VAPOR TRANSFER FOOD PREPARATION AND HEATING APPARATUS


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Related U.S. Application Data

Continuation of Ser. No. 165,569, July 23, 1971, abandoned.

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Field of Search 165/105; 126/19; 107/63; 432/121

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Food preparation apparatus involves a heat transmitting zone and a heat source located remotely from the transmitting zone. Heat energy is transferred from the heat source to the transmitting zone by a fluid vapor which travels from the heat source to the transmitting zone, condenses upon the transmitting zone and then returns in a liquid state to the heat source.

In one described embodiment, the apparatus includes a casing enclosing a working fluid and defining a relatively large flat cooking surface. Heat energy is transferred to the working fluid from a heat source across a perforated baffle by directing products of combustion through the baffle, against a portion of the fluid container remote from the cooking surface. The fluid vaporizes and then travels to the portion of the enclosure defining the cooking surface where it condenses to transfer heat energy to the cooking surface. Another embodiment of this invention involves an oven wherein a fluid enclosure within the oven walls confines the vapor which transfers heat energy from a central heat source to heat transmitting surfaces.

14 Claims, 6 Drawing Figures
VAPO R TRANSFER FOOD PREPARATION AND HEATING APPARATUS

This is a continuation of application Ser. No. 165,569, filed July 23, 1971, now abandoned.

BACKGROUND OF THE INVENTION

Food preparation apparatus constructed with a view to providing either uniform temperature along a substantial surface area or substantially uniform temperature in several different areas ordinarily involves a plurality of individual heat source elements and a corresponding plurality of temperature control elements, or means to circulate heat by natural or forced convection.

A relatively large cooking surface is typically heated by locating individual heat sources adjacent one side of a thick plate and providing a control element for each heat source. Separate control elements result in apparatus which does not conveniently lend itself to automatic control. Further, the surface or surfaces being heated tend to be characterized by hot spots opposite each heating unit. The tendency to form hot spots may be reduced as a function of increased plate thickness. A relatively thick plate, however, results in an undesirably heavy apparatus which responds slowly to temperature change.

BRIEF SUMMARY OF THE INVENTION

The invention pertains to food preparation apparatus wherein heat is transferred from a heat source to a heat transmitting, or food preparation, surface by vaporized working fluid. Working fluid is confined in a sealed enclosure which extends from the heat source to the food preparation surface. The working fluid is vaporized at a surface adjacent the heat source and fills the sealed enclosure. It then condenses on a portion of the sealed enclosure adjacent the food preparation surface and releases heat energy.

The food preparation surface may be one which directly applies heat to the food or food containing utensils by conduction, as for example, a cook stove heating unit or a griddle surface, or one which heats an enclosure so as to heat material by convection or radiation, as for example, an oven wherein the transmitting surface forms inner surfaces of the oven. In preferred embodiments, the temperature of the heat transmitting surface is controlled by automatically controlling the amount of heat produced by the heat source.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a preferred embodiment of the present invention;
FIG. 2 is a cross-sectional view taken along line 2—2 of FIG. 1;
FIG. 3 illustrates an alternate embodiment of the apparatus shown in FIG. 1;
FIG. 4 illustrates another embodiment of the invention;
FIG. 5 shows an oven embodying the present invention; and FIG. 6 is a perspective view showing a further embodiment.

DETAILED DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a preferred embodiment involving a griddle 10. The griddle includes a lower housing 12 and an upper housing 14. Supported by upper housing 14 is a splash guard 18 and means 16 forming a cooking surface. The means 16 comprises a casing 20 of plates defining a substantially flat heating surface 22, a heated surface 24, and sides 26, the surface plates 22 and 24 and the sides 26 forming a sealed enclosure. The length and width of the cooking surface, or any other dimension defining the overall dimensional extent of the cooking surface, may be several orders of magnitude greater than the distance between the heating surface plate 22 and the heated surface plate 24. For example, in the apparatus of FIG. 1, the heating surface covers an area of several square feet, typically being two to six feet long and two to three feet wide. The distance between the heating and heated surfaces may be approximately one inch.

