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MULTI-LAYER FILM HEATERS IN STRIP FORM

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FIG. 1

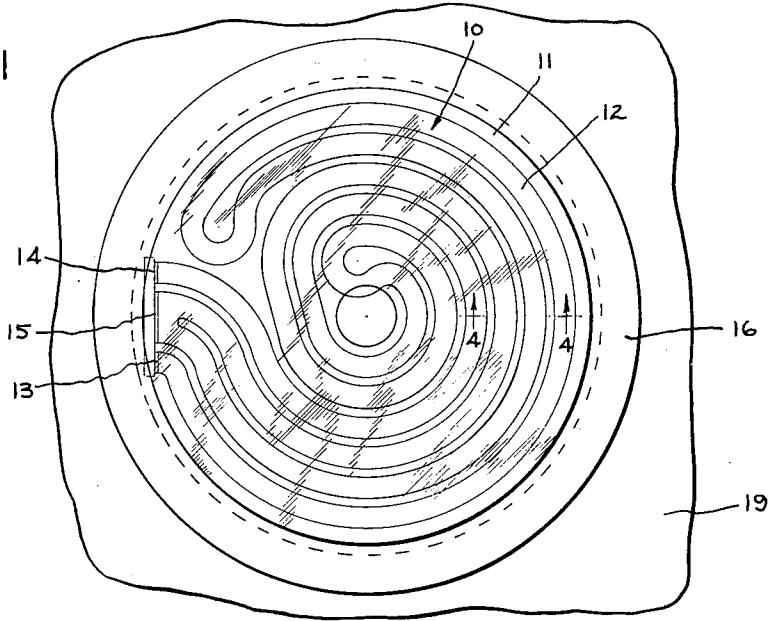


FIG. 2

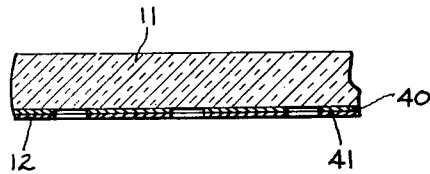
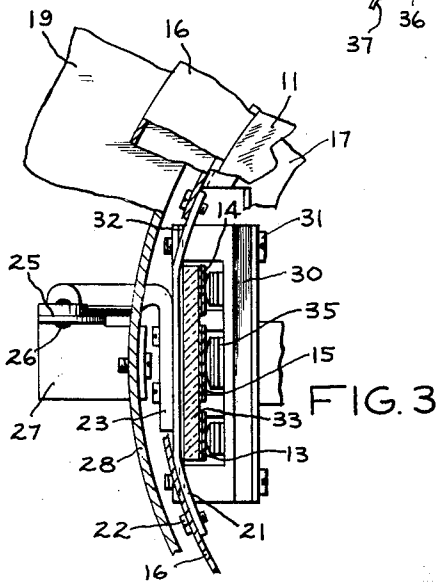
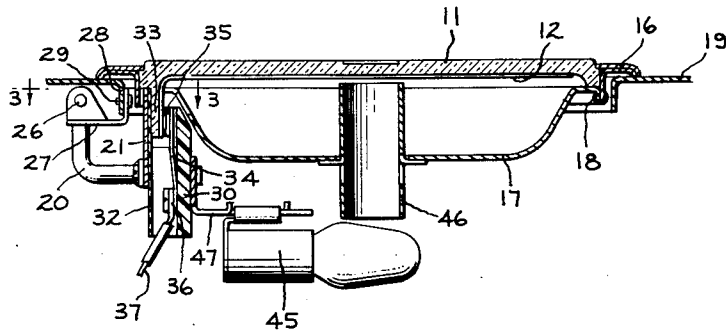


FIG. 4

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1

3,067,315

MULTI-LAYER FILM HEATERS IN STRIP FORM
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The present invention relates to resistance heating units and particularly to film heaters which would be suitable for use as either the surface heating unit for an electric range or for an oven heating unit where the unit has to operate at a temperature of about 1500° F. and with a power output of nearly forty watts per square inch.

Present metallic sheath type resistance heaters which are used as both the surface and oven heating units for electric ranges have more than forty years of research and development work behind them. Since they have been improved to such a degree and used successfully for so many years, it is believed possible to state at the present time that the design of the sheath type heating unit is close to perfection. Other heat sources have been investigated such as induction heating but the one that appears most promising as an improvement in this art is a film heater using multiple film layers of noble metal such as gold and platinum.

The most common type of film heater uses a conducting film of a thin layer of tin oxide. A metal base is first covered with an insulating layer and then the tin oxide film is supplied. Relatively low operating temperature, low watts density and high resistance makes this type of film heater unsuitable for surface heating unit application.

