United States Patent

[11] **3,632,980**

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[54] **CONVECTOR SURFACE COOKING UNIT**
13 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **219/370,** 219/368, 219/369, 219/374
[51] **Int. Cl.** **F24h 3/04**
[50] **Field of Search** 219/366, 367, 368, 370, 374, 375, 376, 369

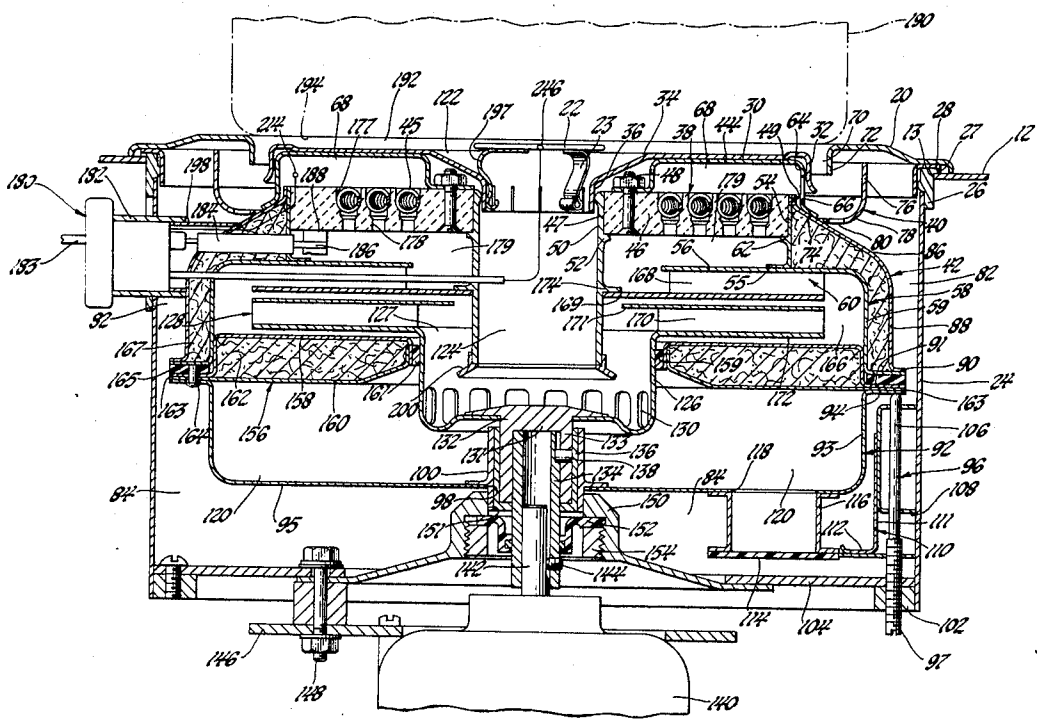
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ABSTRACT: An air convection range surface heater has a centrifugal air impeller for recirculating electrically heated air and includes fixed stator vanes operative with the impeller to increase the mass airflow through a heat exchanger and into an air circulation space adjacent a utensil to thereby distribute maximum heat flux to the utensil. The unit provides both inner and outer cooperating spill chambers that readily separate the heated air from spillage to eliminate fire and electrical short circuiting hazards. A solid state air monitor and control circuit is provided for throttling power input to limit the maximum air temperature in the unit's heat exchanger at any desired value.