Within the casing 20, a capillary structure 28 covers substantially the entire heated surface 24. The capillary structure may be a woven wire mesh wick. Alternately, the capillary structure may be any porous media capable of withstanding working temperatures of the griddle. Porous sintered material is suitable. The pores may be any size which will sustain capillary action. Pore sizes ranging from .001 to .200 inch give acceptable results and pore sizes between .005 and .100 inch are particularly effective in most situations.

A working fluid 30 is sealed within the casing 20 and, when in the liquid state, is distributed over the plate 24 by the capillary structure 28. Supporting members 32 within the casing provide dimensional and volumetric stability thereto. Openings 34 in the supporting members 32 provide free passage for working fluid vapor through and around the support to enable working fluid vapor to be evenly distributed throughout the interior of the casing.

Beneath the upper housing 14, and spaced from the cooking surface means 16 along the upper portion of the lower housing 12 is a partition 36. Centrally along this partition is a combustion chamber 38, of which is located a means 40 forming a jet impingement baffle structure. Along the baffle structures 40, opposite the combustion chamber 38, a pair of exhaust passages 42 extend. The baffle structures 40 each comprise a partition 44 defining passageways 46 for products of combustion. The products of combustion pass from the combustion chamber 38 through the passageway 46 into an enclosed plenum chamber 48 bordered by a surface 52 with exit ports 50 directed toward the heated surface 24. The surface 52 is corrugated and the ports 50 are formed along the portions of the corrugated surface closest to the heating surface 24. The surface corrugation enhances the heat transfer capability of the baffle structure 48 in a manner which will be hereafter described. It should be understood, however, that surface 52 may be of other configurations.

Positioned mainly in the lower housing 12 is a combustion means 54 which includes a flame-supporting surface 56 within the combustion chamber 38. The combustion means 54 comprises a fuel inlet 56, an air inlet 57, a blower 58 with a motor 59, and a passage 60 extending from the blower 58 to a manifold 62. From the manifold 62, a fuel-air mixture is distributed along the flame-supporting surface 56.

Also associated with the griddle 40 is a vent means 64 extending from the rear of the exhaust passages 42. At the front of the griddle, forward of the heating surface 22, is a grease tray 66 equipped with grease drains.
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The grease drains lead to an appropriate receptacle, not shown. At the forward portion of the griddle is an apron 70 to protect the operator of the griddle from the hot parts of the device.

The above described embodiment of this invention operates in this manner. The motor 55 operates the blower 58 to draw fuel, such as natural or other gas, through the inlet 56 and air through the inlet 57. A fuel-air mixture is driven along the passageway 60 into the manifold 62. From the manifold 62, the fuel-air mixture passes to the flame-supporting surface 56 in the combustion chamber 38. Combustion of the fuel within the combustion chamber heats a center section of the heated surface 24 and products of combustion pass from the combustion chamber through passageways 46 into the plenum chamber 48. Products of combustion are directed from the plenum chamber through the ports 50 onto additional portions of the surface 24. Products of combustion passing through the ports 50 are formed into individual jets which impinge forcibly on heated surface 24. Products of combustion then pass to the exhaust passages 42 and finally through the vent 64.

There tends to develop along the surface 24 a boundary layer of fluid which acts as an insulator inhibiting transfer of heat across the surface 24. This boundary layer is interrupted by the jets impinging forcibly upon the surface. Each jet establishes an efficient heat transfer zone absent the boundary layer. The most effective condition prevails when the number of jets is maximized and each jet acts substantially independently of the other jets.

The surface 52 forming the ports 50 is corrugated to permit location of ports 50 closely adjacent the heated surface 24 and to form channels between rows of ports. This construction provides an enlarged volume in the plenum chamber 48 for permitting passage of products of combustion therethrough with minimized interference to the individual jets.