A principal object of the present invention is to provide a film heater that has heating characteristics that are comparable to a metallic sheath type resistance heater.

A further object of the present invention is to provide a novel surface heating unit of the film heater type which is easy to clean and presents an attractive appearance.

A further object of the present invention is to design a resistance heating unit which has a low thermal mass so that the unit will heat up and cool down at faster rates than the standard sheath type resistance heater.

A further object of the present invention is to design a novel resistance heating unit of the film heater type that has a more uniform temperature distribution and more heated surface for transmitting the electrical energy in the form of heat to the utensil in which the food is to be cooked.

A still further object of the present invention is to provide a film heater in strip form of multiple layers of noble metal to prevent the crystallization of the conductive layers at high temperatures.

A preferred embodiment of the present invention incorporates a base material with a high resistivity and dielectric strength such as Vycor which is a trademark of the Corning Glass Works and consists of approximately 96% silica. Bonded to one side of the base member is a continuous strip of metallic film which is built up of multi-layers that include at least one inner layer of platinum and an outer layer of gold. The layer of gold is the conductive layer and it has a low enough resistance to provide the necessary power density. The gold film would be satisfactory when used alone except that it begins to crystallize at a temperature of about 400° C. As the temperature increases the gold grains grow and they gather metal into small globules that are connected by a thin layer of the original finer crystalline structure layer. In the process of this local metal agglomeration the layer connecting the coarse grains becomes thinner. Eventually fine cracks in the film are formed and the base material is exposed. When the film is heated by an electric

2

current, arcs are struck in these fine film cracks and the metal melts until the film breaks completely rendering the heater unusable. It has been found that a material with a higher melting point and a higher recrystallization temperature than the gold such as platinum may be used with the gold to protect the conductive film from the complete agglomeration at the higher operating temperatures.

My invention will be better understood from the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

FIGURE 1 is a plan view of a surface heating unit embodying the present invention showing the film heater in strip form affixed to the underside of a glass or ceramic base plate that is transparent to the infrared radiation.

FIGURE 2 is a cross-sectional elevational view of a surface heating unit embodying the invention taken through the center of the heating unit of FIG. 1.

FIGURE 3 is a fragmentary plan view in cross-section taken on the lines 3—3 of FIGURE 2 showing a method of pivotally mounting the surface unit to the cooktop of a range.

FIGURE 4 is a fragmentary elevational view in cross-section taken along the lines 4—4 of FIGURE 1 showing the multiple layers of noble metal forming a film heater in strip form on the underside of the base plate.

Turning now to a consideration of the drawing and in particular to FIGURE 1, there is shown a surface heating unit 10 that is a continuous sheet of glass or ceramic material 11 such as Vycor. On the underside of the base plate 11 is formed a continuous film heater 12 in strip form which is arranged in a serpentine shape. Each end of the strip is provided with a terminal or electrode such as 13 and 14, while the mid-portion has a third terminal 15 so that different degrees of heat can be selected as with standard surface heating units.

A better understanding of the construction can be had by a study of the cross-sectional view of FIGURE 2. The base plate 11 is confined within a flanged trim ring 16 by a bottom reflector pan 17 that is fastened to the ring by rivet means such as 18. The surface unit is hinged to the cooktop 19 of a range by means of a hinge strap 20. A metal plate 21, is fastened by screws 22 to the lower extremity of trim ring 16 as is best seen in FIGURE 3. The mid-portion of the hinge strap 20 is of L shape. The end of the strap that is fastened to the metal plate 21 is horizontally disposed at right angles to the strap as at 23 for fastening the strap to the plate. At the opposite end of the strap there is a vertical flattened portion 25 which includes an aperture for receiving a hinge pin 26. This hinge pin extends through a similar aperture in a bracket member 27 that is fastened to a down-turned flange 28 of the cooktop as is best seen in FIGURE 2. First the bracket 27 is assembled to the hinge strap 20, then the strap is assembled by means of the plate 21 of the surface unit. Accordingly, the surface unit is fastened to the cooktop by pivoting the unit upwardly and placing the bracket 27 in the location as shown in FIGURE 2 so that a screw 29 may be threaded through the bracket 27 and flange 28.

The metal plate 21 also supports a terminal block 30 which is of molded insulating material such as a phenolic resin. It is of generally U-shape in plan view as is best seen in FIGURE 3. Elongated screws 31 extend through the arms of the U member for threading into the supporting plate 21. A flat strip of insulating sheet 32 is sandwiched between the plate 21 and terminal member 30 as is seen in FIGURES 2 and 3 so that the terminal block may receive a down-turned tongue portion 33 of the glass base plate 11 of the heating unit. The terminal block is equipped with three spring blades 34 for making electrical contact with the terminals of the film heater 12.