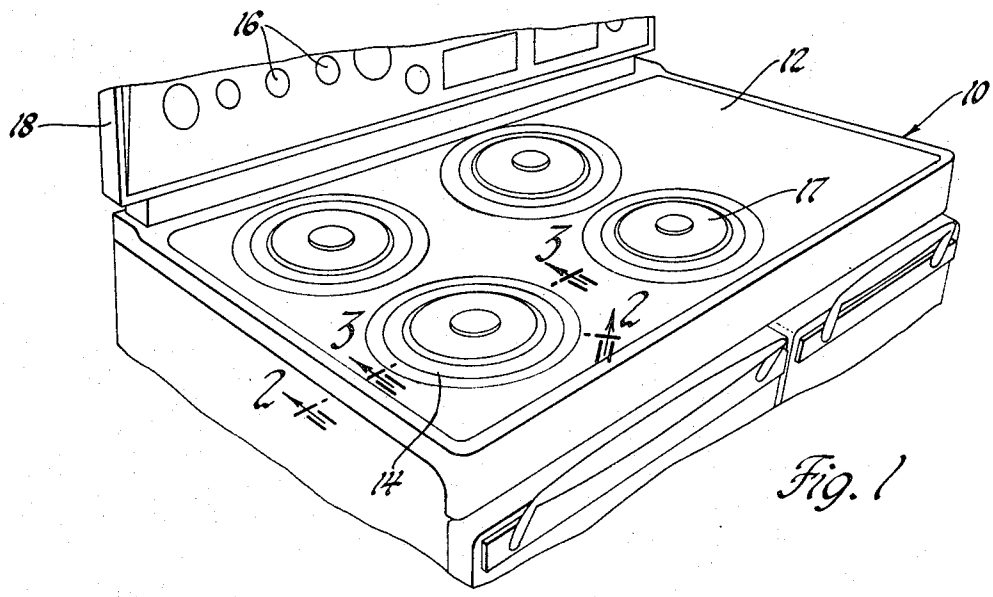


Fig. 1

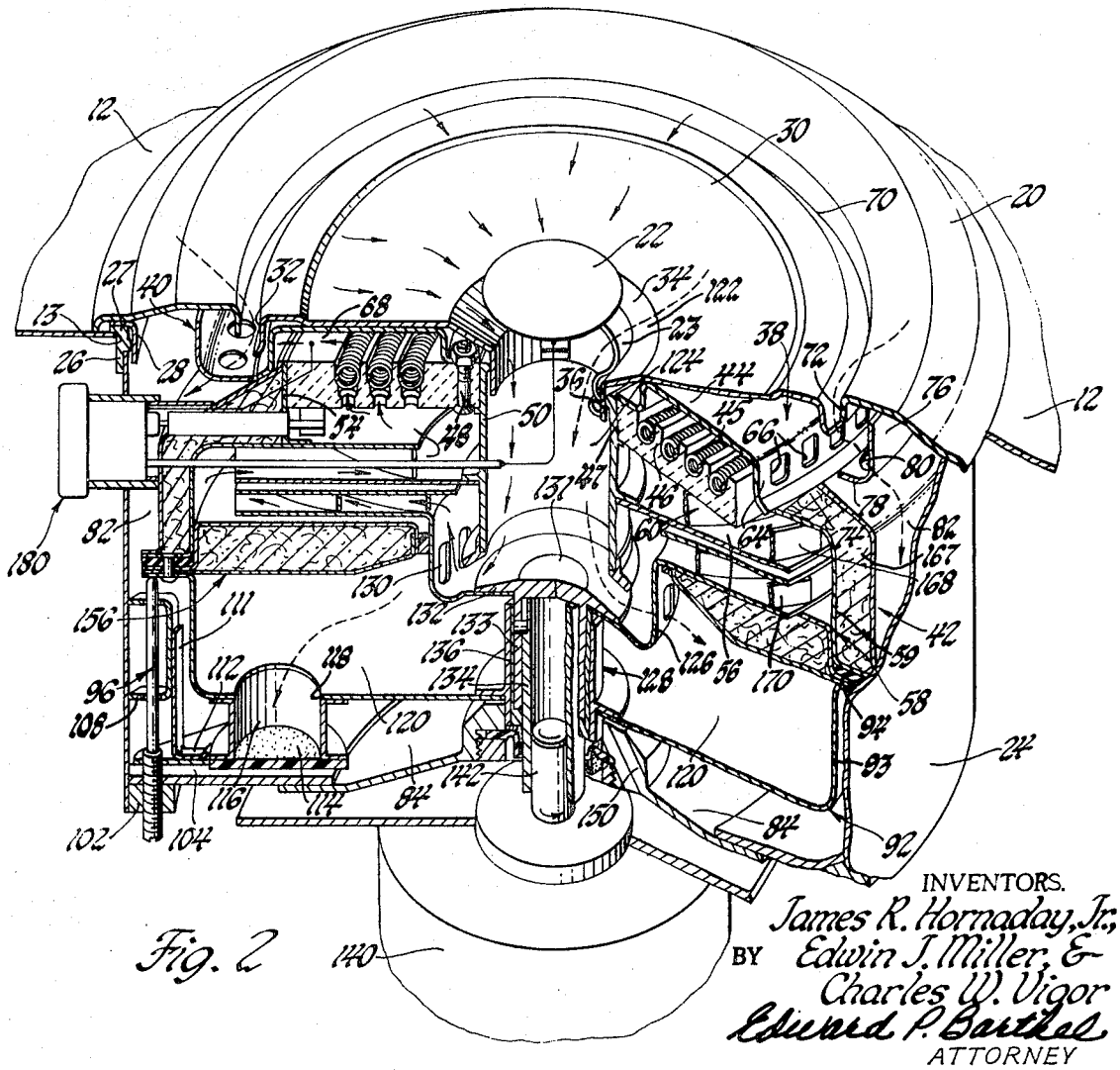


Fig. 2

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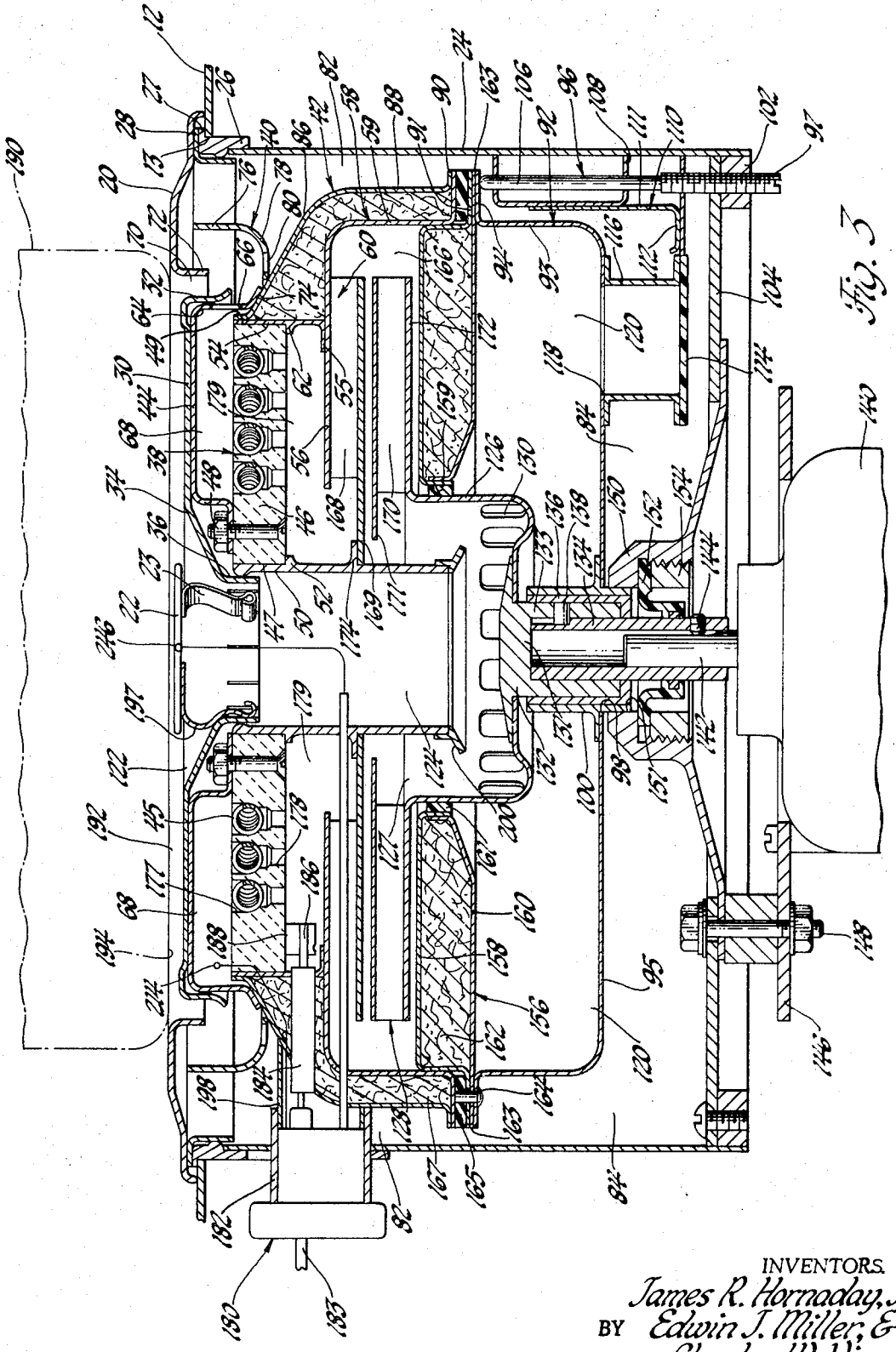