Accordingly, the baffle structures 40 enhance the transfer of heat to the heated surface 24 and thereby increase the overall efficiency of the griddle. The surface 24 could be heated by other methods than that described above, including methods wherein it is heated along a relatively small portion of its surface, even distribution of heat thereover not being essential to even heat distribution at the surface 22.

The heated surface 24 serves as evaporator for liquified working fluids distributed substantially evenly thereover by the capillary structure 28. If a relatively large amount of working fluid is evaporated from one portion of the heated surface plate 24, the capillary structure 28 will draw more fluid to that portion from lesser heated portions. If gravity flow or other pumping action is effective to locate the liquified working fluid adjacent the heat source, the capillary structures may be omitted. Evaporated working fluid fills the casing 20 and condenses upon the heating surface plate 22, thus giving up to the heating surface an amount of heat functionally related to its latent heat of vaporization and the mass of the fluid condensed. Heat transfer by the flow of vapor from the evaporator to the heating surface plate 22, which acts as a condenser, results in a temperature uniformity at the heating surface and quick response of the heating surface to heat energy applied at the heated surface 24.

A working fluid with a high latent heat of vaporization is preferred since temperature uniformity is enhanced by the resulting relatively large quantities of heat which can be transferred to the heating surface with a relatively small mass transfer of working fluid vapor. The desired operating temperature of the heated surface 24 further influences the choice of working fluid. The working fluid may be any fluid which is chemically stable and chemically compatible with the casing 20 and other elements inside thereof and which has physical properties permitting a heat pipe type of operation at the contemplated temperature range. The vapor pressure of the working fluid determines the amount of vapor developed for a given heat input and thereby governs the transfer of energy from the heated surface to the heating surface; the surface tension of the fluid in the liquid state must sustain capillary action in systems where capillary pumping is essential; and a low viscosity enhances return of the condensed working fluid from the heating surface to the heated surface. For relatively low temperatures, water may be used as a working fluid. At intermediate and high temperature ranges, however, undesirably high pressures are encountered when water is used. Practical working fluids at operating temperatures associated with food preparation are hydrocarbon oils and silicone based oils. Examples of suitable products are those marketed by Dow-Corning Corporation of Midland, Michigan, and designated Dow-Corning 702, 704 and 705 oils and Dowtherm A which is marketed by Dow Chemical Corporation of Midland, Michigan. In the event the apparatus is to be used for purposes other than food preparation at temperature levels above those required for food preparation, potassium and sodium are examples of suitable working fluids.

The interior volume of the casing 20 is substantially evacuated of air and backfilled with the desired amount of working fluid. The system is isothermal, as subsequently explained, and operable over a wide range of temperatures. The system will operate without substantial evaporation, but only non-isothermally and over a reduced temperature range. The amount of working fluid sealed within the casing 20 may vary, but an amount, when in the liquid state, which is sufficient to saturate the capillary structure yields good performance.

The casing 20, its associated capillary structures 28 and working fluid 30, operate in a manner which corresponds to heat pipe theory. The operation is very nearly isothermal with the evaporation and condensation of working fluid taking place at a single working pressure which is constant throughout the interior of the casing. In fact, however, small temperature and pressure gradients exist. The system, though closely approximating constant temperature and constant pressure operation, actually operates in the following manner. As the working fluid vaporizes, the pressure at the surface of evaporation increases. The result is a small pressure differential within the casing 20 between the heated surface 24 and the heating surface 22 which causes vapor to move toward the heating surface 24 where it encounters a temperature lower than the temperature present at the surface of evaporation adjacent the heated surface 24. As a consequence, the vapor liquifies and releases the thermal energy stored in its heat of vaporization. As the fluid condenses, the vapor pressure adjacent the heating surface 22 decreases so that the relatively small
pressure differential necessary for continued vapor heat flow is maintained. The vaporized fluid stores heat energy at the temperature at which the vapor was created and retains the energy at this temperature until it meets a cooler surface. The result is that the temperature across the casing 20 tends to remain constant. The principles involved are essentially those described in the article by T. P. Cotter entitled "Theory of Heat Pipes," Los Alamos Scientific Laboratory, LA-3246-MS, 1965; the article by P. K. Shefsiek and D. M. Ernst entitled "Heat Pipe Development for Thermionic Applications", 4th IECEC Conference, Washington, D.C., 1969; the article by H. Cheung entitled "A Critical Review of Heat Pipe Theory and Applications," University of California, Livermore, California, UCRL-50454, July 1968; the article by Feldman, Jr. and Whiting in Mechanical Engineering of February 1967 and the article by Eastman in the May 1968 issue of Scientific American.

