the present invention is particularly well suited for use as an oven heating panel that can supplement and most preferably replace conventional oven baking elements. Replacing conventional oven baking elements with the heating assembly of the present invention provides an oven that is significantly easier to clean. The non-stick outer surface of a thin film heating assembly that is incorporated into an oven heating panel and elimination of conventional baking elements facilitate cleaning the oven after use. Replacement of conventional baking elements with a heating panel utilizing the thin film heating assembly increases the effective oven volume. Moreover, replacement of conventional baking elements with a heating panel utilizing the thin film heating assembly results in energy savings and promotes temperature uniformity within the oven interior.

[0042] Referring to FIG. 4, the oven heating panels 330 can be disposed along any wall or portion thereof within the oven interior. Preferably, one or more oven heating panels are disposed along the rear wall of the oven interior. Similarly, one or more oven heating panels are located on the bottom wall of the oven interior, preferably replacing a conventional lower baking element. Likewise, one or more oven heating panels are located on the top wall of the oven interior, preferably replacing a conventional upper heating element such as a broiling element. It is also contemplated to incorporate one or more heating panels on the inward facing surface of the oven door 346. All of the noted oven heating panels could be employed in any combination. Thus, the present invention includes a range or oven comprising a plurality of oven heating panels 330 disposed on any combination of surfaces defining the oven interior. It is also contemplated that a plurality of oven heating panels 330 may be located on a single wall or common surface of the oven interior. This may be desirable so that exposed noncovered portions of the underlying wall such as between spaced apart adjacent oven heating panels 330, can provide mounting or support provisions for oven racks, rotisserie components, lights, viewing windows, or other items. The shape of the oven heating panels is not critical.

[0043] It is also preferred that the oven heating panels be provided as movable panels that can be oriented or positioned within the oven interior in any desired configuration. Thus, in an alternate preferred embodiment, a range comprises a plurality of oven heating panels disposed in the lower portion of the oven interior. At least one of the oven heating panels is adapted to be selectively positioned to different locations within the oven interior, much like an oven rack may be placed at various locations within the oven interior. FIG. 4A illustrates an alternate preferred embodiment range 305 comprising one or more selectively positionable oven heating panels 332. The range 305 preferably comprises many of the same components as previously described with respect to the range 300 shown in FIG. 4, such as the griddle 310, one or more oven heating panels 330, one or more heating element elements 348, an enclosure 340, a door 346, one or more indicators 342, and one or more controls 344. The range 305 further comprises a selectively positionable oven heating panel 332 that can be placed at various locations within the oven interior. The range 305 will typically include one or more upper racks 320 disposed near the upper portion of the oven interior, and one or more lower racks 322 disposed near the lower portion of the oven interior. As evident in FIG. 4A, it is preferred that the interior side walls of the oven provide horizontally extending support ridges or ledges 324 for supporting an upper or lower oven rack 320 or 322, or a positionable oven heating panel 332.

[0044] The selectively positionable oven heating panels 332 can be placed at any location within the interior of the oven provided sufficient supports are provided at the desired location such as a pair of support ridges 324. This feature of a selectively positionable heating panel provides significantly greater flexibility in heating or baking operations than with conventional ovens utilizing non-positionable heating elements.

[0045] Referring further to FIG. 4A, the positionable oven heating panel 332 may be moved to a new location within the oven interior, such as location 334 depicted in FIG. 4A by dashed lines, by sliding or otherwise removing the panel 332 outward from the oven interior, as one would remove an oven rack such as upper rack 320, and then placing the panel 332 at the new location, e.g. location 334, within the oven interior.

[0046] Electrical connections are established to the selectively positionable oven heating panel 332 by known techniques. For instance, a flexible cable housed within an appropriate flexible cover or conduit, can be used to provide both electrical power and control signals to the panel 332. The flexible cable may extend from a rear wall of the oven interior to a rearwardly directed edge or the underside of the panel 332. Alternately, a plurality of plug receptacles could be provided on one or more walls of the oven interior, and one or more corresponding mating receptacles provided on the panel 332 such that upon appropriate placement of the panel, such as between a pair of support ridges 324 and against the oven rear wall, the plugs are engaged thereby completing the requisite power and control circuits between the panel 332 and the range 305.