Fig. 3

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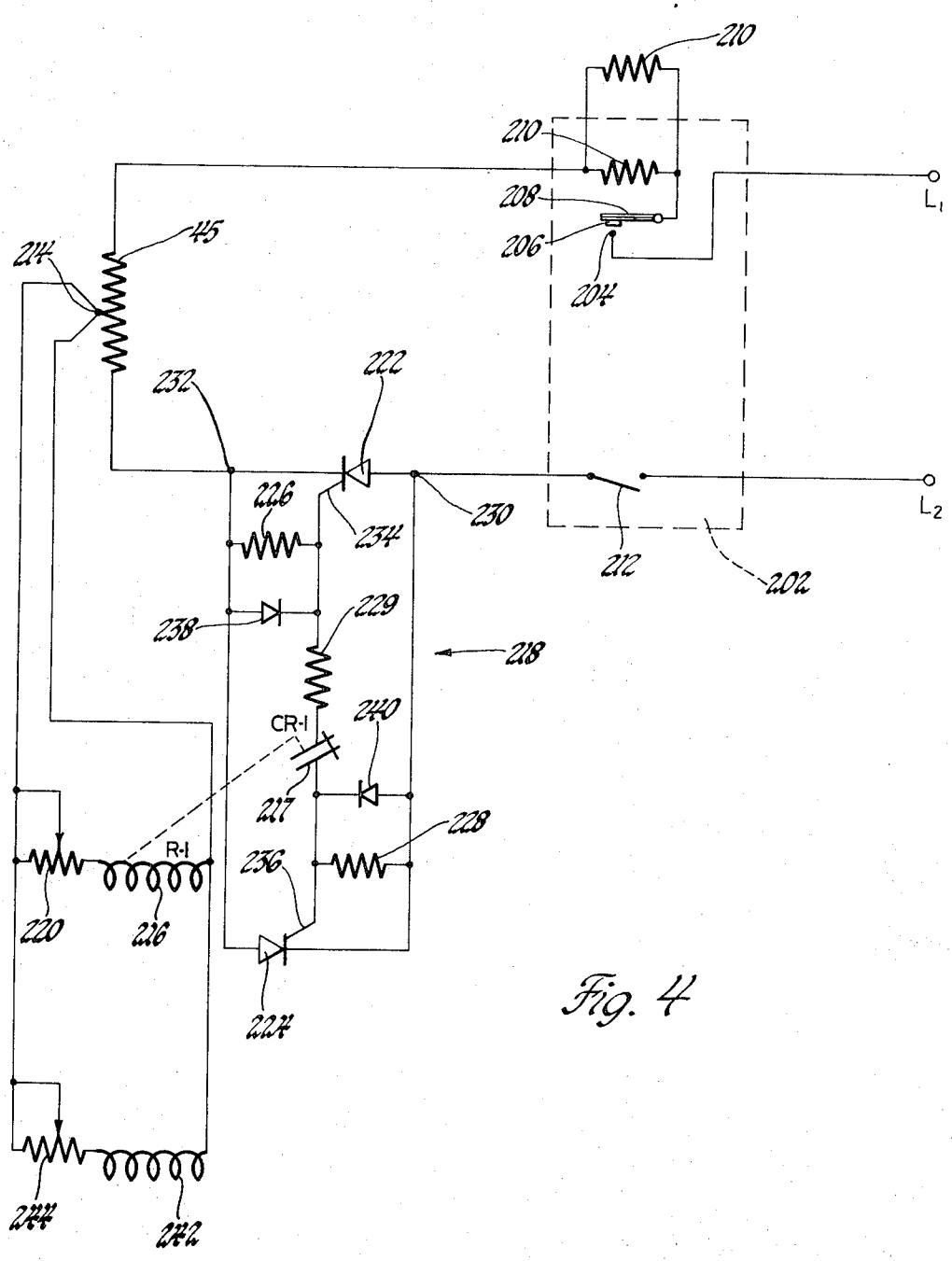


Fig. 4

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CONVECTOR SURFACE COOKING UNIT

This invention relates to a domestic appliance and more particularly to an improved electric range surface unit operating on the principal of convection heat transfer.

The use of convection heating in a surface unit of an electric range is broadly disclosed and claimed in applicant's U.S. Pat. No. 3,167,638 entitled "Surface Cooking Unit" issued Jan. 26, 1965 to J. R. Hornaday, Jr., et al. and assigned to the same assignee as the present application. Reference may be had to that patent for the broad principles underlying the present invention.

The present invention, although utilizing some of the teachings shown in that prior disclosure, contemplates a convector air-type surface heating unit having an improved recirculating air system, means for separating the heated air from spilled material the provision of a novel control circuit for limiting the maximum air temperature. Also applicants' discovered a novel arrangement whereby the airflow rate through the surface unit could be improved by a design that increases the pressure of the air and eliminates undesirable air swirl prior to its entry into the heat exchange portion of the unit.

Accordingly it is an object of this invention to provide a convector-type air cooking unit which is designed for the ready separation of spilled materials from the heated air.

Another object of this invention is the provision of a convector-type air cooking unit which provides for gravity flow bypass means for the ready separation of spilled material from both the supply and return airflow passages of the unit.

Still another object of the instant invention is to provide outer and inner spill chambers that are interconnected to insure the prompt segregation of spilled material from the heated areas of the unit while also facilitating cleaning thereof.

A still further object of this invention is the provision of an improved convection heat transfer electric range surface unit which provides for optimum thermal efficiency by improving the air mass flow and air direction flow within the unit.

A still further object of this invention is the provision of an improved air convection range surface heater which increases the total heat flux between the surface heater and a vessel thereon.

Yet another object of the present invention is to provide a convector-type air cooking unit in which the air temperature adjacent the heating coils is maintained at or below a maximum temperature.

Still another object of the invention is the provision of a solid state semiconductor control means for a convector-type air cooking unit to prevent over heating of the heater coils from any cause.

A further object of the present invention is to provide a control means for convector-type air cooking unit in which the air temperature is maintained at or below a preselected setting having solid state semiconductor switch means therein for varying the power supply to the heater element in accordance with sensed conditions within the hot air plenum and including means for completely deenergizing the unit.

Other advantages found in the improved range surface heater of the invention are the use of ceramic coatings on the surface components, available in a range of colors made possible because of the lower temperatures of the surface components; reduction in the number of hardware components required for construction of the cooking top; provision for adjustment of the air circulation gap between a utensil and the unit; a unit having low-thermal mass; rapid attenuation of heat flux to the cooking vessel on shutoff of the unit; and whereby uniformity of temperature of the cooking surface is maintained because dynamic means are provided to monitor and control the temperature of the heating medium rather than only the power input.

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

In the drawings:

FIG. 1 is a fragmentary perspective view of an electric range suitable for use with the invention;

FIG. 2 is a fragmentary perspective sectional view taken along the line 2—2 of FIG. 1 with parts broken away to show in detail one of the convection air cooking units;

FIG. 3 is a fragmentary section taken along the lines 3—3 of FIG. 1; and

FIG. 4 is a diagrammatic view of an electrical circuit constructed in accordance with principles of the present invention.

In accordance with this invention and with reference to FIG. 1, an electric range **10** is illustrated. The range **10** is provided with a range top **12** having a plurality of surface heaters or cooking units such as **14** on the side thereof. Suitable controls such as **16** are provided on a console **18** of the range and adapted for selectively energizing the surface cooking unit **14**.

FIG. 1 depicts a novel air convection range surface heater or cooking unit **14** wherein a current of superheated air radially traverses the top of the surface cooking unit from the outer periphery to the center of the unit. As explained in the above-mentioned U.S. Pat. No. 3,167,638 in its flow the air will transfer its heat very evenly to any utensil placed thereon. The surface of the heating element **14** may be kept clean and bright because the cooking vessel contact area operates at a relatively low temperature, permitting the use of special high-temperature vitreous enamel as a coating for parts of this area. The enamel, more properly called the ceramic coating, remains bright and lustrous during operation and in the case of soiling can be cleaned easily by using kitchen methods. Further, such enamel can be modified to match a wide variety of colors obtainable with conventional vitreous enamels. These factors enhance the styling possibilities with the surface cooking units **14**.

In the prior art convector units spilled materials may be allowed to come into prolonged association with the heated air resulting in a possibility of overheating the spillage and a possible blockage of the airflow ducts. Furthermore, many prior art convection heat-transfer designs have a centrifugal-type fan such that the air leaving the fan has a large undesirable tangential velocity component or "swirl." It was discovered by applicant' that if the air leaving the fan could be redirected radially inwards by some means it would not only improved the airflow through the heat exchanger by eliminating the swirl but would convert the high velocity of the air of a high pressure whereby the desired mass flow of air through the heat exchanger could be maintained. In the following description of the cooking unit **14** of this invention it will be seen how the spillage and air mass flow problems, among others, have been eliminated.