Among the advantages of the griddle described above is its ability of maintaining substantially even heating surface temperatures under all operating conditions and to almost instantly respond to changes in required heat output of the heating surface whether the change in heat output required is over the entire surface or merely over a relatively small section thereof. For example, if the heat output of the entire surface is to be either increased or decreased, a change in the output of the combustion means 54 is almost immediately reflected at the heated surface 22 since there is no large mass between the heating surface and the combustion means to constitute a heat sink. Quick response also occurs when relatively cold cooking utensils or food materials are placed on the heating surface 22. When relatively cold material is placed on the heating surface 22, there is immediately created, within the casing 20, a relatively cool zone adjacent the portion of the heating surface 22 on which the cool material rests. This temperature differential causes an increased amount of vapor to condense at this zone and correspondingly, causes an increase in the amount of heat energy transferred to this zone. It can be appreciated that this results in heat energy being given up at the exact location of greatest need. In addition to quick response, a further increased efficiency of operation is achieved.

Cooking apparatus constructed according to this invention requires only a single burner. The output of this burner may be manually controlled to provide a desired temperature level at the heating surface. However, since only a single burner is required, the apparatus lends itself to automatic control of the temperature level at heating surface 22. Any suitable automatic control device may be used. For example, the apparatus shown in FIGS. 1 and 2 may be provided with a solid state thermistor 31 for sensing the temperature of the heating surface 22. The thermistor is connected by an electrical conductor 33 to a solenoid valve 35 which determines the amount of fuel permitted to pass through the fuel inlet 56 to the combustion means 54. A thermostatic control mechanism 37 of conventional construction maybe provided to enable a desired temperature level to be set. The temperature level of the heating surface 22 is sensed by the thermistor 31 and maintained at the set level by control of the amount of fuel admitted to the combustion means. In one possible alternate, the thermistor, electrical conductor and solenoid valve could be supplanted, respectively, by a liquid filled bulb for sensing temperature level of the heating surface, a capillary line and a mechanical valve connected to the liquid filled bulb by the capillary line for controlling the admission of fuel to the combustion means 54. According to a third and novel alternate, the pressure of the working fluid itself could be used as a temperature sensor by connecting a pressure line between a pressure sensitive fuel metering device to the casing 20.

FIG. 3 illustrates an alternate embodiment wherein the combustion means 54 includes an enlarged manifold 62 associated with permeable plate means 56 through which a fuel-air mixture passes to provide combustion over an enlarged area within the combustion chamber 38. The embodiments of FIGS. 1 and 2 and FIG. 3 contemplate use of a combustible fuel, such as gas, the heating of the heated surface 24 taking place in the zone of combustion and along the path of the products of combustion. It should, of course, be understood that the heated surface 24 may be heated by an electrical or other appropriate heat source.

FIG. 4 illustrates another alternate embodiment of the griddle wherein the heat source is positioned a substantial distance from the cooking surface. This has the advantage of permitting the heat source to be located in a room or compartment away from the room in which the cooking surface is located to thereby reduce the amount of heat energy escaping into the latter room. A cooking surface 70 and a radiant heat source 72 are positioned on opposite sides of a partition 74. An enclosure 76 incorporates the cooking surface 70, confines the working fluid 78 and surrounds a portion of the radiant heat source 72. A capillary structure 80 is disposed along a portion of the interior of the casing 76, including that portion which surrounds the radiant burner section. In this manner, liquified working fluid is distributed over the entire interior portion 82 of the casing which is adjacent the radiant heat source 72. The apparatus of FIG. 4 operates substantially in the same manner as the apparatus described in connection with the FIGS. 1 and 2. The radiant heat source 72 evaporates liquified working fluid 78 present at the portion 82 of the casing 76. This evaporated working fluid then moves to the cooking surface 70 and condenses thereon to release heat energy. Condensed working fluid then travels along the casing 76 and encounters the capillary structure 80 which draws it eventually back to the portion 82 of the casing 76. Automatic means 82 controls the temperature of the surface 70.