[0047] The oven heating panel 330 or 332 comprises a thin film heating assembly generally corresponding to the previously described thin film heating assemblies, and further comprises a coating or layer of suitable material adapted for exposure to the oven interior. Thus, an oven heating panel 330 or 332 can be formed by utilizing a suitable oven interior coating material known in the art as the previously described non-stick layer (iv) in conjunction with any of the previously noted preferred embodiment thin film heating assemblies.

EXPERIMENTAL

[0048] A series of experiments were conducted in which the response characteristics of heating assemblies in accordance with the present invention were analyzed. In a first trial, a warmer element corresponding to the previously described warming assembly 400 was connected to an electrical power supply and the temperature measured as the assembly reached its steady state operating temperature. Table 1 set forth below indicates the relationship between the power applied and the resulting temperature as a function of time.

TABLE 1

Power [W]	Steady State [°C]	Time to Steady State [Minutes]	Time to 120°C [Minutes]	Watt Density [W/cm^2]
50	107	9.6		0.25
100	167	8.9	4.4	0.51
150	204	8.1	2.5	0.76
200	228	8.1	2.1	1.02
250	264	8.2	1.6	1.27
300	304	8.0	1.2	1.53

[0049] It can be seen from Table 1 that in order to reach a temperature of 120°C, a typical recommended warmer temperature, within a reasonable time, i.e. about 2.0 minutes, a power density of at least 1.0 W/cm^2 should be used.

[0050] In a second trial, the response characteristics of a warmer according to the previously described warming assembly 700 were similarly tested. The results of that testing are set forth below in Table 2 as follows:

TABLE 2

Power [W]	Resistance [ohms]	Voltage [v]	Steady State [°C]	Time to Steady State [Minutes]	Time to 120°C [Minutes]	Watt Density [W/cm^2]
50	42	45.83	59.5	30	---	0.20
100	42	64.81	97.5	35	---	0.39
150	42	79.37	123.3	45	36	0.59
200	42	91.65	153.0	50	12.5	0.79
250	42	102.47	161.3	32.5	9.5	0.98
300	42	112.25	182.0	32.5	6.9	1.18

[0051] It is evident from the results presented in Table 2 that in order to reach a temperature of 120°C in less than about 7 minutes, a power density of at least 1.18 W/cm^2 should be used. It is surprising and remarkable that such low amounts of power can be utilized to rapidly reach the noted temperature. Table 2 also illustrates that even at significantly lower power levels, e.g. 250W and 200W, the warming assembly reached 120°C within relatively short time periods, e.g. 9.5 and 12.5 minutes, respectively.

[0052] In yet another trial, a heating assembly in accordance with the present invention comprising a substrate of porcelainized steel and a resistive film of tin oxide was continuously cycled at 260°C for more than 7500 hours, without any significant change in performance. Cycling was performed at 260°C and included energizing the heating assembly for 45 minutes followed by deenergizing the assembly for 15 minutes. It is surprising and remarkable that such cycling could be performed over such a long period of time without degradation of performance. This feat is even more remarkable since the cycling was performed at 260°C.

[0053] The present invention provides electrically powered thin film heating elements that are both reliable and serviceable. The elements provide excellent heating characteristics and performance. The elements are particularly amenable for incorporation in domestic and industrial heating or cooking appliances.

[0054] While the foregoing details are what is felt to be the preferred embodiments of the present invention, no material limitations to the scope of the claimed invention are intended. Further, features and design alternatives that would be obvious to one of ordinary skill in the art are considered to be incorporated herein. The scope of the invention is set forth and particularly described in the claims herein below.