With reference to FIG. 2, a sectional view of the convection air surface heater or cooking unit of this invention is shown comprised of a decorative annular pan rest for pan support ring **20** located on the top surface **12** of the range. The pan support ring **20** which is preferably enamel coated, rests about a circular opening **13** in the range top surface and is outwardly sloped to direct spillage away from the opening. A center baffle rest **22** is provided for downwardly directing the return air and, as seen in FIG. 3, is provided with spaced resilient clip arms **23** for removably retaining the center baffle on the unit at the desired elevation. The upper surface of the center baffle rest can be coated with an enamel finish in the manner such as described above.

In FIG. 2 there is shown a portion of the range top **12** having a surface heating unit aperture **13** adapted to support an outer casing **24** by means of an annular collar member **26** which is fixed to the outer surface of the casing **24** by suitable means such as by welding. The collar **26** has an outwardly directed flange **27** which rests directly on the flat upper surface of the range top **12**. The collar **26** supports a circular trim member **28** having an inverted L cross section for overlying the collar **26** and forming a support for the pan support ring **20**. A disklike burner top member **30**, which also can be coated with enamel, extends radially a spaced distance from the outer ring **20** to a location beneath the center baffle **22** while being pro-

vided with a depending outer snap-flange 32 and an inner inverted conical portion 34 terminating in a downwardly directed spout or cylindrical collar 36 (FIG. 3). In this way, the burner top member or disk 30 may lay in snapfitting relationship to underlying portions of the cooking unit now to be described.

Upon removal of the support ring 20, baffle 22 and burner top disk 30 there is exposed a heater coil assembly, generally indicated at 38, annular deflector member 40 and outer support shell 42. The heater coil assembly 38 comprises an upper U-shaped heater guard 44 for supporting the burner top disk 30 in snap-action fashion thereon, a resistance coil 45, and a coil support ring 46 formed from a refractory material such as ceramic or the like which is suitably secured to the heater guard 44 such as by through bolts indicated at 48. With reference to FIG. 3, it will be seen that the coil support ring 46, composed in the preferred embodiment of six individual pie-shaped sections, has a central opening 47 dimensioned for slidable mounting on center return air tube 50 and is retained on the upper flange 52 of the tube 50 to be substantially flush with the upper end thereof. In this manner the heater coil assembly 38 can be removed from the cooking unit casing 24 by simply lifting it vertically upwards thus permitting ease of maintenance and ready access to the internal portions of the unit. Notice that the coil support ring 46 is supported at its outer periphery 49 by a retaining band 54 having a base leg 55 located on the horizontal plate portion 56 of an inner shell member 58. It will be observed that the inner shell 58 has an annular wall portion 59 enclosing a stator assembly generally indicated at 60, the details of which will be explained subsequently.

As viewed in FIG. 3 the support band 54 has an inwardly directed flange 62 in opposed alignment with tube flange 52 and upon which the outer portion of coil support ring 46 rests. Further, the heater guard 44 has a downwardly directed outer rim 64 having a series of closely spaced, generally rectangular apertures 66 (FIG. 2) providing peripheral outlet means for an upper hot air annular plenum or cavity 68, bounded by the coil support ring 46 and spaced heater guard 44. A supply air outlet or annulus 70 is defined by the outer snap-flange 32 of the burner disk 30 and the opposed concentric lip 72 of the pan support ring 20. It will be observed that heater guard rim 64 has a conical ledge 74 designed to nest on the outwardly sloping portion of the support shell 42.

The air deflector member 40 is formed having a substantially right-angle cross section, the vertical leg 76 of which forms an air deflector to direct the substantially horizontal passage of he hot air (solid arrows in FIG. 2) exiting from the plenum apertures 66 upwardly to the supply air outlet 70. The horizontal leg 78 of the deflector 40 has a continuous series of closely spaced apertures or spillage holes 80, illustrated in FIG. 2 of the drawings, located alignment with gravitational flow of spillage entering through annulus 70. The spillage is outwardly directed past upper plenum apertures 66 by the flared end of snap-flange 32. The bypass apertures 80 in turn provide ready flow of spillage to a vertical spill passage 82, defined by the outer support shell 42 and the casing member 24, leading to an outer spill chamber 84 occupying the bottom of the casing.

Thus, when spillage enters the outlet 70 it will be shunted directly into the passage 82 because of the natural force of gravity acting on the substantially greater mass of liquid and solid spilled material. The result is that such spillage is immediately segregated from the hot airflow and passed directly to the outer spill chamber 84. It will further be seen that applicant's design allows any spilled solid material of a size greater than bypass holes 80 to be retained by the deflector member 40 without blocking the hot airflow from the upper plenum 68 to the supply air outlet 70. In addition it should be observed that the snap flange 32 of the burner top disk acts, together with the heater guard 44, as a shield to prevent possible direct or straight line radiation from the heater coil 45 upwardly to the cooking utensil.

As seen in FIG. 3 the outer shell 42, comprising upper conical wall portion 86 and vertical wall 88, has an outwardly directed stiffening flange 90 supported directly on a projecting ledge 91 of the inner shell 58.

The outer spill chamber 84 is defined in part by the bottom plate 104 of casing 24 and a pan member generally indicated at 92 whose upwardly extending peripheral sidewall 93 ends in an outwardly turned continuous rim 94 resting directly on a plurality of adjusting screws, one of which being indicated at 96. Centered within the flat bottom wall 95 of underlying pan 92 is an opening 98 for reception of the central tubular support member 100 the purpose of which will be discussed hereinafter. The adjusting screws 96 are threadly supported in an O-ring member 102, suitably affixed as by welding to the outer casing 24, for supporting the bottom plate 104 portion of the outer casing 24.

The upper stem 106 of the adjusting screw 96 extends upwardly through vertically aligned apertures in a channel section 108 welded or otherwise suitably affixed to the casing 24. A bracket member 110 has its vertical leg 111 spot welded to the face of the channel section 108 while its inwardly projecting leg 112 serves as the hinge support for the fixed portion of a flapper valve member 114. The valve 114 seals a tubular or spill trap drain 116 communicating with an offset aperture 118 located in the bottom wall 95 surface of the pan member 92. The flapper valve 114, formed of a flexible material such as Teflon (a polytetrafluroethylene plastic), interconnects an inner spill chamber 120 defined by the pan 92 with the underlying outer spill chamber 84. The inner spill chamber 120 receives spilled material from an air return inlet or annulus, indicated at 122, and defined by the center baffle rest 22 and the conical portion 34 of burner top disk 30. In operation, flapper valve 114 is normally closed by the air pressure difference between chambers 84 and 120 and open only when the weight of the ingested liquid entering through inlet 122 is sufficient to open the valve 114 allowing the material to pass into the outer spill chamber 84.

FIG. 2 shows how spillage (dashed arrows) entering through the air return inlet 122 is directed inward and downward into the inner return air passage 124 provided by the tube 50. The lower end of the tube 50 telescopes into a depending housing 126 of a centrifugal impeller means, generally indicated at 128, while defining a return air corridor 127. The depending housing 126 functions as an intermediate spillage trap having closely spaced windowlike openings 130 communicating with the inner spill chamber 120 thus allowing any spillage to readily separate from the return airflow in passage 124 (solid arrows) by gravitational action and cascade into the surrounding chamber 120.