The free end of each spring blade has a contacting surface 35 of silver or the like for making good electrical connection with the film heater. Each spring blade 34 is provided with a terminal screw 36 so that a lead wire such as 37 may be connected thereto. Suitable openings (not shown) are made in the insulating sheet 32 so that a screw driver may extend therethrough for fastening the lead wire 37 to terminal screw 36.

FIGURE 4 shows a cross-sectional elevational view of the surface unit with the base plate 11 and a film heater 12 on its underside. The film heater is constructed with a first layer of platinum 40 and an overlying layer of gold 41. Because these metal films are very thin the cost of this type of heater is quite low. For example the material cost of the film for a six inch diameter plate heater would be in the neighborhood of ten cents. To obtain even heat distribution it is best to use the film in the form of relatively narrow bands or strips of from one-fourth of an inch to one-half of an inch wide rather than to cover the surface completely with the film. Also the use of the strips simplifies the problem of making connection with the terminals of the heater. The width of the strip and the diameter of the surface unit of from six to eight inches limits the choice of precious metal films to those with a resistance in the range of 0.5 to 1.5 ohms per square. A gold film is the only one that has such a low resistance but it tends to break at higher temperatures and at a power density of approximately 30 to 35 watts per square inch. The failure of thin gold coatings when heated by an electric current to a temperature of between 1000° F. and 1200° F. may be explained by examining the crystalline structure of the coating. Microscopic examination shows that at about 400° C. the gold film starts to crystallize. At higher temperatures the gold forms relatively large grains and very thin passages. Fine cracks are eventually formed and the base material is exposed until arcs are generated and the metal starts to melt. Small droplets of melted gold pull together because of a very high surface tension and finally the film breaks. One solution to this problem is to select a noble metal with a higher melting point so that recrystallization will occur at a much higher temperature. Platinum is such a metal since its melting point is 3224° F. or 1279° F. higher than the melting point of gold. However, platinum films have a resistance in the range of 13 to 39 ohms per square which is too high for a surface unit.

This invention includes the use of multiple layers of gold and platinum films or similar low and high resistance combinations in order to obtain the same result. The total resistance of a double film is approximately equal to the lower resistance of the two components. For example, using platinum and gold film the total resistance is that of the resistance of the gold film because both layers are connected in parallel. The platinum with a much higher melting point retards crystallization and migration of the gold. The multiple layers are more stable at higher temperatures and they allow a much higher power density, that is, more watts per square inch.

It was discovered that the gold and platinum films change their high luster to a frosty finish when heated to a high temperature. Microscopic examination shows that the films consists of small metal grains which start to grow at higher temperatures. Coarse grain diffuse the reflected light and the film loses its high mirror finish. When the grains grow in size they pull the metal together and the space between them becomes extremely thin. Films with a small addition of rhodium have a much finer crystalline structure. Also the grain growth is much lower at higher temperature. This is because the molecules of rhodium act as grain growth nuclei and promote fine crystal characteristics of the films.

A detail that is incorporated with this invention is a pilot light 45 that is positioned under the center of the surface unit and is capable of directing light through a tube 46 that is vertically positioned in the center of the reflected

pan 17 for lighting up the center of the base plate 11. This pilot light is fastened onto a supporting bracket 47 that is in turn assembled with the terminal block 30 by means of the fastening screws 31 as is best seen in FIGURES 2 and 3.

During the life tests of this type of film heater failure has occurred more often in the terminals where small sparks develop, especially when the circuit is closed by a switch. The conducting films are extremely thin and even small arcing causes tiny breaks in the film and overheating of the terminals which eventually progress and finally open the circuit. The design of the present invention allows the film heaters to operate at a much higher temperature without a failure. The base plate 11 has a downwardly extending tongue 33 at one side thereof so that the terminals are insulated from the main portion of the film heater by means of the reflector pan 17 as shown in FIGURE 2. The base plate 11 which is of nearly pure silica is a very poor thermal conductor and it has been found that there is a temperature drop of nearly 400° F. between the terminals and the bottom surface of the base plate at spaced points only three quarters of an inch apart.