Claims

1. A heating and/or warming assembly (110) for use in a cooking appliance, **characterized by**
   a, preferably planar, substrate (120) having a first face (124) and a second face (122);
   a thin electrically resistive film (130) disposed on said first face (124) of said substrate (120);
   and
   a non-stick layer (160) disposed on said second face (122) of said substrate (120).

2. Assembly according to claim 1,
   characterized in that said substrate (120) comprises one or more materials selected from the group consisting of glass ceramic, porcelainized steel, aluminium-oxide and Si_3N_4-ceramic.

3. Assembly according to claim 1 or claim 2,
   characterized in that said substrate (120) comprises a first face (124) that is relatively smooth and a second face (122) that is dimpled or wherein said substrate (120) comprises a first face (124) that is dimpled and a second face (122) that is relatively smooth.

4. Assembly according to any of the preceding claims,
   characterized in that said electrically resistive film (130) comprises a metal oxide, preferably doped tin dioxide having a preferred thickness of from about 0.1 to 0.5 micrometers.

5. Assembly according to any of the preceding claims,
   characterized in that said non-stick layer (160) comprises polytetrafluoroethylene and/or crosslinked silicone.

6. Assembly according to any of the preceding claims,
   characterized by a dielectric layer (170) disposed between said electrically resistive film (130) and said substrate (120).

7. Assembly according to claim 6,
   characterized by a second dielectric layer disposed on a face of said electrically resistive film (130) opposite said substrate (120) and/or on a top side of said substrate (120).

8. Assembly according to any of the preceding claims,
   characterized by at least two electrically conductive electrodes (140) in electrical association with said electrically resistive film (130).

9. Assembly according to claim 8,
   characterized in that said electrically resistive film (130) is disposed between said at least two electrically con-

ductive electrodes (140) or said electrically conductive electrodes (140) are disposed between said substrate (120) and said electrically resistive film (130), said electrically conductive electrodes (140) preferably comprising a cermet-based silver thick film material.

10. Assembly according to claim 8 or claim 9,
characterized in that said two electrically conductive electrodes (140) are disposed on said resistive film (130).

11. Assembly according to any of the preceding claims,
characterized in that upon application of electrical current to said electrically resistive film 130), said non-stick layer (160) reaches a temperature in the range of from about 200°C to about 400°C , preferably in the range from about 200°C to about 350°C.

12. Assembly according to any of the preceding claims,
characterized in that a dielectric layer (170) is disposed between said non-stick layer (160) and said substrate (120).

Patentansprüche

1. Eine Heiz- und/oder Erwärmungsanordnung (110) zur Verwendung in einer Kochvorrichtung, **gekennzeichnet durch**

ein vorzugsweise ebenes Substrat (120) mit einer ersten Seite (124) und einer zweiten Seite (122);

eine dünne, elektrische Widerstandschicht (130), die auf der ersten Seite (124) des Substrats (120) angeordnet ist;

und

eine Antihaftschicht (160), die auf der zweiten Seite (122) des Substrats (120) angeordnet ist.

2. Anordnung gemäß Anspruch 1, **dadurch gekennzeichnet, dass** das Substrat (120) ein oder mehrere Materialien umfasst, die aus der Gruppe bestehend aus Glaskeramik, porzellanisiertem Stahl, Aluminiumoxid und Si_3N_4-Keramik ausgewählt sind.

3. Anordnung gemäß Anspruch 1 oder Anspruch 2, **dadurch gekennzeichnet, dass** das Substrat (120) eine erste Seite (124) umfasst, die relativ glatt ist, und eine zweite Seite (122), die mit Vertiefungen versehen ist, oder wobei das Substrat (120) eine erste Seite (124) umfasst, die mit Vertiefungen versehen ist, und eine zweite Seite (122), die relativ glatt ist.

4. Anordnung nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** die elektrische Widerstandschicht (130) ein Metalloxid umfasst, vorzugsweise dotiertes Zinndioxid mit einer bevorzugten Dicke von etwa 0,1 bis 0,5 Mikrometer.