Turning now to the drive arrangement it can be seen that the impeller 128 is connected via a mounting hub 131, extending downwardly from its housing 126, to a vertical shaft 134. The mounting hub 131 has a head portion 132 fixedly attached to the housing 126 ad a stem portion 133 journaled in the tubular support 100 in any suitable manner such as by seating in a cup-type bearing 136. The hub 131 is fastened to the hollow shaft 134 such as by a key 138. Motive means 140 provides the drive for the impeller 128 and is arranged so as to be concealed beneath the range top. The motive means 140 in the instant embodiment is a standard AC universal, 115 volt, electric motor. The motor drive shaft 142 is slip fitted within the tubular shaft 134 and is retained in driving relationship therein by means of a threaded stop bolt 144 on a flat of the shaft. The motor 140 is bracketed to the casing bottom plate 104 by collar 146 and held by suitable securing means such as machine bolts shown at 148.

A pedestal member 150 is fastened to the bottom plate 104 by means of bolts 148 which extend downwardly to support the motor collar 146. The pedestal member has a central upstanding bore 151 for receiving the lower end of the tubular support 100 in sliding-fit fashion. Molded cup packing seal 152 surrounds the shaft 134 and is retained in place by pressure ring nut 154 allowing sealed rotary motion of the shaft 134 for driving the impeller in a counterclockwise direction.

No difficulties have been experienced in the disclosed embodiment with over heating of the motor **140** as a result of the surface unit operation. However, it should be understood that motor design operation within higher ambient temperatures is well within the skill of a mechanic. It should be further understood that a single motor could be used to drive impellers in the other air convection surfaces heating units such as shown at **17** in FIG. **1**—the motor being energized whenever any one of the surface heaters is energized.

The lower pan assembly **92** is closed by an annular cover member **156** comprising an upper cover sheet **158** and a spaced lower cover sheet **160** being heat-insulated therefrom by a suitable material such as a batt of fibrous glass **162** compressed therebetween to minimize the heat transfer into the pan **92**. Note that the cover member **156** has a central opening **159** and includes a sealing gasket **161** formed of silicon rubber, of the like, to thermally isolate the cover from the housing **126** while sealing the return airflow passage. Cover sheets **158**, **160** terminate in a double flanged edge **16** which seats on the continuous rim **94** of the pan **92**, this assembly in turn supporting projecting ledge **91** of the inner shell member **58**. As seen in FIG. **3**, the ledge **91** together with the double flange **163** of the cover member are affixed to the pan rim **94** by suitable means such as rivets **164** and a sealing gasket **165** is placed therebetween for sealing air within inner shell duct **166** and minimizing heat conduction between the shell structure and the pan **92**. It should be noted that the space between outer shell **42** and inner shell **58** is also provided with a suitable heat insulation material **167** such as a batt fibrous glass to further reduce the heat loss from the unit **14** and minimize the requirements for preheating the unit.

As best seen in FIG. **3**, the stator **60** has generally radially directed curved vanes **168** fixedly supported between horizontal plate **56** and the underlying stator plate **169**. The stator vanes **168** are suitably curved in a complemental manner to the forwardly curved impeller blades **170** shown sandwiched between an impeller plate **171** ad the horizontal plate **172** forming a continuation of impeller housing **126**. It will be noted that the term forwardly curved relates to the fact that the blades **170** are curved toward the direction of impeller rotation which in the instant embodiment is counterclockwise. Applicants' air circulation design enables the stator vanes **168** to change the flow path of the air from the fan blades **170**, as viewed by the solid arrows in FIG. **2**, from a high-velocity tangential swirl to a radially inward flow of the lower velocity but higher pressure. The lower stator support plate **169** is affixed to the return air tube **50** by suitable means such as welding to a lower flange **174** of the tube **52**.

Explaining now the heat exchange portion of the unit the continuous resistance coil **45** of known spiral type, is held in a spiral U-shaped groove **177** in the upper face of the coil support ring **46**. The ceramic ring has passage means preferably comprising a continuous series of closely spaced, counterbored air passage holes shown at **178** communicating with the spiral groove **177**. In this way the airflow upon exiting from the stator vanes **168** moves upwardly into a lower plenum or cavity **179** and is heated by traveling vertically through holes **178** past the resistance coil **45** and into the upper plenum **68**. Applicants' new heat exchange design permits maximum efficiency in the transfer of heat exchange energy to the air through balanced distribution to the coil. Further it allows for a pressure differential between lower plenum **179** and upper plenum **68** thereby increasing the mass flow of air to the cooking utensil.

Power is delivered to the coil **45** by means of plug adapt **180** which extends into casing **24** through tube **182** shown protruding into vertical passage **82**. Leads **183** extend through plug **180** and insulation sleeve **184** terminating in a pair of contactor receiving members **186**. A pair of spade connectors **188** are provided on the underside of ceramic ring **46** for ready insertion in the two receiving members **186**. This arrangement provides an insulated plug-in connection to insure against short circuiting and shock hazards due, for example, to possible salt water spillage into the air supply outlet. The plug-type connectors **186**, **188** provide for connecting the coil **176** across a 230-volt AC Edison power supply to obtain various wattage outputs, as well understood in the art.

Considering now the loaded condition of the surface unit **14**, FIG. **3** illustrates a recirculating air system. With the energization of the motor **140** and the heating coil **45** and with a utensil such as pan **190** (shown in phantom) resting on the support ring **20** a closed air circulation space or gap **192** will be formed between the bottom **194** of the pan and the burner top disk **30**. Thus, as previously indicated by means of the solid arrows of FIG. **2** air is forced by the impeller blades **170** into the air supply duct **166** the air turns substantially 180° and enters between the stator vanes **168**. The stator vanes **168** change the flow of the air from a high-velocity tangential or cyclonic swirl imparted by the forwardly curved fan blades **170** to a radially inward flow of lower velocity but higher pressure. The decrease in density of the air accompanying the temperature increase in the heat exchange upper plenum **68** requires additional pressure rather than velocity to maintain the desired mass flow of air to the air circulation gap **192**.

When it is desired to initially adjust the height of the air circulation gap **192** upon installation of the unit the adjusting screws **96** are rotated by insertion of a screwdriver into the slotted head portion **97** of the screws. Rotation of adjusting screws **96** vertically shifts the inner assembly including the shell members **42** and **56** which in turn vertically adjusts the height of the burner top disk **30** with respect to the plane of a utensil bottom supported on the unit. By adjusting the gap **192** the optimum gap spacing can be attained which is a balance between a large air mass flow provided by a large gap and an increased convective heat-transfer coefficient dependent upon several factors including increased air velocity and air turbulence provided by a small gap. The optimum gap spacing is therefore that spacing which will maximize the heat transfer flux between the airflow and the utensil. It is to be noted that the adjusting screws are located at 120° spaced intervals and this arrangement ensures proper leveling of the heating unit. The slip fit between the bore **151** and tubular support **100** allows the heating unit assembly to move up and down when the adjusting screws are rotated.