FIG. 5 shows an oven embodying the present invention. The oven walls 90 enclose a casing 92 configured to form shelves. Each shelf 94 is equipped with leveling means 96 on which food materials 98 may rest. Enclosed within the casing 92 is a working fluid 93 and a capillary structure 95. The capillary structure extends over a heated surface 114 for distributing theretover overcrow liquified working fluid. The capillary structure 95 may optionally be installed in the shelves 94 of the casing 92. When the capillary structure 95 is installed in the shelves, it serves to draw liquified working fluid from the shelf area down to the heated surface 114. Beneath the casing 92 is a combustion means 111. The combustion means includes a fan 102, an air inlet 104, and burners 106. There is also a baffle means 108 provided with a plurality of ports 112 and an exhaust 110. The
fan mixes fuel and air and drives the mixture to the burners. The products of combustion are then driven through the ports 112 in the baffles to form jets which impinge forcibly upon the heated surface 114. Liquidified working fluid which is distributed over the surface 114 by the capillary structure 95 is evaporated. Vaporized working fluid is distributed throughout the interior of the casing 92, entering all of the hollow shelves 94, so that the shelf surfaces are heated to thereby heat the interior of the oven and the food utensils 98. Insulation 116 is installed between the top side and back surfaces of the casing 92 and the walls 90 of the oven to prevent excessive heat loss through the walls of the oven.

Thermostatic controls, for example those discussed regarding FIG. 1, may be utilized to govern the oven temperature.

FIG. 6 illustrates a broiler wherein a burner 120 evaporates working fluid distributed along capillary structure 122. The evaporated working fluid passes into the manifolds 124 which are connected by a plurality of hollow tubules 126. The hollow tubules 126 constitute a condensing structure on which material to be cooked is placed for heating. Condensed working fluid drains from the tubules 126, through the manifolds 124, to a chamber 128 where the capillary structure 122 again draws it to the burner 120 for evaporation. Temperature control means 130 is provided for controlling the output of the burner 120 in accordance with the desired temperature level of the tubules 126.

The present invention has been described in reference to particular preferred embodiments. It should be understood that modifications may be made by those skilled in the art without departing from the scope of the invention.

We claim:

1. Food preparation griddle apparatus comprising:
   a. means forming a sealed enclosure substantially purged of fluids which are non-condensable over the working temperature range and having along a portion thereof a food heating zone and a heat receiving zone;
   b. working fluid means, said fluid in the liquid phase partially filling said sealed enclosure through said range;
   c. means forming a combustion chamber;
   d. means for admitting air and fuel to said combustion chamber to provide thereto a combustible mixture;
   e. baffle means external of said enclosure having jet forming perforations therein and extending along said heat receiving zone closely adjacent thereto to form plenum chamber means along the side of said baffle means facing away from said heat receiving zone;
   f. means for forcing combustion products from said combustion chamber to said plenum chamber, then through said perforations and onto said heat receiving zone as a plurality of discrete jets to thereby heat said heat receiving zone and vaporize working fluid within said sealed enclosure, whereby working fluid vapor substantially fills said sealed enclosure and condenses internal of said sealed enclosure on said food heating zone for heat receiving zone to a substantially uniform temperature and transmitting heat energy to food material adjacent said food heating zone;

2. Apparatus according to claim 1 further comprising means for automatically controlling the output of combustion products from said combustion chamber means in response to the pressure internal of said sealed enclosure.

3. Apparatus according to claim 1 wherein said food heating zone comprises a relatively large flat food heating surface having a minimum dimensional extent several orders of magnitude larger than the average distance between said food heating zone and said heat receiving zone.

4. Apparatus according to claim 3 further comprising capillary means internal of said sealed enclosure covering said heat receiving zone for distributing working fluid in the liquid state over said second zone to thereby facilitate evaporation of said working fluid.

5. Food preparation griddle apparatus according to claim 1 wherein said sealed enclosure comprises a first flat plate means internal of said heat receiving zone and a second plate means substantially parallel to and coextensive with said first plate means forming said heat receiving zone, the minimum dimensional extent of said first and second plate means being several orders of magnitude larger than the distance between said plates.

6. Cooking apparatus according to claim 5 wherein said combustion chamber is positioned immediately adjacent a portion of said heat receiving zone thereby to transfer heat energy directly from the products of combustion in said combustion chamber to a portion of said second plate means prior to passage of the products of combustion through said baffle means.

7. Cooking apparatus according to claim 6 further comprising means for automatically controlling the output of combustion products from said combustion chamber in response to the pressure internal of said sealed enclosure.

8. Food preparation griddle apparatus comprising:
   a. means forming a sealed enclosure substantially purged of fluids which are non-condensable over the working temperature range of said device and having along a portion thereof a food heating zone and a heat receiving zone;
   b. working fluid means, said fluid in the liquid state partially filling said sealed enclosure throughout said range, substantially the entire remainder of said enclosure being filled by working fluid vapor;
   c. heat source means positioned externally of said sealed enclosure adjacent said heat receiving zone for heating said heat receiving zone and vaporizing working fluid within said sealed enclosure, whereby working fluid vapor substantially fills said sealed enclosure and condenses internal of said food heating zone for heat receiving zone to a substantially uniform temperature and transmitting heat energy to food material on said food heating zone; said heat source means comprising:
      1. means forming a combustion chamber;
      2. means for admitting air and fuel to said combustion chamber to provide thereto a combustible mixture;
      3. baffle means external of said enclosure having jet forming perforations therein and extending along said heat receiving zone closely adjacent thereto to form at least one plenum chamber along the side of said baffle means facing away from said heat receiving zone; and
4. means for forcing combustion products from said combustion chamber to said plenum chamber, then through said perforations and onto said heat receiving zone as a plurality of discrete jets to thereby heat said heat receiving zone and vaporize working fluid within said sealed enclosure; and

d. means for sensing pressure internal of said sealed enclosure and automatically controlling the output of said heat source means in response thereto, thereby to control the temperature level of said food heating zone.

9. Food preparation griddle apparatus according to claim 8 wherein said sealed enclosure comprises a first plate means forming said food heating zone and a second plate means substantially parallel to and coextensive with said first plate means forming said heat receiving zone, the minimum dimensional extent of said first and second plates being several orders of magnitude larger than the distance between said plates.

10. Food preparation griddle apparatus according to claim 9 further comprising structural support means internal of said enclosure for maintaining said first plate flat and in parallel relationship to said second plate, said first and second plates having a thickness dimension sufficient only to provide structural integrity throughout said working temperature range for enhancing heat transfer through said enclosure from said heat source means to material supported upon said first plate means.

11. Apparatus according to claim 8 wherein:
   a. said combustion chamber means comprises a single combustion chamber; and
   b. said air and fuel introducing means comprises:
      i. a single fuel line, and
      ii. flow control means responsive to said pressure sensing means for controlling fuel input from said fuel line to said combustion chamber means as a function of the pressure internal of said enclosure.

12. Apparatus according to claim 11 further comprising capillary means covering said second plate means for distributing working fluid means in the liquid state thereover.

13. Apparatus according to claim 12 wherein said heat transfer fluid is organic.

14. Apparatus according to claim 12 wherein said baffle means comprises a plurality of baffles each having a multiplicity of said perforations and each forming a said plenum chamber.