5. Anordnung nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** die Antihaftschicht (160) Polytetrafluorethylen und/oder vernetztes Silikon umfasst.

6. Anordnung nach einem der vorangehenden Ansprüche, **gekennzeichnet durch** eine dielektrische Schicht (170), die zwischen der elektrischen Widerstandsschicht (130) und dem Substrat (120) angeordnet ist.

7. Anordnung nach Anspruch 6, **gekennzeichnet durch** eine zweite dielektrische Schicht, die auf einer Seite der elektrischen Widerstandschicht (130) gegenüber dem Substrat (120) und/oder auf einer Oberseite des Substrats (120) angeordnet ist.

8. Anordnung nach einem der vorangehenden Ansprüche, **gekennzeichnet durch** mindestens zwei elektrisch leitende Elektroden (140) in elektrischer Verbindung mit der elektrischen Widerstandschicht (130).

9. Anordnung nach Anspruch 8, **dadurch gekennzeichnet, dass** die elektrische Widerstandschicht (130) zwischen den zwei elektrisch leitenden Elektroden (140) angeordnet ist oder die elektrisch leitenden Elektroden (140) zwischen dem Substrat (120) und der elektrischen Widerstandschicht (130) angeordnet sind, wobei die elektrisch leitenden Elektroden (140) vorzugsweise ein Silber-Dickschichtmaterial auf Cermet-Basis umfassen.

10. Anordnung nach Anspruch 8 oder Anspruch 9, **dadurch gekennzeichnet, dass** die zwei elektrisch leitenden Elektroden (140) auf dem Widerstandfilm (130) angeordnet sind.

11. Anordnung nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** nach dem Anlegen von elektrischem Strom an die elektrische Widerstandschicht (130) die Antihaftschicht (160) eine Temperatur im Bereich von etwa 200°C bis etwa 400°C erreicht, vorzugsweise im Bereich von etwa 200°C bis etwa 350°C.

12. Anordnung nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** eine dielektrische Schicht (170) zwischen der Antihaftschicht (160) und dem Substrat (120) angeordnet ist.

Revendications

1. Assemblage chauffant et/ou réchauffant (110) pour l'utilisation dans un appareil de cuisson, **caractérisé par**
un substrat (120), de préférence plan, ayant une première face (124) et une seconde face (122) ;
un film mince électriquement résistif (130) disposé sur ladite première face (124) dudit substrat (120) ; et
une couche anti-adhérente (160) disposée sur ladite seconde face (122) dudit substrat (120).

2. Assemblage selon la revendication 1, **caractérisé en ce que** ledit substrat (120) comprend un ou plusieurs matériaux choisis dans le groupe constitué par une vitrocéramique, un acier porcelainé, un oxyde d'aluminium et une céramique Si_3N_4.

3. Assemblage selon la revendication 1 ou la revendication 2, **caractérisé en ce que** ledit substrat (120) comprend une première face (124) qui est relativement lisse et une seconde face (122) qui est alvéolée, ou dans lequel ledit substrat (120) comprend une première face (124) qui est alvéolée et une seconde face (122) qui est relativement lisse.

4. Assemblage selon l'une quelconque des revendications précédentes, **caractérisé en ce que** ledit film électriquement résistif (130) comprend un oxyde de métal, de préférence du dioxyde d'étain dopé ayant une épaisseur préférable d'environ 0,1 à 0,5 micromètre.

5. Assemblage selon l'une quelconque des revendications précédentes, **caractérisé en ce que** ladite couche anti-adhérente (160) comprend un polytétrafluoroéthylène et/ou une silicone réticulée.

6. Assemblage selon l'une quelconque des revendications précédentes, **caractérisé par** une couche diélectrique (170) disposée entre ledit film électriquement résistif (130) et ledit substrat (120).

7. Assemblage selon la revendication 6, **caractérisé par** une seconde couche diélectrique disposée sur une face dudit film électriquement résistif (130) à l'opposé dudit substrat (120) et/ou sur un côté supérieur dudit substrat (120).

8. Assemblage selon l'une quelconque des revendications précédentes, **caractérisé par** au moins deux électrodes électriquement conductrices (140) en association électrique avec ledit film électriquement résistif (130).

9. Assemblage selon la revendication 8, **caractérisé en ce que** ledit film électriquement résistif (130) est disposé entre lesdites au moins deux électrodes électriquement conductrices (140), ou lesdites électrodes électriquement conductrices (140) sont disposées entre ledit substrat (120) et ledit film électriquement résistif (130), lesdites électrodes électriquement conductrices (140) comprenant de préférence un matériau à couche mince d'argent à base de cermet.

10. Assemblage selon la revendication 8 ou la revendication 9, **caractérisé en ce que** lesdites deux électrodes électriquement conductrices (140) sont disposées sur ledit film résistif (130).

11. Assemblage selon l'une quelconque des revendications précédentes, **caractérisé en ce que**, lors de l'application d'un courant électrique audit film électriquement résistif (130), ladite couche anti-adhérente (160) atteint une température dans la gamme d'environ 200 °C à environ 400 °C, de préférence dans la gamme d'environ 200 °C à environ 350 °C.

12. Assemblage selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**une couche diélectrique (170) est disposée entre ladite couche anti-adhérente (160) et ledit substrat (120).

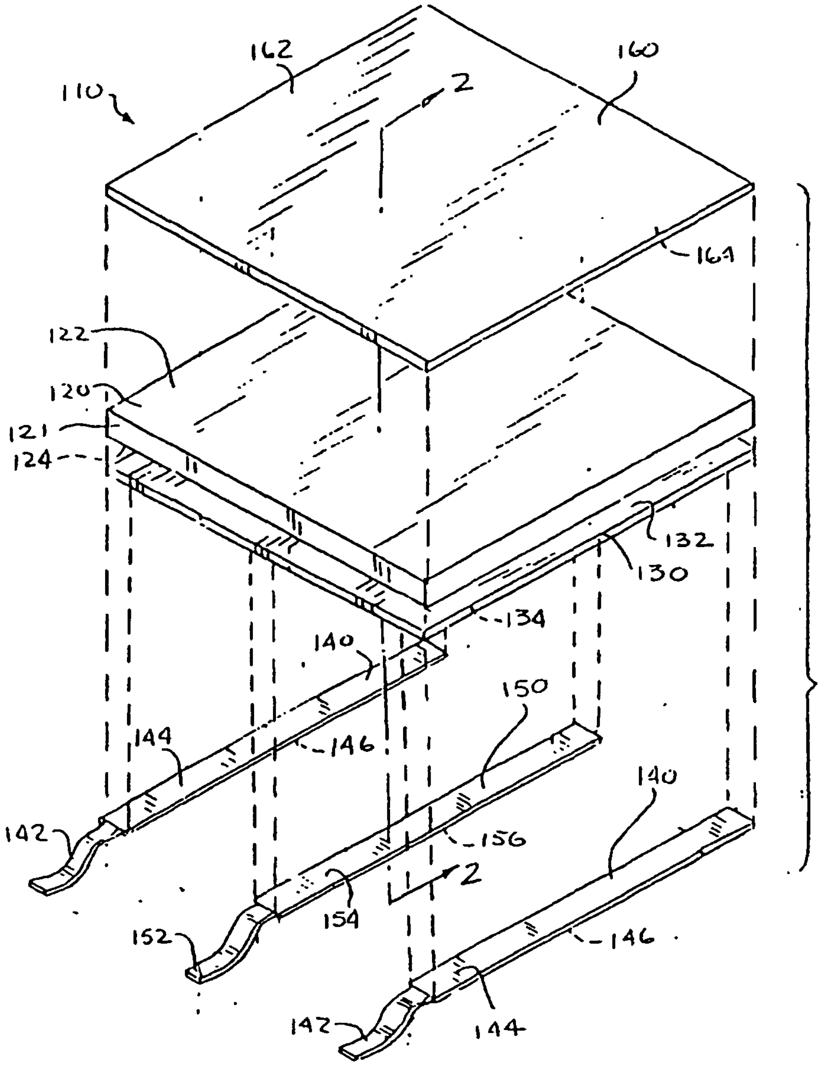


FIG. 1

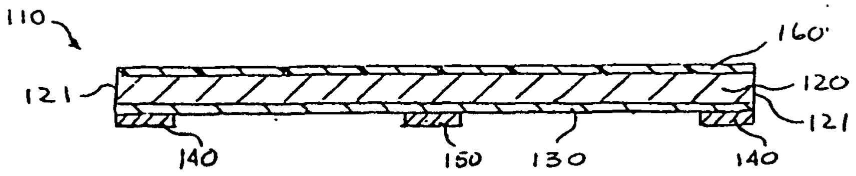


FIG. 2

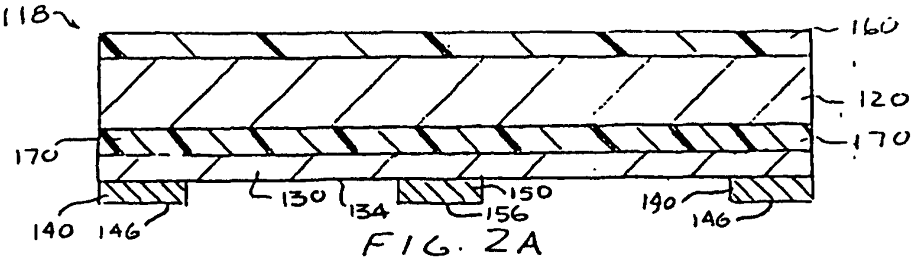


FIG. 2A

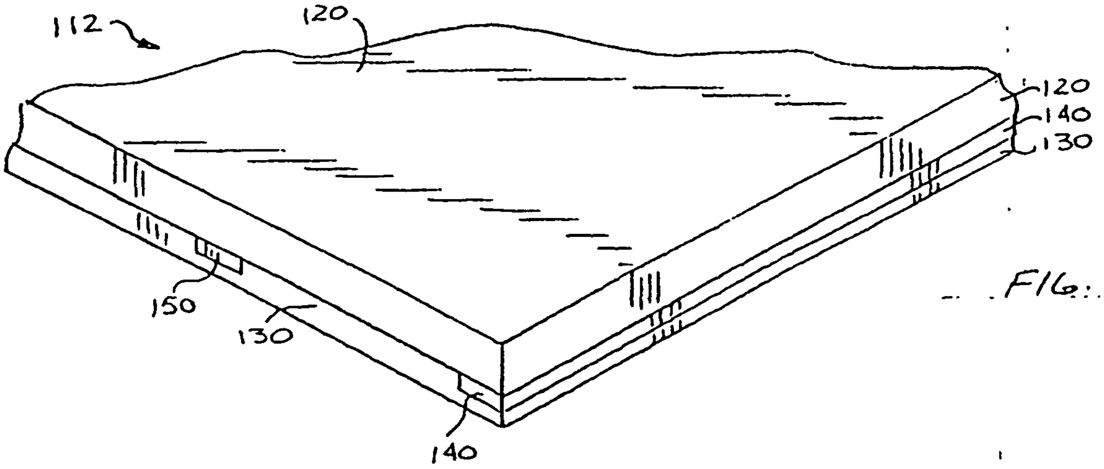


FIG. 1A.

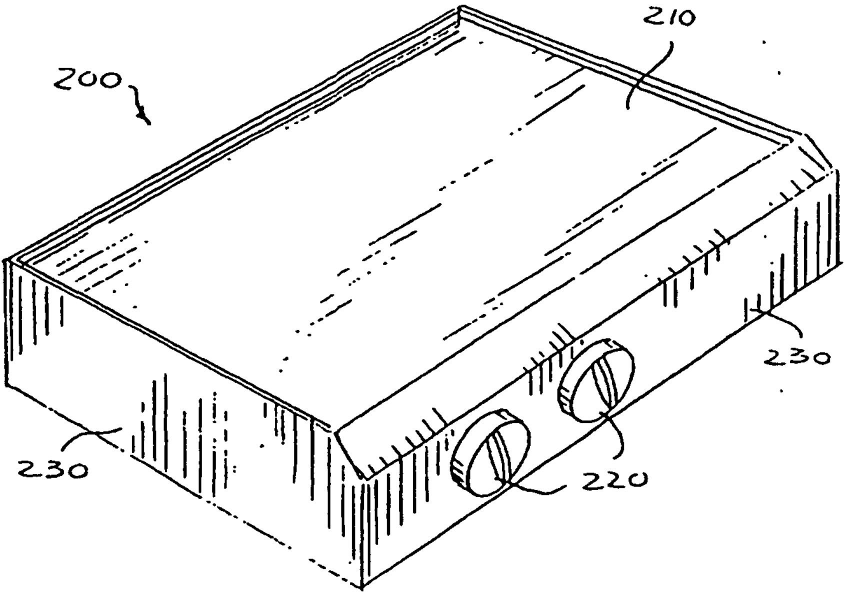


FIG 3

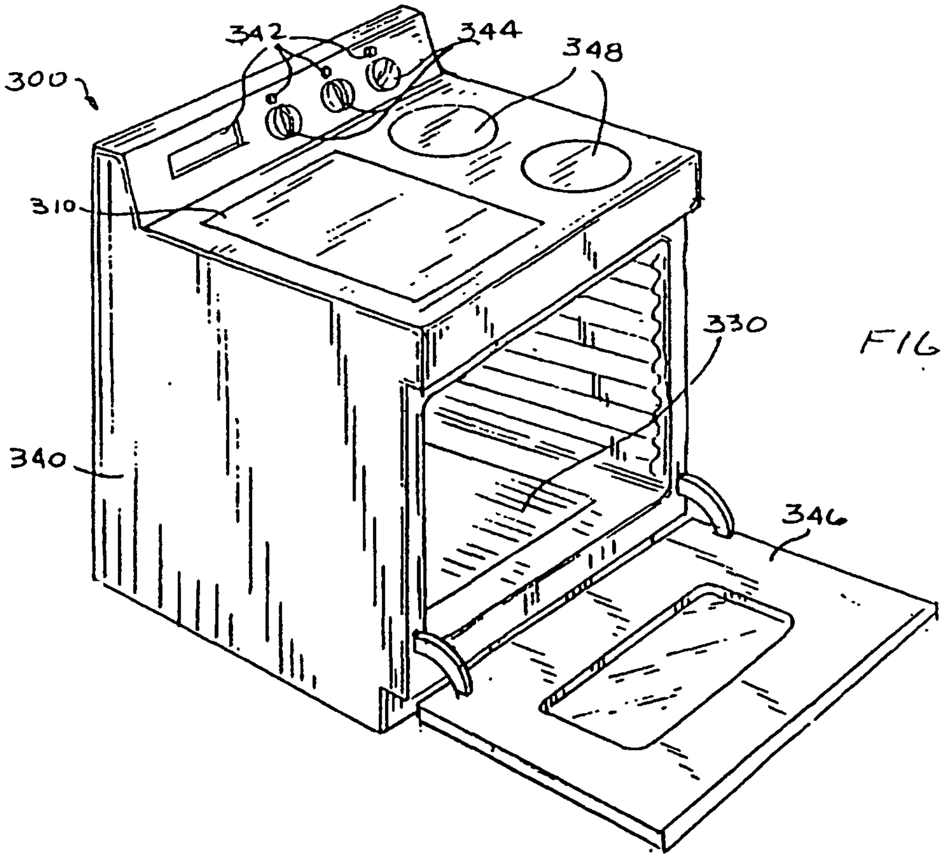
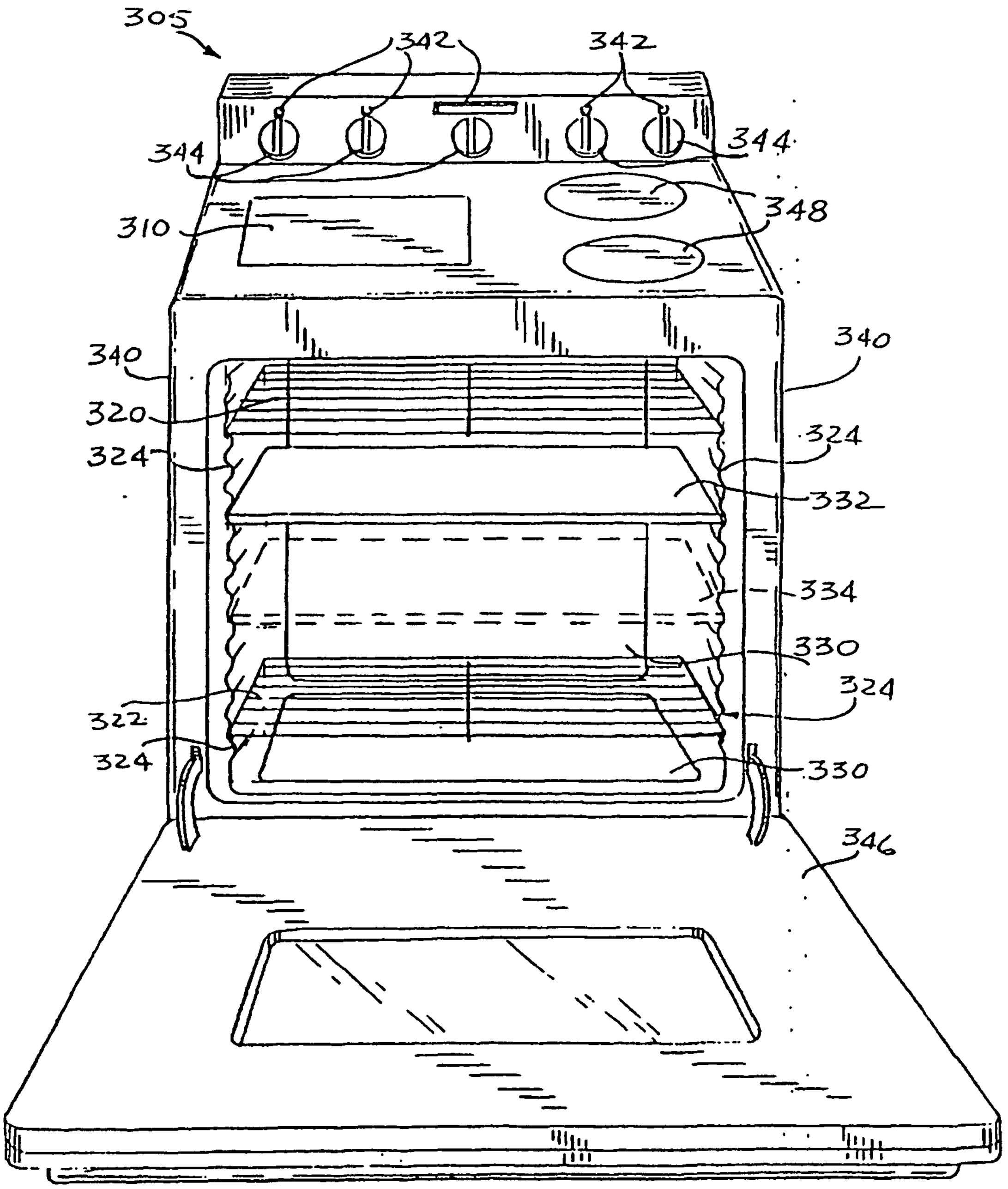


FIG. 4

FIG. 4A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