With respect to the heating element the entire air stream is heated by passing vertically upward normal to the principal axis of the coil **45** after exciting from the vertical holes **178** in the coil support plate **46**. By virtue of distributing the air vertically past a single section of the coil **45** rather than having the same airflow past successive coil sections, local flow restrictions within the heat exchange area are reduced to improve the airflow through the unit. It has been found that for efficient operation the space between helical or individual spirals of coil **45**, wound from round wire, should be at least equal to the wire diameter. The air exists the heat exchange plenum **68** through the rectangular openings **66** in the heater guard **44** and is then directed to the under pan space **192** via the supply air outlet **70**. After contact with the pan bottom **194** the air is drawn down by means of inlet **122**, into the return air passage **124** of the center of tube **50** and makes a 180° turn upward into air corridor **127** and finally returns to the impelling means.

Referring now to FIG. **3**, it will be seen that the heated air is directed substantially vertically through the outlet **70**. It has been found that when the heated air emerges from the outlet **70** and is aimed directly at the utensil bottom, requiring the air to change direction before flowing radially in towards the center inlet **122**, the convective heat-transfer coefficient relative to the utensil is higher that when the initial direction of the heated air is radially inward. It should be mentioned that the instant design does not require that a cooking utensil be in place on the unit to seal the outer ring **20** because the remainder of the airflow path is sealed.

The external top plate hardware consisting of the trim and pan support ring **20**, the burner top disk **30**, and the center baffle **22** have been formed from austenitic stainless steel (Type 304) which can also be used to form the interior por-

tion of the unit such as shell members **42** and **58**, if desired. Such stainless steel was selected for its superior hot strength over carbon steel grades. However, it is contemplated that a lower grade of alloy will have sufficient hot strength for such interior portions of the unit while being able to meet the temperatures encountered in the air convection range surface heater of this invention.

While in the subject of the cooking unit hardware it will be observed that the surface hardware portions of the invention are designed in such a manner that it is virtually impossible for a small cooking utensil, a utensil with an irregular shaped bottom, or an improperly positioned utensil to choke off the airflow across the gap **192**. This result is achieved in part because the center baffle rest **22** has a convex portion **197** on its clip arms **23** operative to shoulder on the conical area **34** of the burner disk **30**. Thus the upper surface of the baffle **30** is maintained in a plane that is vertically spaced from the plane of disk **30** to insure against inadvertent blocking of the gap **192** or inlet **122**.

With regard so the design for spill handling, the flow path of liquid spillage passing through the air outlet **70** of the surface unit, as indicated by the line dashed arrows in FIG. **2**, will be directed away from the apertures **66** of the heater coil guard by the outwardly turned flange **32** of the burner top **30**. The spillage travels downwardly through the apertures **80** in the deflector **40**, into the vertical spill passage **82** and finally into the outer spill chamber **84**. A shield **198**, forming a continuation of tube **182**, protects the electrical leads **183** from contact with the spillage.

From the foregoing, it can be appreciated that a unique design for the removal of foreign materials from the recirculating air path has been accomplished by taking advantage of the relatively large density variance between air and the liquid spillage. Food and liquid spillage adjacent the center of the unit will drain into the center air return **122** of the unit as indicated in FIG. **3** where it is separated from the airflow by the natural force of gravity and conveyed into the fan housing **126**. Centrifugal force imported to the spillage by the rotation of housing **126** accelerates the movement of spillage through the openings !**130** and into inner spill chamber **120**. The return airflow is directed up into the return air corridor **127** to the blades **170** of the fan. The outlet of tube **50** is provided with a splash deflector **200** at its discharge end to prevent spillage from entering the corridor **127**. The spill trap **116** below pan **92** interconnects the two spill chambers **84** and **120** by means of the flapper valve **114** providing greater spill storage capacity of the unit.

The air convection surface unit incorporates a control system which will provide cyclic off-on operation to control the electrical inputs to the resistance coil **45** at the discretion of the operator. The system also allows over-riding maximum air temperatures control to prevent overheating of the unit. A preferred circuit arrangement for controlling the mean flux heat is illustrated in FIG. **4** of the drawings. A conventional pulsating infinite heat switch of a type shown in U.S. Pat. No. 2,623,137 issued to W. H. Vogelsberg for example, is indicated at **202** including a pair of electrical contacts **204** ad **206** with the contact **206** located on a bimetal cycler **208** thermally actuatable in reference to electrical resistance windings **210**. Additional contacts **212** provided for the L2 side of the power line and a conventional signal lamp circuit (not shown). When the operator rotates the control **16** on the control panel of the range from the off position all contacts within the switch **202** close and a current of 230 volts, 60-cycle AC is supplied to the heater coil **45** of the surface unit and 118 volts is supplied to the signal lamp circuit. After a time interval, depending upon the user's control setting, the bimetal cycler **208** is sufficiently heated **210** to cause the bimetal to warp and open the circuit through the heater coil **45** after which the bimetal cools and returns to its normal shape thus closing the contacts **204** and **206** against completing the circuit to the heater coil. Thus the switch **202** provides a cyclic off-on operation with stepless variable ratios of off-on time, controlling heat inputs that can vary from 5 percent to 100 percent of rated power.

The overriding maximum air temperature control portion of the circuit allows a new concept for surface burner control by making it possible to monitor and control the temperature of the heating medium itself rather than only regulation of the power input. The preferred embodiment of the invention is designed as a conventional 230-volt unit of sufficient power (3500 watts) to produce a rapid warmup and thereafter be throttled back. The throttling action is based on limiting the maximum air temperature in the upper plenum **68** of the heat exchange section such that a maximum temperature cutout overrides s the other control inputs.

As seen in FIG. **3** the control system includes an electric temperature sensor such **4**) conventional thermocouple probe indicated at **214** that is supported in the ceramic ring **46** of the unit to sense the air temperature in the upper hot air plenum **68**. While the description will be concerned with an electrical control and specifically a thermoelectric type sensing element it will be understood that the instant temperature control system could be modified using resistance elements such as thermistors or resistance bulbs. In addition differential expansion or fluid expansion type thermostats could also be employed without departing from the scope of the invention. The thermocouple **214** is wired directly into a sensitive relay **216** (FIG. **4**) having contacts **217** which open or close the gate circuit of a power supply switch which is the preferred embodiment is a solid state silicon controlled rectifier bank generally indicated at **218**. The voltage generated in thermocouple **214** acts as a control signal which operates the silicon controlled rectifier bank **218** for supplying power to the heater's resistance coil **45**.

The thermocouple **214** functions to open the relay **216** at a preselected level determined by the setting of the potentiometer **220** inserted in series with the thermocouple **214** and he relay **216**. In the disclosed unit the potentiometer is adjusted to limit the air temperature in plenum **68** to a maximum of 1,100° F.

As seen in FIG. **4** the rectifier bank **218** is representatively illustrated as being a pair of oppositely facing silicon controlled rectifiers **222**, **224** which are actuated by the induced voltage in their associated resistors **226** and **228**, respectively, and which are conductive for a predetermined period of the full waveform of the AC power supply across electrical supply lines L1 and L2. The resistor **229** functions as a voltage divider in the circuit.

The rectifier **222** has its anode connected to the terminal **230** and the rectifier **224** has its anode connected to the terminal **232** while gate electrodes **234**, **236** are provided respectively with each rectifier. The gate electrode **234** is connected to the cathode of a diode **238** while the gate electrode **236** s connected to the cathode of a diode **240**. If the current flow occurs through diode **238** the voltage drop thereacross will cause the gate electrode **234** to be positive with respect to the cathode of the rectifier **222** and the rectifier will conduct. On the next half-cycle current flows through conduit diode **240** the voltage drop across the diode **240** will be applied between the gate electrode **236** and the cathode of the rectifier **224** causing the gate **236** to be positive with respect to the cathode and the rectifier **224** will conduct. Thus, either the rectifier **222** or the rectifier **224** is rendered conductive depending on the direction of current flow between the terminals **230** and **232**.