The gold and platinum films are obtained in liquid form and are essentially solutions in volatile oils of organic gold and platinum compounds. When the films are painted on the base plate and heated to a curing temperature the organic parts are burned out and the metallic film is left on the surface. These liquids contain some base metal organic compounds such as Bi, Sn, and Cr which oxidize and serve as fluxes to fix the metal firmly to the supporting material. The pattern of the film heater is printed on a silk screen or stainless steel screen and these screens are covered with photo emulsion which is applied thinly so it does not add to the thickness of the screen, as it fills only the voids in the mesh. When the pattern is printed on the screen the emulsion is removed so that the liquid can be passed. A rubber squeegee with a V-sharpened edge forces the liquid material through the screen and onto the base plate. Then the films are dried either at room temperature for one hour or they may be dried faster by passing them through a warming chamber. After the films are dried, the printed plates are placed on moving belts in a furnace. During this firing process it is very important to allow all organic material to burn out. The furnace atmosphere should be strongly oxidizing. This organic matter is especially difficult to burn out completely when the films are thick. Any small residue of these materials left in the films make the films much weaker. After the firing process of approximately 60 minutes the base plate is cooled down in the furnace and the next coating is applied.

There are many advantages in a surface heating unit made with film heaters in strip form. The most important advantage is its clean and attractive appearance. This type of heater has a low thermal mass, therefore it stores less heat when heated up and it heats up and cools down faster than a sheath type heating unit. It has a more even temperature distribution, and has more heated surface in contact with the cooking utensil. It has been found that it performs better at lower temperatures than a sheath type surface unit. Finally, it is simple to manufacture and its cost is low.

Modifications of this invention will occur to those skilled in this art and it is to be understood, therefore, that this invention is not limited to the particular embodiment disclosed but that it is intended to cover all modifications which are within the true spirit and scope of this invention as claimed.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A heating unit comprising a glass-like base of high dielectric strength, good thermal shock resistance, chemical inertness, good abrasion resistance and mechanical

strength, and being transparent to infrared radiation, a narrow continuous strip of multi-layer metallic film bonded to the base, the film being a composite material comprising at least one inner layer of platinum having a relatively high resistance in the range of about 13 to 39 ohms per square, and an outer layer of gold having a relatively low resistance in the range of about 0.5 and 1.5 ohms per square, the platinum having a higher melting point than the gold to protect the gold so that the gold will not crystallize at high temperatures of around 1200°, the two film layers representing resistances that are arranged in parallel so that the total resistance of the narrow strip is approximately equal to the low resistance of the outer gold layer.

2. A resistance heating unit comprising a narrow continuous strip of multi-layer metallic film bonded to a dielectric base material, the film having at least one inner layer of platinum having a relatively high resistance in the range of about 13 to 39 ohms per square, and an outer layer of gold having a relatively low resistance in the range of about 0.5 and 1.5 ohms per square, the platinum having a much higher melting point than the gold to retard the crystallization and migration of the gold, the two film layers representing resistances that are arranged in parallel so that the total resistance of the narrow strip is approximately equal to the low resistance of the outer gold layer.

3. A resistance heating unit comprising a narrow continuous strip of multi-layer metallic film bonded to a dielectric base material, the film having at least one inner layer of platinum and an outer layer of gold, the gold being a relatively low resistance conductor of electrical current while the platinum is a relatively high resistance material with a much higher melting point than the gold to retard the crystallization and migration of the gold, the narrow strip of metallic film being arranged in a serpentine pattern having electrical terminals at each

end of the strip as well as one adjacent the mid-portion thereof.

4. A resistance heating unit as recited in claim 2 wherein the dielectric base material is a sheet of nearly pure silicon oxide that is etched on both sides, and the multi-layer metallic film heater is positioned on the underside of the base material.

5. A surface heating unit for an electric range comprising a dielectric plate member having a film heater in strip form bonded to the underside thereof, one side edge of the plate having a down-turned tongue on which the terminal ends of the film heater are disposed, a reflector pan positioned under the plate to shield the terminals from the high temperatures of the main portion of the film heater.

6. A surface heating unit as recited in claim 5 wherein the dielectric plate member is a glass with high resistivity and thermal shock resistance as well as being transparent to infrared radiation.

7. A surface heating unit as recited in claim 5 wherein the film heater has at least one layer each of platinum and gold where the platinum has a much higher resistance and melting point than the gold to retard the crystallization and migration of the gold.

References Cited in the file of this patent

UNITED STATES PATENTS

617,375	Voigt et al.	Jan. 10, 1899
2,021,661	Kisfaludy	Nov. 19, 1935
2,603,740	Buttero	July 15, 1952
2,640,906	Haynes	June 2, 1953
2,693,023	Kerridge et al.	Nov. 2, 1954
2,757,104	Howes	July 31, 1956

FOREIGN PATENTS

486,639	Great Britain	June 8, 1938
611,250	Great Britain	Oct. 27, 1948