The state of the control rectifiers **222**, **224** determines whether the circuit operates, and the direction in which it operates. Thus, when the contacts **217** of relay **216** are opened by the output voltage from the thermocouple **214**, induced by the air temperature in plenum **68** exceeding 1,100° F., being fed directly to the relay **216** neither of the rectifiers **222**, **224** is conductive and the power in the circuit is throttled. The gates **234**, **236** have to be energized by a very small current in each half-cycle, or they will not conduct. The thermocouple-relay-rectifier bank system of applicants' invention responds readily to the overheating of the heater coil **45** from any cause.

The normal operation of the maximum air temperature control circuit of FIG. 4 is to throttle the power input at the silicon controlled rectifier bank 218. If the rectifier bank fails or is shorted out for any reason, a second relay 242 and associated potentiometer 244 may be connected in parallel with the regular maximum temperature limiting relay 216, and can be adjusted to react if the air temperature in plenum 68 reaches a critical level such as 1,250° F. This second relay 242 can be designed to activate another set of relays (not shown) which will completely deenergize all the cooking units of the range.

In cooking, it is often desirable to stop the effective heat flux very quickly. The effective heat flux in applicants' convection-type surface unit is closely related to the air mass flow and the fan speed. As the motor used in he preferred embodiment is of the type having low-friction ball bearings. the motor fan inertia forces will keep the fan rotating for as long as 30 seconds after the motor has been deenergized. Under these circumstances, the "quick-stop" potential of an air convection unit will not be fully realized. Applicants' surface unit motor therefore can be provided with an automatic dynamic braking control circuit (not shown) of conventional design by cutting off AC power to the motor and applying DC current across the stator windings. The result is a more rapid attenuation of heat flux to the cooking utensil or shutoff which is notably superior to conventional radiant coil surface units.

It will be noted that suitable controls may also be provided to hold the temperature of the cooking utensil, a so-called pan control. Thus, a second thermocouple probe 246 is shown located in the center baffle rest 22 to enable a modified unit to sense the temperature of the vessel 190. By means of the thermocouple 246 the range is able to control the power input according to the demand for maintaining the utensil at a preset temperature. The thermocouple can be wired to a suitable thermostatic switch with conventional temperature indicator markings therein (not shown) located in the front control panel 18 to control the power input to the heater coil 45.

In view of the foregoing, it will be appreciated that an improved air convection surface heater has been devised for an electric range having a unique airflow system for optimum heat flux transfer to the cooking utensil by increasing the air mass flow and thereby increasing the convective heat-transfer coefficient for the system. A major improvement of the present invention is the uniformity of temperature distribution to the cooking surface and the precision of temperature control. Further, by providing a design allowing for the heat-insulation of the unit applicants' have minimized the flow of heat from the heat exchange area to the adjacent portions of the surface heater 14 and range top. The heat insulation barriers 162 and 167 together with the low-thermal mass of applicants' unit and the heat-breaker structure incorporating the insulating gaskets 161 and 165 will minimize the requirements for preheating the unit.

Applicants' improved cooking unit also o markedly reduces the heat flow or output to the cooking utensil on deenergization of the heater-fan combination by means of the heater coil 45 not only being shielded by members 30 and 44 to prevent direct or straight line radiation to the utensil bottom but by providing intervening plenum 68 as well. By designing the plenum 68 in overlying relation to the heater coil the instant invention eliminates the need for heat sink material, such as heat insulation, being located intermediate the air circulation space 192 and the heater coils 45. These and other advantages readily appreciated by one skilled in the art are all embodied in the improved air convection range surface heater of this invention.

While the embodiments of the present invention as herein disclosed, constitute preferred forms, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. A surface cooking unit for an electric range comprising range top means having an opening therein, means in said opening for supporting a utensil on the range top, disk means spaced slightly below the plane of a utensil bottom supported on said supporting means to define a planar air circulation space in said range top means immediately below said utensil bottom, said air circulation space closable at least partially by a utensil supported thereon, a casing member depending from said range top, pan means providing an inner spill chamber located in spaced relation within said casing member and underlying said disk means in space relation thereto, said pan means cooperating with said casing to provide an outer spill chamber therebetween, electrical heating means, means in said unit for supporting said electrical heating means in spaced relation intermediate said disk means and said pan means whereby upper and lower plenums are defined respectively above and below said heating means, supply air outlet means connecting said upper plenum with said air circulation space, vertical passage means connecting said supply air outlet space for heating said utensil, with said outer spill chamber, central air passage means in the form of a central vertical tube having its upper end in communication with said air circulation space and its lower end extending vertically below said air impelling means into said pan means to thereby bypass said heating means and pass spillage directly from said return air inlet means into said inner spill chamber, air return inlet means connecting said air circulation space with said central air passage means which in turn is connected to said lower plenum, air impelling means intermediate said pan means and said lower plenum for circulating air between said heating means and said air circulation space for heating said utensil, and said central air passage means communicating with said inner spill chamber whereby spillage on said unit entering said return air inlet means and said supply air outlet means will pass into said inner and outer spill chambers respectively and bypass said heating means.

2. The surface cooking unit of claim 1, wherein valve means are provided for interconnecting said inner spill chamber and said outer spill chamber said valve means being normally closed in response to the differential air pressure between said inner and outer spill chambers, and said valve means being automatically opened by spillage in said inner spill chamber.

3. The surface cooking unit of claim 1, wherein said impelling means includes a cup-shaped depending fan housing telescopically received in space relation in said pan means, said lower end of said central tube concentrically spaced within said depending housing defining return air corridor means therebetween for supplying return air to said impelling means, said depending fan housing having aperture means spaced vertically below the lower end of said central tube whereby the flow of return air is redirected vertically upwardly to said impelling means while allowing gravitational flow of the spillage into said inner spill chamber.

4. The surface cooling unit of claim 1 wherein air deflecting means are positioned between said upper plenum and said vertical outer passage means, and air deflecting means having an upstanding air deflecting portion redirecting the heated airflow from said upper plenum from a substantially horizontal outward flow to a substantially vertically upward flow.

5. The surface cooking unit of claim 4 wherein said air deflecting means having aperture means underlying said air supply outlet allowing gravitational flow of spillage into said vertical passage to whereby readily separate the spillage from the heated airflow.

6. Surface cooking unit for an electric range comprising range top means in said opening therein, means in said opening for supporting a utensil on the range top, disk means spaced slightly below the plane of the utensil bottom to define a planar air circulation space in said range top means immediately below the utensil bottom, a casing member depending from said range top surrounding said cooking unit, said casing member having concentrically spaced pan means therein underlying said disk means defining an outer spill chamber between said pan means and said casing, said pan means defining an inner spill chamber, concentrically spaced shell means in said casing supported on said pan means, central tube means depending from said disk means and concen-

trically spaced within said shell means establishing supply air duct means therebetween, said shell means ans said tube means cooperatively supporting electrical heating means in spaced relation below said disk means thereby defining an upper plenum intermediate said disk means and heating means, outer supply air outlet means connecting said upper plenum with said air circulation space, vertical passage means defined intermediate said casing member and said shell means connecting said supply air outlet means with said outer spill chamber, air impelling means supported in said supply air duct means in spaced relation below said heating means operative to circulate air between said heating means and said air circulation space for heating the utensil, said central tube means providing a return air passage connecting said air circulation space with said supply air duct means, stator means concentrically supported in said supply air duct means in overlying relation to said impelling means defining a lower plenum intermediate said stator means and said heating means, said lower plenum communicating with said supply air duct means via said stator means whereby air exiting from said stator means is directed radially inwardly to said lower plenum means.

7. The surface cooking unit of claim 6 wherein said impelling means includes a depending housing concentrically spaced within said pan means, and said central tube means being telescopically received in spaced relation within said depending housing thereby defining a vertical return air corridor therebetween connecting said return air passage with said impelling means.

8. The surface cooking unit of claim 7 wherein said depending housing has aperture means therein providing communication between said return air passage and said inner spill chamber permitting spillage from a cooking operation to bypass said heating means and pass from said air return passage and into said inner spill chamber.

9. The surface cooking unit of claim 6 wherein said heating means comprises an electrical resistance coil, a coil support ring and an annular heater guard having an inverted channel-shaped cross section disposed in overlying concentric relation to said coil support ring said coil support ring and said heater guard forming said upper plenum, said heater guard having peripheral air outlet means connecting said upper plenum with said vertical passage means, and deflector means in said vertical passage means operative to deliver the heated air from said upper plenum to said outer supply air outlet means, and aperture means in said deflector means located below said peripheral air outlet means to provide ready spillage segregation from the heated air.

10. The surface cooking unit of claim 6 wherein said pan means having a heat-insulating cover member, said cover member having a central opening therein for passage of said depending housing therethrough, and gasket means substantially sealing said cover member from said depending housing to provide a thermal break in the heat patch between said pan means and the heated air.

11. The surface cooking unit of claim 6 wherein control means are provided for throttling the power input to said electrical heating means to limit the maximum air temperature in said upper plenum of said unit.

12. A surface heating unit for an electric range comprising range top means having an opening therein, means in said opening for supporting a utensil on the range top, a burner disk spaced a predetermined distance below the plane of a utensil bottom supported on said supporting means to define a planar air circulation space in said range top means immediately below said utensil bottom, said air circulation space closable at least partially by a utensil supported thereon, an outer casing member depending from said range top, a heater coil assembly in said casing member including a coil support ring having a central opening a center return air tube said support ring retained on an upper flange of said return air tube so as to be substantially flush with the upper end thereof, said return air tube flange supporting said heater coil assembly in spaced relation below said burner disk whereby an upper plenum is defined between said burner disk and said heater coil assembly, said coil support ring having a convolute U-shaped groove in its upper face, a continuous spiral resistance coil supported in said convolute groove, vertical air passages providing communication between said groove and a lower plenum whereby air from said lower plenum flows through said air passages and is heated by said heating coil as it flows into said upper plenum, supply air outlet means connecting said upper plenum with said air circulation space, air impelling means in the form of a centrifugal fan having forwardly curved blades located in spaced relation below said heater coil assembly, stator means in the form of stationary forwardly curved vanes fixedly supported between parallel horizontal plates defining said lower plenum between said stator means and said heater coil assembly, return air passage means connecting said air circulating space with said lower plenum, said centrifugal fan operative for recirculating air serially from said lower plenum, through said heater coil assembly to said upper plenum, and then to said air circulation space for heating the utensil, whereby the flow of air from said centrifugal fan blades to said stator vanes is changed from an outwardly directed tangential swirl to a radially inward and thence upwardly directed flow of air into said lower plenum such that he resultant pressure in said lower plenum is increased to thereby provide a sufficient air mass flow to said air circulation space to maximize the convection rate of heat transfer along the plane of a utensil bottom supported on said surface cooking unit, and means for adjusting said burner disk relative to the plane of a utensil bottom supported on said supporting means to change said predetermined distance thereby to vary the air mass flow to said air circulation space.

13. The surface heating unit of claim 12 including an alternating current power supply for energizing said resistance coil, said power supply having first and second conductors, bimetal switch means connected in series circuit with said first conductor for controlling said resistance coil in accordance with a predetermined operating temperature selection, temperature sensing means in said upper plenum for controlling said power supply in accordance with with a preselected maximum temperature in said upper plenum, said temperature sensing means including ta thermocouple sensing device for generating a voltage proportional to said preselected maximum temperature in said upper plenum, semiconductor switch means in the form of a silicon-controlled rectifier bank in series with said power supply, said rectifier bank including a pair of opposed silicon-controlled rectifiers in parallel with said second conductor, each of said silicon-controlled rectifiers including a gate electrode, a diode connected between said power and each said gate electrode whereby each said silicon-controlled rectifier is rendered conductive during one half-cycle of the current from said power supply, relay contact means in series with said temperature sensing means interposed between said silicon-controlled rectifiers wherein said relay is operative to open and close the gate circuit of said silicon controlled rectifiers on each half-cycle of current from said power supply and potentiometer means in series with said relay contact means for adjusting the flow of current through said relay contact means to limit the air temperature in said upper plenum to the desired maximum value.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,632,980 Dated January 4, 1972

Inventor(s) James R. Hornaday, Jr., Edwin J. Miller, Charles W. Vigor

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the Specification:

Column 2, line 42, "applicant" should read -- applicants --;
line 45, "of" (second occurrence) should read -- to --.

Column 3, line 49, "he" should read -- the --;
line 53, after "located" insert -- in --;
line 68, "cant's" should read -- cants' --.

Column 4, line 13, "threadly" should read -- threadably --;
line 35, "open" should read -- opens --;
line 55, "ad" should read -- and --.

Column 5, line 17, "of" should read -- or --;
line 19, "16" should read -- 163 --;
line 38, "ad" should read -- and --.

Column 6, line 27, "56" should read -- 58 --;
line 44, "exciting" should read -- exiting --.

Column 7, line 22, "line" should read -- long --;
line 41, "'130" should read -- 130 --;
line 53, "temperatures" should read -- temperature --;
line 58, "ad" should read -- and --;
line 72, "against" should read -- again --.

Column 8, line 13, "4)" should read -- as a --;
line 26, "is" should read -- in --;
line 34, "he" should read -- the --;
line 50, "s" should read -- is --;
line 55, delete "conduit" and insert -- the --.

Column 9, line 14, "he" should read -- the --;
line 54, delete "o".

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,632,980 Dated January 4, 1972

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It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Page 2

In the Claims:

Claim 1, line 15, delete "space" and insert -- means --;
(Col.10) line 16, delete "for heating said utensil,".

Claim 4,
(Col. 10) line 53, delete "and" and insert -- said --.

Claim 5,
(Col. 10) line 61, "whereby" should read -- thereby --.

Claim 6, line 64, cancel "in said", first
(Col. 10) occurrence, and insert [illegible] **-- having an --.**

Claim 10,
(Col. 11) line 54, "patch" should read -- path --.

Claim 12,
(Col. 12) line 30, "he" should read -- the --.

Claim 13,
(Col. 12) line 46, delete "with" (second occurrence).
line 48, "ta" should read -- a --;
line 55, after "power" insert -- supply --.

Signed and sealed this 1st day of August 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents