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Inventor(s)	Carbone; Philip C. et al.

Cooking appliance employing radiative flux

Abstract

A heating assembly for a cooking appliance, such as a toaster or oven. The heating assembly can have one or more elements arranged to emit radiation in a wavelength range of 0.75 to 10 microns with a radiative flux of at least 3,000 to 5,000 Watts/sq.cm at a distance of 10 cm from the plurality of heating elements, and/or to emit visible light in a wavelength range of 570 to 800 nanometers, and/or emit radiation in a wavelength range of 0.75 to 10 microns with a ratio of the radiating area to the total area of each heating element being 5% to 25%, and/or emit radiation in a wavelength range of 0.75 to 10 microns toward a cooking space with a ratio of a total radiating area of the plurality of heating elements to an area of the cooking space receiving the radiation is 1% to 20%.

Inventors: **Carbone; Philip C. (North Reading, MA), Loftus; Peter J. (Cambridge, MA), Benedek; Karen R. (Winchester, MA), Poon; James (Woburn, MA)**

Applicant: **Revolution Cooking, LLC** (Potomac, MD)

Family ID: **1000008748703**

Assignee: **Revolution Cooking, LLC (Potomac, MD)**

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Primary Examiner: Jennison; Brian W

Attorney, Agent or Firm: Wolf, Greenfield & Sacks, P.C.

Background/Summary

RELATED APPLICATION (1) This application claims priority under 35 U.S.C. § 119(e) to U.S. Provisional Application Ser. No. 63/113,758, filed Nov. 13, 2020, which is herein incorporated by reference in its entirety.

BACKGROUND

(1) Various appliances are available for cooking or otherwise heating food. An oven, for example, is often used for cooking food at lower to moderate temperatures for fairly long periods of time. A microwave oven, on the other hand, utilizes microwave energy and can heat at least some foods more rapidly. Toasters and toaster ovens may suffer from certain drawbacks, such as slow cooking times and/or poor cooked food quality.

SUMMARY

(2) In general terms, this disclosure is directed to a heating element assembly for a cooking appliance, such as a toaster or oven. In some embodiments, and by non-limiting example, the heating assembly includes a heating element and support that provides infrared radiation to a cooking cavity. The infrared radiation may provide faster cooking times and improved results.

(3) In some embodiments, by providing infrared radiation, e.g., at wavelengths between 0.75 to 10 microns, at a relatively high radiative flux, e.g., of 3,000 to 5,000 Watts/sq.cm at a distance of 10 cm from a food item, certain foods and/or cooking operations can be performed in a superior way. For example, most toasters cook bread and other objects relatively slowly, which causes moisture in the bread to escape the bread interior and evaporate before the toasting operation is complete. The result is a hard, dry piece of toast. However, employing infrared radiation at certain wavelengths and at relatively high radiative flux can toast bread and cook other food items relatively quickly so that moisture is not driven out of the food, and the food item is toasted, browned or otherwise heated in a desired way. Suitable infrared radiation can be provided by one or more heating elements that each have an electrically conductive portion defining a sheet with a plurality of openings. Electrical current passed through the conductive portions causes the emission of infrared radiation at the desired wavelengths and radiative flux. In some embodiments, the radiating area of the conductive portion of the sheet is arranged in a particular way with respect to the total area of the sheet so as to provide particular infrared wavelengths and radiative flux. As a result, the heating element assembly can emit the desired infrared radiation over a desired cooking cavity area at the desired radiative flux. That is, the heating element(s) can have a total radiating area (or portions of the elements that emit infrared radiation) that is balanced with respect to an area of the cooking space that receives the radiation so that food is heated in a suitably rapid fashion, e.g., so the food is properly heated throughout but not dried of moisture in an undesirable way. In some embodiments, the heating element can be visible to a user of the cooking device, e.g., through an opening into the cooking cavity, and the heating element can emit visible light in addition to infrared radiation that is used to heat the food. The visible light can be in a wavelength range of 570 to 800 nanometers and be emitted as a result of the heating element operating in such a way as to emit infrared at a desired wavelength range and radiative flux to rapidly heat food items. Thus, the visible light can confirm to a user that a food item is being cooked or otherwise heated in a particular way, e.g., rapidly, uniformly and without drying.

(4) In some embodiments, a cooking appliance includes a housing defining a cooking cavity for receiving food therein. A heating assembly may be arranged to provide infrared radiation into the cooking cavity and may include a support and one or more electrical resistance heating elements coupled to the support. For example, each heating element may include a metal material that emits infrared and other electromagnetic radiation when electrical current is passed through the metal material. The heating element(s) may be exposed to the cooking cavity, meaning that there is no other component between all or most portions of the heating element and the cooking cavity. For example, infrared radiation emitted by the heating element may travel directly from the heating element to the cooking cavity without passing through a guard, screen, filter, protective cover or other component. In the case of a heating element including a metal material, infrared radiation may be emitted from the metal material and travel directly to the cooking cavity (or a food item in

the cooking cavity) without passing through any other portion of the cooking appliance.
(5) In some embodiments, an electrical resistance heating assembly, e.g., that is part of a cooking appliance, includes a plurality of heating elements with each heating element having first and second terminal ends and electrically conductive portions between the first and second terminal ends. The electrically conductive portions can define a sheet with a plurality of openings and first and second opposed faces, e.g., in the same way that a sheet of paper has two opposed faces or surfaces. In some embodiments, the plurality of heating elements can each be arranged with first faces exposed and oriented toward a same direction, e.g., toward a cooking cavity, and to emit radiation in a wavelength range of 0.75 to 10 microns with a radiative flux of at least 3,000 to 5,000 Watts/sq.cm at a distance of 10 cm from the plurality of heating elements. The radiative flux can be emitted by the heating elements for an extended period, e.g., 50 seconds to 5 minutes or more, and/or over an area of a cooking cavity or other space of 25 sq.cm inches to 520 sq.cm. In some embodiments, the plurality of heating elements can each be configured to emit visible light in a wavelength range of 570 to 800 nanometers and to emit radiation suitable to heat a food item associated with the food cooking device, e.g., radiation in a wavelength range of 0.75 to 10 microns with a radiative flux of at least 3,000 to 5,000 Watts/sq.cm at a distance of 10 cm. The visible light can have a luminous flux of at least 100 lumens, e.g., 100 to 300 lumens. In some embodiments, the heating elements can be arranged so as to emit the visible light within 10 to 20 seconds after electrical power having a power of 50 to 150 Watts is applied to the heating element. In some cases, the heating elements can be arranged in a housing of a food cooking device that has an opening arranged in the housing and through which a user can view the heating element. In some embodiments, the opening can also be arranged to receive a food item into a cooking cavity. In some embodiments, the electrically conductive portions can define a sheet having a total area, and each of the heating elements can have a radiating area arranged to emit radiation in a wavelength range of 0.75 to 10 microns, where a ratio of the radiating area to the total area of each heating element is 5% to 25%. In some embodiments, each of the heating elements can have a radiating area arranged to emit radiation in a wavelength range of 0.75 to 10 microns toward the cooking space, and a ratio of a total radiating area of the plurality of heating elements of the assembly to an area of the cooking space receiving the radiation is 1% to 20%.
(6) In some embodiments, the plurality of heating elements are arranged electrically in series or in parallel. The heating elements can be arranged to operate with 100V to 250V AC electrical power. In some cases, the heating assembly emits the radiative flux while consuming less than 1800 Watts of electrical energy. The heating assembly can be incorporated into a variety of different cooking appliances, such as in a housing of a toaster to emit radiation into a cooking cavity of the toaster.
(7) In some embodiments, the sheet defined by each heating element has a total area of 12 sq.cm to 24 sq.cm and an open area defined by the plurality of openings of 10 sq.cm to 20 sq.cm.
(8) The heating elements can be supported in various ways, such as by having the heating elements attached to a reflector such that the second faces of each of the plurality of heating elements are oriented toward the reflector. The reflector, which can reflect infrared energy in a direction toward the heating elements, can have a surface that spans across the second faces of the plurality of heating elements. In some cases, each of the heating elements can be arranged to have an elongated rectangular shape having a length and a width, and the heating elements can be arranged on the reflector so that the lengths of the plurality of heating elements extend in a same direction, e.g., vertically.
(9) In some embodiments, each heating element has a radiating area of 0.5 sq.cm to 3.5 sq.cm, and/or has a total area of 10 sq.cm to 24 sq.cm. In some embodiments, the total area of the heating element is defined as a smallest rectangular area required to completely contain the sheet. In some embodiments, a ratio of a sum of the total areas of the heating elements of an assembly to the area of the cooking space is 15% to 70%.
(10) In some embodiments, the heating element has a curved shape with a concave side facing

towards the cooking cavity. For example, the heating element may define a sheet having a length and a width, and a plurality of openings are formed in the sheet. The sheet may have first and second opposed sides, and the heating element may be curved so that the first side of the sheet defines the concave side and faces the cooking cavity. As an example, the sheet may define a cylindrical shell-type or other curved shape with a concave side facing the cooking cavity. In some cases, the heating assembly includes a plurality of heating elements, and each of the plurality of heating elements may have an approximately equal curved shape, or may have different curved shapes. The heating element may be flexible, e.g., so a sheet defined by the heating element can be selectively bent into a curved shape. The heating element may be resilient, e.g., so that the element returns to a flat planar shape when a stress used to bend the element into a curved shape is released. Alternately, the heating element may be plastically deformed to take a curved shape, e.g., an initially planar heating element may be deformed into a curved shape that is maintained when the bending force is released. The heating element may be out of contact with the support at portions along the length of the sheet, e.g., at portions between longitudinal ends of the sheet. Thus, the heating element (or plurality of elements) may only contact the support (e.g., a reflector) in a few areas along a length of the heating element. This may help prevent heat loss of the heating element to the support, allowing the element to more effectively emit infrared radiation.
(11) In some embodiments, a retainer may be positioned between the heating element(s) and the cooking cavity with the retainer extending over and contacting a part of the heating element(s). The retainer may help properly position the heating element(s) with respect to the support, e.g., holding the heating element(s) close to the support without contacting the support. The heating element(s) may be movable relative to the retainer, e.g., to allow the heating element(s) to thermally expand and contract and move relative to the support and retainer. In some cases, the retainer may cause the heating element(s) to take the curved shape. For example, the heating element(s) may be coupled to the support using a retainer (at least in part) with the heating element(s) and the support initially in a flat or planar configuration. The support may be bent to take a curved shape, and bending of the support may cause the heating element(s) to take a curved shape as well. For example, the retainer may hold the heating element(s) relative to the support so that the heating element(s) must move with the support as it is bent.
(12) As noted above, in some embodiments the support has a curved shape with a concave side facing the cooking cavity, e.g., the curved shape may be similar to a curved shape of the heating element(s). In some cases, the support is configured to reflect infrared radiation emitted by the heating element in a direction toward the cooking cavity, and a curved shape may help the support direct radiation in a focused or otherwise directed way toward the cooking cavity. The support may be formed of a flexible sheet of material, and the heating element may be coupled to the support such that bending of the support forms the curved shape of the heating element. A coefficient of thermal expansion of the support may be less than a coefficient of thermal expansion of the heating element, e.g., the support and heating element may expand or contract at different rates for a same change in temperature. The heating element may be slidably coupled to the support, e.g., so the heating element can move relative to the support in directions along a surface of the support. For example, the heating element may have an elongated shape having a length, and the heating element may be fixed to the support at one end and free to move relative to the support along the length of the heating element due to thermal expansion and contraction.
(13) The heating assembly may be mounted in the cooking appliance in various ways. For example, the appliance may have a chassis that defines the-cooking cavity and is disposed at least partially within the housing. The heating assembly may be supported in at least three different locations by the chassis, e.g., at a top wall, a bottom wall, and at least one side wall of the chassis. The top and bottom wall may apply a compressive force on the support that holds the support in a bent or curved shape, and the side wall may help the support maintain or assume a desired curvature. For example, the heating assembly may be supported at the at least one side wall by a clip that at least

partially defines the curved shape of the heating element. The clip may not contact the heating element, e.g., may only contact the support, yet still help define the curved shape of the heating element by helping define the curved shape of the support. In some embodiments, an air gap is formed at least partially between the housing and the chassis, e.g., so that heat generated by the heating assembly in the chassis can be vented or prevented from being conducted to the housing.
(14) In one embodiment, a heating assembly for a cooking appliance includes a support and an electrical resistance heating element defining a sheet having a length and a width and a plurality of openings formed in the sheet. The support may provide physical support to the heating element, or perform other functions such as reflecting infrared radiation emitted by the heating element in a direction toward the heating element. The heating element, or a plurality of such elements, may be slidably coupled to the support such that the heating element is movable relative to the support along the length of the heating element. Such coupling of the heating element(s) to the support may allow movement relative to the support, e.g., if the heating element thermally expands or contracts, or if the support is bent or otherwise manipulated. For example, the support may be bent to take a curved shape with a concave side at the side where the heating element is mounted to the support. Such bending of the support may put stress on the heating element if the heating element is unable to move relative to the support. However, by coupling the heating element so as to be slidably movable relative to the support, the support may be bent from a flat, planar shape to a curved shape without placing stress on the heating element in directions parallel to the plane of the heating element sheet. Thus, bending of the support may cause the heating element to bend as well to take a curved shape similar to that of the support, but the heating element may slide or otherwise move relative to the support in one or more directions along the surface of the support and/or parallel to the heating element sheet so that heating element is not stressed or deformed along its length or width. Thus, in some cases, the support may include a flexible sheet of material, and the heating element(s) and support may be configured to bend such that the support and the heating element(s) each have a curved shape.
(15) In some embodiments, a retainer may be coupled over the heating element(s) and to the support such that the heating element is positioned between the support and the retainer. The heating element may be slidable along its length relative to the retainer, but the retainer may limit movement of the heating element in directions away from the support, e.g., perpendicular to the surface of the support and/or the sheet of the heating element. As a result, the retainer may cause the heating element(s) to be bent or curved with bending of the support, but allow the heating element(s) to slidably move relative to the support in directions along the surface of the support and/or of the heating element sheet. For example, the support may have a first side to which the heating element(s) and the retainer are coupled, and the support, heating element(s) and retainer may be configured such that bending of the support causes the support and the heating element(s) to have a curved shape with a concave side at the first side of the support. In some cases, the heating element(s) may have first and second opposed sides and the second side of the heating element(s) may be positioned nearer to the support than the first side. However, the heating element may contact the support in only one or more locations, e.g., the second side may be out of contact with the support at portions along the length of the heating element. This may help prevent heat loss from the heating element to the support by conduction. One or more retainers may extend over a part of the heating element(s), e.g., to restrain movement away from the support, but still allow the heating element(s) to largely avoid contact with the support. In some cases, a retainer may include a space that is positioned between the heating element and the support to maintain a separation distance between the heating element and the support. The retainer may be positioned over a part of the heating element(s) at a location between opposite ends of the heating elements, e.g., at a point midway along the length of the heating element(s).
(16) In one embodiment, a method of assembling a cooking appliance includes providing a chassis that defines at least one cooking cavity for receiving food therein, where the chassis includes a top

wall, a bottom wall, and at least one side wall. At least one heating assembly, e.g., including a support and a heating element attached to the support, may be inserted at least partially within the chassis. Prior to inserting the at least one heating assembly, the support is substantially flat, but is formed into a curved shape and held within the chassis. A concave side of the heating assembly created by forming the heating assembly into a curved shape may face towards the at least one cooking cavity.

(17) In some embodiments, a cooking appliance includes a housing defining a cooking cavity for receiving food therein, and a heating assembly arranged to provide infrared radiation into the cooking cavity. The heating assembly may include a support having a curved shape with a concave side facing toward the cooking cavity, and an electrical resistance heating element coupled to the support and exposed to the cooking cavity. The heating element may be curved, or not, e.g., have a flat, planar configuration. The support may be configured to have a planar shape when in an unstressed state and to have the curved shape when in a stressed state. For example, the support may include a sheet of flexible material that is flat and planar when unstressed and can be stressed, e.g., by bending, to take a curved shape. The support may be mounted in the cooking appliance in the stressed state such that the support maintains its curved shape with the concave side facing towards the cooking cavity even with thermal expansion and thermal contraction of the support. Thus, if the support elongates or contracts in one or more dimensions due to heating or cooling of the support, the support may remain in a stressed state and maintain a curved shape.

(18) In some embodiments, one or more heating elements attached to the support may each define a sheet having a length and a width and having a plurality of openings formed in the sheet. As noted above, the support may include a flexible sheet of material, and the heating element and support may be configured to bend such that the support and the heating element each have the curved shape. For example, bending of the support may also cause bending of the attached heating element(s) to take a curved shape. A retainer may be coupled over the heating element and to the support such that the heating element is positioned between the support and the retainer. The heating element may be slidable along its length relative to the retainer and the support, and the heating element may be out of contact with the support at portions along its length. Each of the one or more heating elements may have first and second opposed sides with the second side positioned nearer to the support than the first side. The second side of the heating element(s) may be out of contact with the support at portions along the length of the heating elements, e.g., to reduce heat loss by conduction to the support. The retainer may be positioned over the part of the heating element(s) at a location between opposite longitudinal ends of the heating element(s). In some cases, the retainer may include a spacer between the heating element and support to keep the heating element out of contact with the support. The support may be configured to reflect infrared radiation emitted by the heating element in a direction toward the heating element, e.g., to help heat the heating element more rapidly to allow emission of infrared radiation.

(19) A variety of additional aspects will be set forth in the description that follows. The aspects can relate to individual features and to combination of features. It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the broad inventive concepts upon which the embodiments disclosed herein are based. To the extent various aspects are not mutually exclusive, such aspects can be combined together or employed separately in any suitable way in any suitable embodiment.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. **1** is a perspective view of a cooking appliance arranged as a toaster in an illustrative embodiment.

(2) FIG. **2** is a schematic block diagram of an illustrative cooking appliance.
(3) FIG. **3** is a schematic diagram illustrating an example heating assembly arrangement having three heating assemblies.
(4) FIG. **4** is a schematic diagram illustrating another example heating assembly arrangement having four heating assemblies.
(5) FIG. **5** is a schematic diagram illustrating an example of a heating element configuration for a heating assembly.
(6) FIG. **6** is a front plan view of another example heating element configuration for a heating assembly.
(7) FIG. **7** is a perspective view of the FIG. **6** heating element configuration.
(8) FIG. **8** is a front plan view of a heating assembly including the FIG. **5** heating element configuration attached to a support.
(9) FIG. **9** is a rear plan view of the FIG. **8** heating assembly in a cooking appliance.
(10) FIG. **10** is a front sectional view of a cooking appliance that includes the FIG. **8** heating assembly.
(11) FIG. **11** is an enlarged view of a heating element in the FIG. **8** heating assembly.
(12) FIG. **12** is another enlarged view of a portion of the heating element shown in FIG. **11**.
(13) FIG. **13** is a perspective view of another illustrative cooking appliance arranged as a toaster.
(14) FIG. **14** is perspective view of the FIG. **13** cooking appliance with a portion of a housing removed.
(15) FIG. **15** is a cross-sectional perspective view of the FIG. **13** cooking appliance.
(16) FIG. **16** is a perspective view of an exemplary clip used to engage with a heating assembly in the FIG. **15** embodiment.
(17) FIG. **17** is a perspective view of a heating assembly of the FIG. **13** cooking appliance.
(18) FIG. **18** is perspective view of the FIG. **13** cooking appliance illustrating a drive assembly for lifting arms of the cooking cavity.
(19) FIG. **19** is a perspective view of a lifting arm of the FIG. **13** embodiment.
(20) FIG. **20** is a perspective view of an exemplary rear wall of the FIG. **13** cooking appliance housing.

DETAILED DESCRIPTION

(21) Various embodiments will be described in detail with reference to the drawings, wherein like reference numerals represent like parts and assemblies. Reference to various embodiments does not limit the scope of the claims. Additionally, any examples set forth in this specification are not intended to be limiting and merely set forth some of the many possible embodiments for the claims.
(22) FIG. **1** is a perspective view of an illustrative cooking appliance **100** that includes a housing **102** which at least partially encloses one or more cooking cavities **104**. In use, food is placed within one of the cooking cavities **104** and is heated by the cooking appliance **100**. In this embodiment, the cooking appliance **100** is a toaster, but can take other forms, such as a toaster oven (including, for example, a pizza oven), a microwave oven, an electric grill, a contact cooker (including, for example, a contact grill or griddle), or a slow cooker.
(23) FIG. **2** is a schematic block diagram of selected portions of the cooking appliance **100** and illustrates the housing **102**, a cooking cavity **104**, a heating assembly **106** including at least one heating element **108**, an electrical coupling and control **110**, and a power cable **112**. In some embodiments, the power cable **112** includes electrical conductors **112**A and **112**B and a plug **118** which can connect to a mains power source **90**, e.g., by connecting the plug **118** to an outlet of the mains power source **90**. Thus, the cooking appliance **100** can be powered by the mains power source **90**, which can supply alternating current (AC) or direct current (DC) power to the appliance **100** at any suitable voltage (e.g., 6V to 250V), frequency (e.g., 0 Hz to 60 Hz), and current (e.g., 1 A to 100 A or more). In some embodiments, the appliance **100** receives AC current at a voltage of 100-250 Volts and is configured to use no more than 1800 Watts during operation. The electrical

coupling and control **110** can control whether and how electrical power is provided to the heating assembly **106**, e.g., the electrical coupling and control **110** can condition or otherwise adjust power received from the power cable **112** and provide the adjusted power to the heating assembly **106** so food is heated in the cavity **104** at a desired rate. For example, the electrical coupling and control **110** could adjust the electrical power from the mains power source **90** by converting AC power to DC power, by switching the power on and off, and/or by adjusting a voltage and/or frequency of the power, and providing the adjusted power to the heating assembly **106**. In such a case, the electrical coupling and control **110** can include suitable components such as relays or other switches, a voltage transformer and/or other power regulation electronics, a battery, capacitor or other storage device, etc. to supply a conditioned or otherwise adjusted electrical power from the mains power source **90** to the heating assembly **106**. In some embodiments, the electrical coupling and control **110** can directly connect the heating assembly **106** to the mains power source **90**. For example, the electrical coupling and control **110** can include electrical conductors **114** (including conductors **114**A and **114**B) and a coupling **116** to provide electrical power directly from the power cable **112** to the heating assembly **106**. The coupling **116** can include a switch or other control device for selectively connecting the heating assembly **106** to the mains power source **90**, i.e., to turn on and off the heating assembly **106**. For example, a switch can be manually controlled by a user (e.g., by pressing down on a toaster actuator, or by depressing a power button) to provide power to the heating assembly **106**, or power to the assembly **106** can be controlled by an electronic control system.

(24) The heating assembly **106** may include one or more heating elements **108**, e.g., electrical resistance heating elements that emit infrared radiation when electrical current is passed through the elements. For example, FIG. **3** shows an arrangement in which a cooking appliance **100** includes three heating assemblies **106**, and each heating assembly **106** includes four heating elements **108**. FIG. **4** shows another arrangement in which a cooking appliance **100** includes four heating assemblies **106**, and each heating assembly **106** includes four heating elements **108**. Of course, other arrangements are possible, such as a cooking appliance **100** including one heating assembly **106** having one heating element **108**, etc. In short, an appliance **100** may include any suitable number of heating assemblies **106**, and each assembly may include any suitable number of heating elements **108**. In the embodiments of FIGS. **3** and **4**, each heating assembly **106** includes a support **146** to provide structural or mechanical support to the heating elements **108** of the assembly **106**. For example, each support **146** may include a sheet of material (e.g., which may be thermally and electrically insulating and/or reflective of electromagnetic energy) to which the heating elements **108** are attached. Alternately, the support **146** may be eliminated and heating elements **108** may support themselves, or the support **146** may be arranged in other ways.

(25) In at least some examples, each heating element **108** includes terminal ends (e.g., where electrical connections are made) and a sheet between the terminal ends having a length and a width (which can be seen in FIGS. **3** and **4**) as well as a thickness (in a direction perpendicular to the plane of FIGS. **3** and **4**). The sheet can have a plurality of openings **140**, e.g., so the sheet forms a mesh or screen-type structure. The sheet of the heating elements **108** may be electrically conductive to at least some extent such that when suitable electrical power is applied across the terminal ends of a heating element **108**, the heating element **108** generates heat by electrical resistance. For example, current flow in the heating element **108** may cause a temperature of the conductive portions of the sheet of the heating element **108** to increase in at least some areas, causing the heating element **108** generate infrared and/or other electromagnetic radiation. As will be explained further. the heating element **108** can be arranged to emit infrared radiation toward the cooking cavity **104** where food is heated by the radiation. Some electromagnetic radiation emitted by the heating elements **108** can be visible, e.g., at temperatures between about 500 and 550 degrees C. (about 1,000 degrees F.) the heating elements **108** may emit visible light as well as infrared radiation. (Although some infrared radiation may be visible to humans at least in some

conditions, reference to visible light herein is to electromagnetic radiation that is generally not considered part of the infrared spectrum.) In some embodiments, at least portions of the heating elements **108** have a temperature in a range from about 800 to about 900 degrees C. (e.g., about 850 degrees C.) during operation to heat a food product in the cooking cavity.

(26) As noted above, electrical power can be provided to a heating assembly **106** or set of heating assemblies **106** in different ways. In the example shown in FIG. **3**, the heating assemblies **106** are selectively coupled to a power source, e.g., by a switch, such that the assemblies **106** are directly coupled to a mains power source **90**. In North America, a mains power source **90** supplies an alternating current (AC) signal typically having a voltage of +/−120 V and a frequency of 60 Hz. In other parts of the world, other signals (such as having different voltages and or frequencies) are used and the heating assemblies **106** can be designed to work with any appropriate mains power source **90**, or even a DC power source such as from a battery or utilizing a power inverter. (Alternately, the electrical coupling and control **110** can adjust an input mains power to suit a heating assembly **106**). In the example herein, a mains power source **90** that provides a voltage of +/−120 V is discussed for illustrative purposes. As can be seen in FIG. **3**, the heating assemblies **106** are connected in series such that the mains power supply of 120V is across all three assemblies **106**. Moreover, the heating elements **108** in each assembly **106** are arranged in series as well, and thus all of the heating elements **108** in the three assemblies **106** are arranged electrically in series. This is only one example, however, and other arrangements are possible, e.g., with the heating assemblies **106** arranged in parallel with respect to the power supply, and heating elements **108** in each assembly **106** arranged in series or parallel. In the configuration of FIG. **3**, the heating assemblies **106** act as a voltage divider to divide the +/−120 V signal across the three assemblies **106** and the assemblies **106** have a same resistance. As a result, each heating assembly **106** has a voltage applied of about 40 V (120V divided by 3 assemblies).

(27) To obtain a desired power output from each heating assembly **106** and/or heating element **108**, the heating elements **108**, and particularly the sheet section having conductive portions and openings, can be designed or otherwise arranged to have a desired resistance. For example, to obtain a power output of 500 Watts from each heating assembly **106** in FIG. **3** (1500 W total from each of the three assemblies **106**), the resistance of each heating element **108** can be 0.8 Ohms. That is, as known to those of skill, output power (P) for a heating assembly **106** is equal to the voltage (V) applied across the assembly **106** times the current (I) passing through the assembly **106**, i.e., P=V*I. If P equals 500 W, and V is 40V, I equals 12.5 Amps. As is also known in the art, the voltage (V) applied across an assembly **106** equals the current (I) passing through the assembly **106** times the resistance (R) of the assembly **106**, i.e., V=I*R. If V=40V and I=12.5 A, then R is 3.2 Ohms. Since the heating elements **108** are arranged in series, the resistances of the heating elements **108** added together should equal 3.2 Ohms to achieve the desired 500 W power output. If each heating element **108** has an equal resistance, each element **108** should have a resistance of 0.8 Ohms (3.2 Ohms divided by four elements **108**). Of course, other power outputs and resistance arrangements may be employed in other embodiments. For example, in FIG. **4**, to achieve a total power output of 1500 W from the four heating assemblies **106**, each heating assembly **106** will output 375 W when a voltage of 30V is applied across it at a current of 12.5 Amps. Thus, each assembly **106** should have a total resistance of 2.4 Ohms, and if the four heating elements **108** of each assembly **106** have an equal resistance, each element **108** should have a resistance of 0.6 Ohms.

(28) As noted above, each heating assembly **106** can have one or more heating elements **108**, such as two or more. One benefit of having multiple heating elements **108** and/or heating assemblies **106** in a cooking appliance **100** is that the heating elements and/or assemblies can be positioned in different locations with respect to one or more cooking cavities **104**. For example, in a toaster there may be one heating assembly **106** positioned on each side of the cooking cavities **104** so as to heat a slice of bread on each side. In a multi-slice toaster, additional heating assemblies **106** can be used

for each cooking cavity. As another example, a toaster oven or microwave can have heating assemblies **106** arranged on the top and bottom of the cooking cavity such that radiative heating may be combined with one or more additional mechanisms such as free/forced convection and microwave. Other embodiments are also possible having various numbers of heating assemblies and/or elements arranged in various possible configurations.

(29) FIG. **5** is a schematic diagram of a heating assembly **106** similar to that shown in FIGS. **3** and **4**. In this example, the heating assembly **106** includes terminals **130** (including terminals **130**A and **130**B), heating elements **108** (including elements **108**A, **108**B, **108**C, and **108**D), and buses **136** (including buses **136**A, **136**B, and **136**C). FIG. **5** shows four heating elements **108**, but the ellipsis represents that embodiments can have more or fewer heating elements **108**. The heating elements **108** are electrically arranged in series, and terminals **130**A and **130**B arranged at each end of the assembly **106** (e.g., electrical input and output ends). The terminals **130** are electrically conductive contact points by which the heating assembly **106** can be connected to a power source. In this example, the terminals **130**A and **130**B are also each connected to at least one heating element **108**, e.g., terminal **130**A is connected at one terminal end of heating element **108**A and terminal **130**B is connected at one terminal end of heating element **108**D. The buses **136** are arranged to connect the heating elements **108** in series. In this embodiment, the buses **136** are electrically conductive strips that are connected at terminal ends of adjacent heating elements **108** and act to conduct electricity between the adjacent heating elements **108**. In this example, bus **136**A is connected to ends of heating elements **108**A and **108**B, bus **136**B is connected to ends of heating elements **108**B and **108**C, and bus **136**C is connected to ends of heating elements **108**C and **108**D. In some embodiments as shown in FIG. **5**, the heating assembly **106** has heating elements **108** and buses **136** arranged in a zig-zag shape, although other arrangements are possible.

(30) When a suitable voltage is applied across the terminals **130**A and **130**B, such as shown in FIGS. **3** and **4**, the heating elements **108** generate infrared and/or other electromagnetic radiation. Thus, the heating elements **108** may be formed of, or otherwise include, a conductive material such as a metal that is heated by electrical resistance. In one example, the heating elements **108** may be made of an alloy of at least nickel and chromium, also known as Nichrome, although other materials or combinations of materials are possible. For example, heating elements **108** may be made of an electrically insulating material that is coated with a suitably conductive material. The electromagnetic power output of a heating element **108** can be adjusted in different ways, such as by varying the material(s) used in the element **108**, adjusting the length L, width W and/or thickness T of the heating element **108** (thickness T is a dimension of the heating element **108** is a direction perpendicular to the plane of FIG. **5**), varying the size and/or shape of openings **140** in the element **108**, varying the cross sectional area of conductive portions of the element **108** (e.g., portions that define the openings **140**), and other characteristics. In some cases, a ratio of the length L to width W may be adjusted to vary power output of an element **108**, e.g., power output may be decreased (or increased) by increasing (or decreasing) the length L and/or decreasing (or increasing) the width W.

(31) While in the FIG. **5** embodiment the heating elements **108** each have a length L and width W that are the same, heating elements **108** in a heating assembly **106** may be arranged in any suitable way. For example, FIGS. **6** and **7** show an example in which a heating assembly **106** includes six heating elements **108** where one set of two elements **108**A, **108**F have a length L**1**, another set of two elements **108**B, **108**E have a length L**2** and a third set of two elements **108**C, **108**D have a length L**3**. This arrangement of different heating element **108** lengths (or widths or other dimensions or shapes) may be used for different purposes, e.g., to emit infrared radiation over an area having a desired shape or size. For example, the heating element arrangement in FIGS. **6** and **7** may emit radiation in a shape that corresponds to a shape of a piece of bread that is toasted by the heating assembly **106**. In this embodiment, the heating elements **108** each have a same width W**1** and thickness T**1**, but these dimensions may be varied as desired. Similar to the FIG. **5**

embodiment, the heating assembly **106** of FIGS. **6** and **7** includes terminals **130** (including terminals **130**A and **130**B) at input and output ends of the assembly **106**, and buses **136** (including buses **136**A-E) connected to respective terminal ends of adjacent heating elements **108** so the elements **108** are arranged in a zig zag pattern. Of course, other numbers of heating elements **108**, buses **136**, etc. are possible. As in the FIG. **5** embodiment and other embodiments herein, the terminals **130** and buses **136** may have a suitably low resistance relative to the heating elements **108** such that the terminals **130** and buses **136** are not heated by current flow through the heating assembly **106** to any great extent, e.g., such that the terminals **103** and buses **136** do not emit infrared radiation to a significant degree.
(32) In the embodiment of FIGS. **6** and **7**, the heating assembly **106** has a total width W**2** and total length L**0**. The total width W**2** may be greater than the sum of the widths W**1** of the heating elements **108**. In certain examples, the total width W**2** of the heating assembly may be about 35% to about 45% greater than the sum of the widths W**1** of the heating elements. For example, the total width W**2** may be about 2 inches to about 18 inches, or in a range from about 3 inches to about 12 inches, or in a range from about 4 inches to about 6 inches.
(33) The length of each heating element **108** (e.g., L**1**, L**2**, or L**3**) may be greater than the width W**2** of each heating element **108**. For example, the ratio of the lengths L**1**, L**2**, L**3** to the width W**2** can be selected to obtain a desired power output, current flow, and/or resistance for each heating element **108**. In some examples, the heating elements **108** each have a width W**1** in a range from about 0.1 inches to about 6 inches, or in a range from about ¼ inch to about 1 inch. In some examples, the width W**1** is about ½ inch. In some examples, the lengths L**1**-L**3** of the heating elements **108** may range from about 2 inches to about 12 inches, or may range from about 3 inches to about 8 inches. In certain examples, the length L**1** of the first set of heating elements is about 70% to about 90% of the length L**3** of the third set of heating elements. In certain examples, the length L**2** of the second set of heating elements is about 80% to about 99% of the length L**3** of the third set of heating elements. In certain examples, the thickness T**1** is in a range from about ⅛ mm to about ⅜ mm, or about ¼ mm.
(34) In the example depicted in FIGS. **6** and **7**, the bus **136**A which connects heating elements **108**A and **108**B has an elbow or bent shape for accommodating the different lengths L**1**, L**2** between these heating elements. The bus **136**E which connects heating elements **108**E and **108**F also has an elbow or bent shape for accommodating the different lengths L**1**, L**2** between these heating elements. Buses **136**B, **136**C, and **136**D each have a straight or linear shape for connecting adjacent heating elements **108** (e.g., heating elements **108**B and **108**C, heating elements **108**C and **108**D, and heating elements **108**D and **108**E). In certain examples, the shapes of the terminals **130** (e.g., terminals **130**A-B) and the buses **136** (e.g., buses **136**A-E) may vary.
(35) The buses **136**A-E and the terminals **130**A, **130**B may each include one or more apertures **144** by which the heating elements **108** can be mechanically supported. In certain examples, electrically insulated mechanical supports are engaged with the apertures **144** to hold the terminals **130** and buses **136**, and thus the heating elements **108**, in a desired position with respect to a cooking cavity **104** of an appliance **100**. In some examples, the engagement of the mechanical supports with the apertures **144** may support the heating elements **108** so that the heating element can thermally expand and contract without placing stress on the heating element **108**. For example, the heating elements **108** may be supported so that the elements **108** can freely change dimension along the length L and/or width W (i.e., in directions parallel to a plane of the heating element) with temperature variations of the element **108**.
(36) In some embodiments, one or more heating elements **108** may be attached to a support that provides physical support to the heating elements **108**, and may provide other functions such as reflecting electromagnetic radiation emitted by the heating elements **108** toward a cooking cavity, causing the heating elements **108** to take or maintain a particular shape, and/or helping to keep heat within a cooking cavity **104**. For example, FIGS. **8-10** show an embodiment in which a heating

assembly **106** including the heating element arrangement of FIGS. **6** and **7** has a support **146**. Although the support **146** may be arranged in various different ways, in some embodiments the support **146** is formed from a sheet of flexible material, such as a sheet of dielectric material like phlogopite high temperature mica or similar materials having a thickness of about 0.015 to about 0.045 inches. In some embodiments, the support **146** may be electrically insulating and/or thermally insulating, although this is not required. For example, a support **146** could be made of, coated with, or otherwise include an electrically conductive metal or other material. In some embodiments, the support **146** may be reflective of at least some wavelengths of electromagnetic radiation emitted by the heating elements **108**, such as infrared radiation emitted by the elements **108**. This may allow the support **146** to reflect infrared radiation that is emitted by a heating element **108** in a direction toward a cooking cavity **104** and/or toward the heating element **108**. In some embodiments, the support **146** is thermally insulating and reflective of infrared radiation. As a result, the support **146** tends to absorb relatively little heat from the heating elements **108**, and tends to reflect or otherwise emit infrared radiation toward a cooking cavity **104** and the heating element **108**. That is, the heating elements **108** may be positioned between the support **146** and the cooking cavity **104** so that infrared radiation emitted by the heating elements **108** in directions away from the cooking cavity **104** may be reflected by the support **146** back toward the cooking cavity **104** and the heating elements **108**. The reflected infrared radiation not only makes heating of a food product in the cavity **104** more efficient, but also helps to heat the heating elements **108**, allowing the elements **108** to heat up more quickly and to generate additional infrared radiation. In some embodiments, the heating elements **108** may be out of contact with the support **146** at portions along the length and/or width of the heating elements **108**, e.g., at portions between longitudinal ends of the heating element. Thus, the heating elements **108** may be mostly out of contact with the support **146**, reducing heat loss to the support **146** by conduction. Additionally, the support **146** may provide both thermal and electrical insulation in the cooking appliance **100** such that heat tends to remain in the cooking cavities **104**, and electrical current in the heating elements **108** is not conducted to the housing **102** of the cooking appliance **100**. The support **146** may also, or alternately, provide physical support to the heating elements **108** so the elements **108** maintain or take on a particular shape. As discussed more below, the support **146** and heating elements **108** may be flexed or otherwise bent to take on a curved shape, e.g., so radiant energy can be focused toward a cooking cavity **104**. The support **146** may aid in keeping the heating elements **108** in a desired shape.

(37) As described above, heating elements can have electrically conductive portions defining a sheet with a plurality of openings and configured so that the sheet has first and second opposed faces, e.g., as a sheet of paper has two opposed sides or faces. In some embodiments, one or more heating elements of a heating assembly can be attached to a reflector or other support such that first faces of the heating elements are oriented away from the support and second faces of the heating elements are oriented toward the support. In some cases, the support can have a surface that spans across the second faces of the plurality of heating elements, e.g., to reflect infrared radiation emitted from the second faces back toward the heating elements. In some cases, each of the heating elements can be arranged to have an elongated rectangular shape having a length and a width, and the heating elements can be arranged on the support so that the lengths of the plurality of heating elements extend in a same direction. This can be seen, for example, in FIG. **8** where heating elements **108** each have a length dimension extending in a same direction, e.g., vertically.

(38) In some embodiments, the heating elements may be attached to the support so that the heating elements are movable relative to the support at least in one or more directions, e.g., in directions parallel to a plane of the heating elements. For example, the heating elements **108** may have a sheet-type configuration with an elongated shape like that shown in FIG. **8** and may be movable along a length and/or width of the heating element relative to the support **146**. Such relative movement may be caused by thermal expansion and/or contraction of the heating elements **108**

(e.g., the heating elements **108** may have a coefficient of thermal expansion that is greater than the support **146** and/or otherwise move to a greater or lesser extent than the support **146** with increase in temperature) or caused by physical distortion of the support **146** and/or heating elements **108** (e.g., when the heating assembly **106** is mounted in a cooking appliance **100**). As a result, the heating elements **108** may be able to maintain or otherwise take a desired physical shape even with heating/cooling of the elements **108** and/or physical distortion of the support **146**. This may help ensure the heating elements **108** emit radiation toward a cooking cavity **104** in a desired way and/or are not damaged during use of the heating assembly **106**. The heating elements **108** may be attached to the support **146** in different ways to allow for relative movement, and in some embodiments rivets or other fasteners may be fixed to the support **146** and extend through the apertures **144** so that the heating element **108** can move vertically and/or laterally (as viewed in FIG. **8**). For example, the apertures **144** may be sized and/or shaped (e.g., formed as slots) so that a heating element **108** can move along its length (vertically) and/or along its width (horizontally) relative to the rivet or other fastener engaged at the aperture **144**. Other arrangements are possible for attaching a heating element **108** to a support **146**, as discussed more below.

(39) A heating assembly **106** like that in FIG. **8** may be used in a variety of different cooking appliances. For example, FIG. **9** shows the heating assembly **106** employed in a cooking appliance **100** arranged as a toaster with a slice of bread **2** partially inserted in a cooking cavity **104** (e.g., a bread slot of the toaster). FIG. **10** shows a front cross-sectional view of the cooking appliance **100** that includes two cooking cavities **104** each accessible via a bread slot at a top of the appliance housing **102**. Each cooking cavity **104** has a pair of heating assemblies **106** positioned on opposite sides of the respective cooking cavity **104**. That is, the heating assemblies **106** are arranged so that the heating elements **108** of each assembly **106** are positioned between the corresponding support **146** and the cooking cavity **104**. Accordingly, in the example of FIGS. **9** and **10**, the cooking appliance **100** includes four heating assemblies **106** with a total of four supports **146** and **24** heating elements **108**. The heating assemblies **106** may be secured in the housing **102** of the appliance **100** in different ways, such as by fasteners, clips, etc. In some embodiments, the supports **146** include several tabs **148** along the top and bottom (and optionally the sides) that secure the support **146** to the chassis of the cooking appliance **100**. As an example, each tab **148** may be inserted into a corresponding slot of the chassis of the appliance **100** so the support **146** is held in place by the chassis. Each tab **148** may include an aperture **152** that can receive a fastener for securing the support **146** to the housing **102** of the cooking appliance **100**, although this is not required. In FIG. **8**, the support **146** is depicted as having a length L**4**, which may be about 5.5 to about 6.5 inches, and a width W**4** which may be about 4.5 to about 5.5 inches. Of course, these dimensions may be suitable for a toaster like that in FIGS. **9** and **10**, but may be varied depending on the application.

(40) In some embodiments, the heating elements **108** may be sized, shaped and/or otherwise configured to present an optimized heating surface area (HSA) for a cooking cavity **104**. For example, as can be seen in FIG. **8**, the arrangement of the heating elements **108** provides an optimized heating surface area HSA that has a general shape of a piece of bread to be toasted or otherwise cooked in a cooking cavity **104**. In this embodiment, the heating surface area HSA is defined by the lengths, widths and relative positions of the heating elements **108**, e.g., so that the heating surface area HSA may match the shape of a typical piece of toast having a square or rectangular bottom and a rounded top. Thus, the heating elements **108** may allow the appliance to operate more efficiently because infrared energy is emitted only toward areas where food is present, and not where no food is located. Of course, a heating surface area HSA is not limited to a "bread" shape as in FIG. **8**, but other shapes and configurations are possible, such as a "pizza" or triangular shape, a "bagel" or round shape, etc. Also, although the cooking appliance **100** in FIGS. **9** and **10** is depicted as a toaster having two cooking cavities **104**, it is contemplated that the heating assemblies **106** in this and other embodiments may be used in different types of cooking appliances including toaster ovens, pizza ovens, microwave ovens, electric grills, contact cookers

(including, for example, contact grills or griddles), or slow cookers having one or more cooking cavities **104**.

(41) In the embodiments of FIGS. **6-10**, the heating elements **108** have electrically conductive portions arranged to define a sheet having a length and width, e.g., generally having a rectangular outer shape, and having a plurality of openings formed in the sheet. FIG. **11** shows an enlarged view of a heating element **108** in these embodiments extending between the bus **136**A and the bus **136**B. The heating element **108** has a pattern **154** that defines a plurality of openings **140** which are spaced apart from one another. In some examples, the pattern **154** defines two columns of openings **140** and a nested third column of openings **140** that overlaps and/or is arranged between the first two columns of openings **140**. However, other arrangements are possible, e.g., including a single column of openings **140** as shown in FIG. **12**. In some embodiments, the openings **140** each have an elliptical shape such that they are substantially oval or circular. For example, each opening **140** can have first and second walls **140***a*, **140***b* that are curved in opposing directions along a vertical axis. In this manner, each opening **140** is separated along the vertical axis from an adjacent opening **140**. Each opening **140** can be symmetrical about the vertical axis and/or horizontal axis. Portions of the heating element **108** that define the walls **140***a*, **140***b* are electrically conductive to at least some extent and are heated by electrical current so that infrared radiation is emitted. The shape of the heating element portions that define the openings **140** increases the current path between the buses **136** or terminal ends of the heating element **108**, so that suitable voltage and/or current may be used to heat the heating element **108**. That is, the shape and size of portions of the heating element **108** that define the openings **140** can be adjusted to provide a desired infrared output for a desired voltage and/or current for the heating element **108**. In some cases, the shape of the openings **140** can provide a complex or otherwise suitable resistance path to help reduce hot spots or other unwanted temperature variations in different areas of the heating element **108**. In this embodiment as depicted in FIG. **12**, the openings **140** can each have an individual width W**5** from about 0.20 inches to about 0.35 inches, and a length L**5** from about 0.06 inches to about 0.16 inches.

(42) In some embodiments, a ratio of a radiating area of a heating element **108** to a total area of the heating element **108** can be arranged to be from 5% to 25%, which has been found to be particularly effective in generating suitable infrared radiation for heating food and/or other items. The radiating area of a heating element **108** is the exposed metal or other portions of a heating element **108** that emit infrared radiation toward a cooking cavity or other location where the infrared energy is used to heat an object. For example, the radiating area of the heating element **108** in FIG. **11** is the electrically conductive portion of the heating element within a total area A**1** of the heating element **108** that emits infrared radiation in a direction out of the plane of FIG. **11**. The total area A**1** of the heating element **108** is a minimum rectangular or other polygonal shape that contains the radiating area of the heating element **108**. In FIG. **11**, the total area A**1** is a rectangular shape that bounds the sheet portion of the heating element **108**. In some embodiments, the total area A**1** of a heating element **108**, or each heating element **108** in a heating element assembly **106**, is from 12 sq.cm to 24 sq.cm, the radiating area is 0.5 sq.cm to 3.5 sq.cm, and the open area defined by the plurality of openings of 10 sq.cm to 20 sq.cm. Note that any narrower range of values in the above ranges can be employed, e.g., 13 to 14 sq.cm for the total area A**1**, or 15 to 22 sq.cm for the total area A**1**, and so on. Arranging each heating element **108** in this way can configure the heating element **108** to emit infrared radiation in a particularly useful and effective way, e.g., having a desired radiative flux at a particular distance from the heating element **108**, and/or to emit visible light in a particular way, e.g., having a wavelength range of 570 to 800 nanometers and a luminous flux of at least 100 lumens, e.g., 100 to 300 lumens, while the heating element also emits infrared radiation.

(43) In some embodiments, a heating element assembly **106**, e.g., including multiple heating elements **108** that are electrically connected together, can have a ratio of the radiating area of all heating elements **108** of the assembly **106** to an area of a cooking space receiving radiation from

the heating assembly **106** to be from 1% to 20%, e.g., 1% to 3%, 2% to 5%, and so on. As discussed above, the radiating area of each heating element **108** of the assembly **106** is the electrically conductive portion of the heating element(s) **108** that emits infrared radiation toward the cooking cavity or space where food or other object is heated. The area of the cooking space or other location that receives infrared radiation from the heating assembly **106** can be defined as the total area A**2** of the heating assembly **106** in which heating element(s) **108** are located. For example, in FIG. **6**, the total area A**2** of the heating assembly is a minimum rectangular or polygonal shape that contains the heating elements **108** of the assembly **106**. This total area A**2** is exposed to a cooking cavity of a corresponding toaster or other appliance, and so is the area of a cooking space receiving radiation from the heating assembly **106**. In some embodiments, the radiating area of the heating element(s) **108** of the assembly **106** can be 2.5 sq.cm to 18 sq.cm, and the area of the cooking space receiving radiation from the assembly **106** can be 25 sq.cm inches to 350 sq.cm. Arranging a heating assembly **106** is this way can configure the heating assembly **106** to emit infrared radiation in a particularly useful and effective way, e.g., having a desired radiative flux at a particular distance from the heating assembly **106**, and/or to emit visible light in a particular way, e.g., having a wavelength range of 570 to 800 nanometers and a luminous flux of at least 100 lumens while the heating assembly also emits infrared radiation.

(44) The features described above regarding a ratio of radiating area to heating element total area or to heating assembly total area or to an area of a cooking space receiving radiation can be used together in a heating element **108** and/or heating assembly **106**, and can be combined with other features described herein including a wavelength range and radiative flux for emitted infrared radiation, a wavelength range for emitted visible light, structural configurations for heating elements and/or heating element supports, cooking device housing configurations, and/or other features described herein. Thus, if a particular feature is described in connection with a particular embodiment, this should not be interpreted as meaning that feature cannot be combined with other features described in connection with another embodiment. To the contrary, various embodiments are described to illustrate various features, and to the extent features are not mutually exclusive, such features can be combined together in any suitable way.

(45) In some embodiments, a heating element assembly can include one or more heating elements that are arranged with first faces exposed and oriented toward a same direction, e.g., toward a cooking cavity, and to emit radiation in a wavelength range of 0.75 to 10 microns with a radiative flux of at least 3,000 to 5,000 Watts/sq.cm at a distance of 10 cm from the plurality of heating elements. In some cases, the heating elements can be arranged to emit such energy for an extended period of time, such as 1 to 5 minutes, 3 to 10 minutes, 10 to 30 minutes or more. This infrared energy emission arrangement for a heating assembly has been found particularly effective in cooking or otherwise heating a food item (such as when toasting bread) so that the food item is uniformly and rapidly heated without drying out or otherwise driving moisture away from the food item in an undesired way. As noted above, this feature can be used with other features of heating elements and/or assemblies described herein, such as arranging the heating assembly to have a particular ratio of radiating area to heating element, heating assembly and/or cooking space area, employing the heating element(s) with a reflective support, and others. In some embodiments, heating elements of an assembly can be configured to emit visible light in a wavelength range of 570 to 800 nanometers and to emit radiation suitable to heat a food item associated with the food cooking device, e.g., having the particular wavelength range and radiative flux discussed above. Arranging the heating element(s) to emit visible light in a particular wavelength range can provide confirmation to a user that the heating element(s) are operating properly to emit suitable infrared radiation, e.g., having a particular wavelength range and radiative flux, to heat a food item. Thus, a user can confirm by simply viewing a heating element, e.g., through an opening in a housing of a cooking appliance, that the heating element is operating properly. In some cases, heating elements can be configured to emit the visible light in a wavelength range of 570 to 800 nanometers within

10 seconds to 20 seconds after electrical power is applied to the heating elements, e.g., after electrical power of 50 to 150 Watts or less than 1800 Watts is applied to the heating element assembly or cooking appliance.

(46) In certain examples, the heating elements **108** of all or part of a heating assembly **106** defines a single sheet of material, e.g., such that the terminals **130** (e.g., including terminals **130**A and **130**B), heating elements **108**, and buses **136** (e.g., including buses **136**A-E) are all continuous or unitary with one another. Accordingly, separate elements or pieces need not be used for connecting the terminals **130**, heating elements **108**, and buses **136** since they are all part of a same continuous sheet of material. By forming the terminals **130**, heating element(s) **108**, and buses **136** all from a single sheet of material, the heating assembly **106** need not have any joints where separate pieces need to be fastened together. This may be advantageous for several reasons. One benefit is that joints may be a potential source of failure because a joint can oxidize over time with exposure to electricity and/or oxygen. Oxidation may reduce conductivity at that point, reducing the amount of current that can flow and creating a cold spot. Eliminating joints may therefore improve the operation and reduce the chance of undesirable oxidation occurring. Another benefit is that the components (terminals, heating elements, and/or buses) are all connected together at fabrication, eliminating any additional steps to connect components together. However, in other arrangements, terminals, heating elements and/or buses may be made separately from each other, and electrically and/or physically attached to form a heating assembly **106**. In certain examples, the heating elements **108** each define a single sheet of Iron-Chrome-Aluminum alloy, an alloy of at least nickel and chromium, known as Nichrome, or similar material.

(47) To form a heating element **108**, whether including terminals, buses or not, a sheet of suitable material may be cut from a roll or other source and processed. In certain examples, the sheet may be processed using photolithography to remove unwanted portions of the sheet by an etching process, e.g., to form the openings **140**. For example, the photolithography process may be used to form the heating elements **108**. In some cases, a photolithography process may optimize the structure of the heating element **108** by imparting a continuous and smooth transition between the terminals **130**, heating elements **108**, and/or buses **136**. This may improve current flow through the heating element **108**, and accordingly, improve the performance of the heating element **108** so that the heating element **108** reaches suitably high temperatures in less time. In another possible example, other techniques such as machining and/or punching are used to form the terminals **130**, heating elements **108**, and/or buses **136** from a single sheet of material. For example, machining or cutting can be performed by a computer numerical control (CNC) router or similar machine.

(48) FIGS. **13** and **14** show views of another cooking appliance **100** that incorporates various aspects of the invention. The cooking appliance **100** in this embodiment is a toaster with a housing **102** that defines one or more cooking cavities **104** and has a heating assembly **106** disposed at least partially therein. Openings **102***a* in the housing **102** provide access to a cooking cavity **104**, e.g., through which to insert food, and allow a user to view one or more heating elements **108** of a heating assembly **106** associated with a cooking cavity **104**. This can allow a user to view visible light emitted by the heating elements **108**. A plug **118** may extend from the housing **102** via a power cable **112** such that power can be supplied to the cooking appliance **100**. As described above, in operation, the heating assembly **106** generates infrared radiation to heat food in a cooking cavity **104** of the cooking appliance **100**. As in other embodiments, the cooking appliance **100** can take a variety of forms, in addition to or alternatively from the example illustrated in FIGS. **13** and **14** (e.g., a toaster, a toaster oven, a microwave oven, and electric grill, a contact cooker, a slow cooker, etc.) as required or desired.

(49) In this embodiment, the housing **102** includes a base **253**, a rear wall **254**, a front wall **256**, and a cover **258** (which is removed in FIG. **14**). A chassis **260** is at least partially disposed within the housing **102**, supports the heating assemblies **106**, and defines the cooking cavities **104**. The front wall **256** includes a user interface **262** to provide information to and/or receive information from a

user, e.g., to control operation of the cooking appliance **100**. The user interface **262** may include one or more input devices(s) such as tactile buttons, knobs, switches, and/or one or more display/control screens, including capacitive touch screens with graphic user interfaces (GUIs) so as to enable user interaction with and control of the cooking appliance **100**. In this example, the user interface **262** is a single capacitive touch screen **264** that provides user control of the cooking appliance **100**. In examples, the touch screen **264** may enable functionality of the cooking appliance **100** such as food product selection, infrared radiation (e.g., toast) level and/or duration, start operations, cancel operations, auto-warming, auto-reheat, etc. Additionally, or alternatively, the touch screen **264** may display information such as time, date, food product images, timers, etc.
(50) The user interface **262** may be part of an electrical coupling and control **110** that includes one or more computing devices and/or other components suitable for implementing one or more functions described herein. For example, the electrical coupling and control **110** may include at least one data processing unit and system memory. Depending on the configuration and type of computing device, the system memory (storing, among other things, instructions to perform the display setting and control methods described herein) can be volatile (such as RAM), non-volatile (such as ROM, flash memory, etc.) or some other combination of memory. The system memory may include an operating system and one or more program modules suitable for performing the various aspects described herein and controlling the cooking appliance **100**. Furthermore, examples of the disclosure may be practiced in an electrical circuit comprising discrete electronic elements, packaged or integrated electronic chips containing logic gates, a circuit utilizing a microprocessor, or on a single chip containing electronic elements or microprocessors. The user interface **262** may also include one or more output devices such as speakers for audio output. Additionally, the electrical coupling and control **110** may include one or more communication connections such as transmitters, receivers, and/or transceiver circuitry allowing communication with external device(s) (e.g., a smartphone) as required or desired.
(51) In operation, electric power is supplied to the heating assembly **106** such that infrared radiation is generated and directed to a food product in a cooking cavity **104**. As such, heat is generated within the chassis **260** during operation, and may be limited to the area of the chassis **260** so that heat does not undesirably impact other portions of the cooking appliance **100**, such as by undesirably heating the electronic components of the user interface **262**. To at least partially control heat transmission in the cooking appliance **100**, the heating assemblies **106** may direct and/or reflect infrared radiation toward the cooking cavities **104**, which are open at a top, so that excess heat, if any, can be exhausted from chassis **260** and reduce heating of other components.
(52) As illustrated in FIG. **14**, the chassis **260** may be spaced apart from the rear wall **254** and the front wall **256**, and is only partially coupled to the cover **258**, thereby forming an air gap **266** between the chassis **260** and the housing **102**. This air gap **266** enables cooling air flow to be induced around the chassis **260** and reduce heat transfer to other components. For example, hot air rises and as such, vent openings **268** are defined within the base **253** so that air flow within the cooking appliance **100** can be directed from the bottom towards the top and pass across the chassis **260**. One or more of the rear wall **254**, the front wall **256**, and the cover **258** may also include vent slots that enable air flow into and/or out of the cooking appliance **100**.
(53) A heat shield **270** may at least partially surround the user interface **262** so as to block the infrared radiation from the electronic components therein. The heat shield **270** may be at least partially open at the top and the bottom so that air flow can be channeled through the heat shield **270** and provide further cooling for the components therein. In addition, the cooking appliance **100** includes a drive assembly **272** (e.g., a motor and actuator components) that drives movement of a lifting arm **274** (shown in FIG. **15**) for the food product within the cooking cavities **104**. The drive assembly **272** may be positioned between the chassis **260** and the user interface **262** so as to further block infrared radiation. The drive assembly **272** is further described below with reference to FIG. **18**, but generally assists with supporting food in the cooking cavities **104**, as well as moving food

into and/or out or a cavity **104**.

(54) As can be seen in FIG. **14**, the cooking appliance **100** includes one or more sensors **276**, **278** that facilitate operation of the appliance. A temperature sensor **276** is coupled to the chassis **260** and is configured to measure a temperature indicative of a temperature in the cooking cavities **104** and provide the temperature information to the electrical coupling and control **110**. This sensor **276** enables control of the cooking temperature, e.g., by providing information to control turning on and off of the heating assemblies **106**. Furthermore, the sensor **276** can be used to turn the heating assemblies **106** off when a predetermined temperature is reached to prevent the cooking appliance **100** from overheating. In one example, the temperature sensor **276** is a thermistor.

(55) A thermal cutoff **278** may be coupled to the chassis **260** and configured to measure a temperature indicative of a temperature within the cooking cavities **104** or elsewhere in the appliance **100**. This information can be used to shut the cooking appliance **100** completely off, or at least to shut off the heating assemblies **106**, when a predetermined temperature is reached. The thermal cutoff **278** may be a one-time use device, such as a thermal fuse, or may be reset manually or automatically as required or desired. In this example, a temperature value detected by the temperature sensor **276** that is used to turn off the heating assemblies **106** is set at a lower value than a temperature value of the thermal cutoff **278** used to shut down the heating assemblies **106**. Thus, the electrical coupling and control **110** may use the temperature sensor **276** to control on/off cycling of the heating assemblies **106** to control a temperature in the cooking cavities **104** without causing the appliance to overheat and trip the thermal cutoff **278**. By using the temperature sensor **276** to control the heating assembly **106** operation, the cooking appliance **100** can use more power than a conventional conduction heating appliance (e.g., about 40% more watts-about 1,400 watts compared to 1,000 watts) while reducing or preventing appliance overheating.

(56) FIG. **15** is a cross-sectional perspective view of the chassis **260** of the cooking appliance **100** in FIGS. **13** and **14**. Each heating assembly **106** includes heating elements **108** and is supported by the chassis **260** such that a cooking cavity **104** is defined between opposed heating assemblies **106**. This allows the heating assemblies **106** to heat a food product held by a lifting arm **274** in the cooking cavity **104**. The chassis **260** includes a plurality of side walls (e.g., a front wall **277**, a rear wall **279**, and left and right walls **280**) extending between a top wall **282** and a bottom wall **284**. The heating assemblies **106** are coupled to and supported by the top and bottom walls **282**, **284**, while being oriented substantially perpendicular to the front and rear walls **277**, **279** and substantially parallel to the left and right walls **280**. The bottom wall **284** includes one or more openings **286** aligned with the cooking cavity **104** so that food product particles (e.g., toast crumb) may fall through the chassis **260** for removal. The openings **286** may be formed as a funnel shape (e.g., tapered) as required or desired.

(57) In some embodiments, each of the heating elements **108** is curved and have a concave side that faces toward a corresponding cooking cavity **104**. That is, the curve of the heating element **108** is concave in the direction towards the cooking cavity **104** and convex in a direction away from the cooking cavity **104**. Since the heating elements **108** each define a sheet with a length and width, the curved heating elements **108** define a cylindrical shell-type shape, or other similar curved shape (such as one that has a variable radius). By arranging the heating element **108** in a curved configuration, infrared radiation emitted by the element **108** may be focused in a direction towards the cooking cavity **104**. Also, the heating element **108** is directly exposed to the cooking cavity **104**, i.e., the metallic or other part of the heating element **108** that emits infrared radiation is directly exposed to the cavity **104** without any intervening component such as electrical insulation, a glass or ceramic covering for the element **108**, or other. As such, the heat transfer from the heating element **108** to the food product may be increased, thereby increasing the efficiency and performance of the cooking appliance **100**. Note again that these features can be combined with other features of a heating assembly and/or cooking appliance, such as configuring the heating elements to emit infrared radiation in a particular wavelength range and having a particular

radiative flux, to emit visible light, to have a particular ratio of radiating area to total heating element or assembly area, etc.

(58) In addition, arranging the heating elements **108** which define a sheet having a length and width so as to have a curved shape can help maintain proper orientation of the heating element **108** with respect to the cooking cavity **104** throughout each cooking cycle, and between separate cooking cycles. For example, as a heating element **108** heats and cools during each cooking cycle, the heating element **108** will generally change length and/or width due to thermal expansion and contraction. By arranging heating elements **108** to have a curved shape that faces the cooking cavity **104**, elongation and/or contraction of the heating element **108** along its length and/or width will tend to keep the heating element **108** in its curved shape. For example, even if a heating element **108** is fixed at its ends relative to the chassis **260**, if the heating element **108** has a curved shape like that shown in FIG. **15**, elongation and/or contraction of the heating element **108** along its length will tend to increase or decrease the radius of curvature of the element **108**, but otherwise the element **108** will maintain the curved shape. As a result, a distance between portions of the heating element **108** and the cooking cavity **104** will not change much and will be consistent for each heating and cooling cycle. In contrast, a heating element that is mounted in a straight or planar configuration with fixed ends relative to the chassis **260** may bend or buckle unpredictably when heated or cooled, e.g., the element may bend toward and/or away from the cavity as the element grows longer due to thermal expansion. As a result, such an element will have different and unpredictable orientations and distances to the cooking cavity for each heating and cooling cycle. In contrast, heating elements **108** arranged like that in FIG. **15** will tend to have a predictable shape, orientation and distance from a cooking cavity, even when experiencing thermal expansion and/or contraction.

(59) In some examples, each of the heating elements **108** of a heating assembly **106** or of different heating assemblies **106** may have a substantially similar shape of curvature. In other examples, one or more heating elements **108** may have a different shapes of curvature than other heating elements **108**, whether included in a same or different heating assembly **106**. For example, heating elements **108** that are proximate to the left and right side walls **280** may have a smaller radius of curvature (e.g., a greater curve) than the heating elements **108** disposed in the center of the chassis **260** (e.g., a more shallow or lesser curve). In some cases, heating elements **108** have a largest curvature possible to focus infrared radiation towards a food product without being smaller in height than the cooking cavity **104**. In still other examples, other curved concave shapes may be used, for example, two oblique surfaces disposed at an angle to one another, a trapezoidal shape, etc.

(60) In this embodiment, each heating assembly **106** includes a support **146** with a heating element **108** coupled thereto. The support **146** may be formed of a material suitably arranged to allow the support **146** to be curved, e.g., when the heating assembly **106** is mounted in the chassis **206**. That is, a support **146** for a heating assembly **106** may have a curved shape with a concave side facing towards a corresponding cooking cavity **104**. This arrangement may allow the support **146** to maintain its curved shape even with thermal expansion and contraction of the support **146** during heating and cooling cycles of a heating element **108** associated with the support **146**. This arrangement may be particularly useful when a support **146** is maintained in a stressed state while in a curved configuration in a cooking appliance **100**. For example, the support **146** may have a planar shape when unstressed, and may be stressed and elastically deformed to take a curved shape when held in a cooking appliance **100**. As a result, the support **146** may maintain the curved shape, even if the support **146** expands and/or contracts due to thermal expansion and/or contraction. This may help the support **146** maintain a suitable shape relative to a corresponding cooking cavity **104** (e.g., so the support can reflect infrared energy in a focused way toward the cavity **104**) and/or help an attached heating element **108** keep a desired curved or other shape relative to the cavity **104**. The support **146** may be arranged in different ways, e.g., of a suitably rigid material that has at least some elasticity so that the support **146** can be bent from a planar shape to a curved shape. In an

example, the support **146** may be formed of a sheet of mica material that has a thickness of 0.16 inches.

(61) To form the curved shape of a support **146**, the support **146** may initially be flat and planar with one or more heating elements **108** attached to the support **146**. As can be seen in FIG. **15**, the support **146** may be flexed (i.e., deformed elastically so the support **146** has a curved shape) and engaged with the chassis **260** so that the chassis **260** holds the support **146** in the curved shape. For example, top and bottom portions of the support **146** (e.g., tabs **148**) may be inserted into corresponding openings of the chassis **260** and the support **146** released from a bending force (which may be applied by hand). The chassis **260** may be sized and arranged so that the support **146** is prevented from returning to its planar shape, and instead is held in the curved shape shown in FIG. **15**, e.g., by the chassis **260** applying a compressive force on the support **146**. For example, a distance between the portions of the chassis **260** that receive the tabs **148** may be smaller than a length of the support **146** at portions that contact the chassis **260**. As a result, the support **146** cannot return to its original planar shape and is held in place in a curved configuration by the top and bottom walls **282**, **284** of the chassis **260**. Additionally, the support **146** may be supported at one or more intermediate positions along its length to form the curved shape. For example, as shown in FIG. **15**, the front and rear walls **277**, **279** of the chassis **260** may include a clip **288** that engages with an edge of the support **146** (though not the heating element) so as to at least partially define the curved shape. FIG. **16** shows a close up view of the clip **288** which may be included with the front and rear walls **277**, **279**. In this embodiment, the clip **288** extends from the front or rear wall **177**, **279** and engages with the support **146** to help hold the support **146** in a curved shape. For example, during assembly the support **146** may be placed within the chassis **260** and then curved in the required or desired direction. Once the support **146** is engaged at the top and bottom walls **282**, **284** of the chassis **260** (e.g., by inserting tabs **148** into corresponding slots), the clip **288** can be folded inwardly as shown in FIG. **16** to secure the support **146** in the curved configuration. In other examples, the clip **288** may be a static structure of the front or rear wall **277**, **279** that the contacts the support **146**. The clip **288** can include a curved surface **294** so as to reduce wear on the support **146**, e.g., during thermal expansion and contraction or other movement of the support **146**.

(62) In this embodiment, the curved shape of the support **146** is formed during assembly of the support **146** within the cooking appliance **100**. Also, a curved shape of the heating elements **108** is formed when the support **146** is bent to take a curved shape. However, this is not required. In other examples, the support **146** and/or heating element **108** may be manufactured with a curved shape that is maintained when assembled within the chassis **260**, e.g., the support **146** may have a curved shape in an unstressed state. Note also that a support **146** or heating element **108** having a curved shape may be used alone or in combination with each other, e.g., a curved support **146** may be used to support one or more heating elements **108** having a flat, straight and/or planar configuration. Alternately, heating elements **108** having a curved shape may be employed with a flat and planar support **146**.

(63) FIG. **17** is a perspective view of a heating assembly **106** used in the embodiment of FIGS. **13-15**. In this embodiment, the heating assembly **106** includes five heating elements **108** that each includes a sheet having a single vertical row of openings **140**. The heating elements **108** are electrically connected in series, but could be connected in other ways to electrical power, e.g., in parallel or having groups of two or more elements in parallel with elements within each group connected in series. In some embodiments, the support **146** and the heating elements **108** attached to the support **146** have a curved configuration or shape, e.g., as held in the chassis **260**. In some embodiments, the heating elements **108** are attached to the support **146** so that the heating elements **108** are slidably coupled and can move relative to the support **146** along a length of the heating elements **108**. This slidable coupling of the heating elements **108** to the support **146** can allow the heating elements **108** to expand or contract along their length and/or other directions parallel to the plane of the heating elements **108** (e.g., due to thermal expansion or contraction), and may allow

the elements **108** to maintain a curved shape during such movement. In this embodiment, one or more retainers **292** are coupled to the support **146** and extend over and contact one or more heating elements **108**, e.g., so a part of the heating elements **108** is between the retainer **292** and the support **146**. The retainers **292** may provide various functions, such as securing the heating elements **108** to the support **146** so that as the support **146** is flexed or otherwise bent from a planar configuration, the retainers **292** cause at least portions of the heating elements **108** to move with the support **146**. As a result, the retainers **292** may contact the heating elements **108** so as to cause the heating elements **108** to take a curved shape when the support **146** is bent into a curved shape. Alternately, or in addition, the retainers **292** may contact the heating elements **108** in such a way that the heating elements can move in directions along the surface of the support **146** (e.g., along a length of the heating element **108**), but are restrained in movement in directions away from the support **146**. Thus, for example, the retainers **292** may cause the heating elements **108** to take a curved shape, but allow the heating element **108** to move relative to the support **146** along the length of the heating elements **108** or other directions along the surface of the support **146** facing the heating elements **108**.
(64) The retainers **292** may also contact the heating elements **108** in a way to restrain their movement in directions away from the surface of the support **146** that faces the elements **108** while also allowing the heating elements **108** to avoid contact with the surface of the support **146**. Instead, the retainers **292** can hold the heating elements **108** such that the heating elements **108** are spaced from the support **146**, e.g., by a distance of a few millimeters. By avoiding contact with the support **146**, at least in some areas, the heating elements **108** may avoid heat loss to the support **146** by thermal conduction, thereby allowing the heating elements **108** to more effectively heat and generate infrared radiation. For example, as shown in FIG. **17**, the retainers **292** may each be formed as a bar or strip that is attached to the support **146** at locations on opposite lateral sides of a heating element **108**. Rather than squeezing or pressing the heating element **108** into contact with the support **146**, the retainer **292** may define a gap or space between the support **146** and the retainer **292** that is larger than the thickness T of the heating element **108**. As a result, the heating element **108** may be free to move in directions along the surface of the support **146** near the retainer **292**. The gap or space between the support **146** and the retainer **292** may be formed by securing the retainer **292** to the support **146** using a washer or other spacer, e.g., at a rivet or other fastener used to attach the retainer **292** to the support. The washer or spacer may have a thickness that defines a desired gap or space height in which the heating element **108** is captured by the retainer **292.** In another embodiment, a spacer may be positioned between the heating element **108** and the support **146** so the heating element **108** is held away from the support **146** by the spacer. The spacer may have a shape that is the same as or similar to the retainer **292**, e.g., a bar or strip-shaped spacer may be attached to the support **146** between the heating element **108** and the support **146** using a same rivet or other fastener used to attach the retainer **292** to the support **146** over the heating element. Thus, the heating element **108** may be captured between the retainer **292** and spacer so the heating element **108** is held out of contact with the support **146**, e.g., at least between longitudinal ends of the element **108**. The spacer and/or retainer **292** may be made of a material having low thermal conductivity and/or thermal capacitance, as well as having minimal dimensions, thereby reducing any heat loss to the spacer and/or retainer **292**.
(65) FIG. **17** shows retainers **292** arranged as multiple strips or bars that extend across an entire width of the support **146** and that are attached to the support **146** by rivets or other fasteners at locations between each heating element **108**. However, retainers **292** may be arranged in other ways, e.g., only one retainer **292** may be provided that extends across the support **146**, and retainers **292** may be attached to the support **146** in other ways, such as by an adhesive. Also, the retainers **292** in this embodiment are arranged to cause the heating elements **108** to take a curved shape when the support **146** is bent into a curved shape. However, in other arrangements, the retainer **292** may be configured to allow the heating elements **108** to keep or take a planar shape when the

support **146** is bent into a curved configuration. Alternately, the retainers **292** may cause the heating elements **108** to be in a curved configuration when the support **146** is planar or flat.

(66) Also in accordance with the aspect of attaching heating elements **108** to a support **146** to allow slidable movement of the element **108**, apertures **144** at lower terminals **130** and/or buses **136** are formed to have a slot shape having a long dimension that extends along a length of the heating elements **108**. Rivets or other fasteners **290** are attached to the support **146** and engage with the apertures **144** so that heating elements **108** are secured to the support **146** but allowed to move in directions along the surface of the support **146** adjacent the heating elements **108**, e.g., the heating elements **108** can move along their length by thermal expansion/contraction and/or due to bending of the heating assembly **106** during assembly of the appliance **100**. In this embodiment, apertures **144** at upper terminals **130** and/or buses **136** are formed as circular openings that are secured to the support **146** by a fastener **290**. Thus, upper ends of the heating elements **108** may be fixed relative to the support **146** although the heating element **108** is otherwise slidably attached to the support **146** by the lower apertures **144**. Other arrangements are possible, such as providing slot shaped apertures **144** at upper ends of the heating elements **108** like at the lower ends. Note that the use of retainers **292** and slot shaped apertures **144** or similar mounting configurations may be used alone, or together as shown in FIG. **17**.

(67) FIG. **18** shows details of the drive assembly **272** which is adjacent to the front wall **277** of the chassis **260** and is configured to automatically raise and lower the lifting arms **274**, one of which is shown in detail in FIG. **19**. The drive assembly **272** may include an electronic motor (not shown) that drives a drive disk **304** about a rotational axis **306**. The drive disk **304** is coupled to a drive bar **308** that is coupled to a carriage **310** supporting the lifting arms **274** so that rotation of the drive disk **304** causes the carriage **310** to move upwardly and downwardly on two parallel posts **312**. Movement of the carriage **310** along the posts **312** causes the lifting arms **274** to move a food product upwardly and downwardly in a cooking cavity **104**, e.g., so a slice of bread can be received into and lifted from a cooking cavity **104**. The lifting arms **274** each include an elongate bar **296** that has one end configured to couple to the carriage **310**. A plurality of ribs **298** extend from the elongate bar **296** and form a support surface **300** for the food product. The elongate bar **296** and/or the ribs **298** include one or more holes **302** defined therein. These holes **302** reduce the thermal mass and thermal capacity of the lifting arm **274** so that the heating elements heat the food product and not the lifting arm **274**, thereby increasing the efficiency and performance of the cooking appliance. Furthermore, since the heating elements generate infrared radiation, the holes **302** facilitate a direct line of sight to the food product so that even portions of the food product that are within the ribs **298** are heated and toasted.

(68) In operation, as the drive disk **304** rotates, the drive bar **308** is pulled either upwards or downwards to raise or lower the carriage **310**. The drive bar **308** is coupled to an elongated channel **314** of the carriage **310** that extends between the two posts **312** and substantially orthogonal to the rotational axis **306**. The channel **314** enables for the drive bar **308** to move laterally between the two posts **312** due to the rotation of the drive disk **304** without moving the carriage **310** laterally. As described above, the drive assembly **272** also provides blocking structure for the infrared radiation on the user interface **262**.

(69) FIG. **20** is a perspective view of the rear wall **254** of the housing **102**. As described above in reference to FIG. **14**, the cooking appliance **100** induces a cooling air flow through the housing **102**. At least a portion of the extracted heat is exhausted out of the top of the housing **102**. Additionally, or alternatively, the rear wall **254** includes a plurality of vent slots **316** so that at least a portion of the extracted heat can be exhausted out of the rear of the housing **102**. In other examples, other housing components, such as the cover **258** or the front wall **256** (shown in FIG. **13**), may include vent slots **316** as required or desired.

(70) The various embodiments described above are provided by way of illustration only and should not be construed to limit the claims attached hereto. Those skilled in the art will readily recognize

various modifications and changes that may be made without following the example embodiments and applications illustrated and described herein, and without departing from the true spirit and scope of the following claims.

Claims

1. An electrical resistance heating assembly for use in a food cooking device comprising: a plurality of heating elements, each heating element having first and second terminal ends and electrically conductive portions between the first and second terminal ends, the electrically conductive portions defining a sheet with a plurality of openings and first and second opposed faces, wherein the plurality of heating elements are configured to emit visible light in a wavelength range of 570 to 800 nanometers and to emit radiation suitable to heat a food item associated with the food cooking device.
2. The heating assembly of claim 1, wherein the heating element is configured in a housing of a food cooking device to emit radiation into a cooking cavity of the food cooking device.
3. The heating assembly of claim 2, wherein the food cooking device has an opening arranged in the housing and through which a user can view the heating element.
4. The heating assembly of claim 1, wherein the visible light has a luminous flux or spectral flux of at least 100 lumens.
5. The heating assembly of claim 1, wherein the radiation suitable to heat the food item has a wavelength range of 0.75 to 10 microns.
6. The heating assembly of claim 5, wherein the radiation has a radiative flux of 3,000 to 5,000 Watts/sq.cm at a distance of **10** cm from the plurality of heating elements.
7. The heating assembly of claim 1, wherein the plurality of heating elements are configured to emit the visible light in a wavelength range of 570 to 800 nanometers within 10 to 20 seconds after electrical power having a power of 50 to 150 Watts is applied to the heating element.
8. An electrical resistance heating assembly comprising: a plurality of heating elements, each heating element having a first and second terminal ends and electrically conductive portions between the first and second terminal ends, the electrically conductive portions defining a sheet with a plurality of openings and first and second opposed faces, the sheet of each heating element having a total area, and each of the heating elements having a radiating area arranged to emit radiation in a wavelength range of 0.75 to 10 microns along with visible light in a wavelength range of 570 to 800 nanometers, wherein a ratio of the radiating area to the total area of each heating element being 5% to 25%.
9. The heating assembly of claim 8, wherein the plurality of heating elements are arranged to emit the radiation with a radiative flux of 3,000 to 5,000 Watts/sq.cm at a distance of 10 cm and/or for a period of time of at least 50 seconds to 5 minutes.
10. The heating assembly of claim 8, wherein the heating element is configured in a housing of a food cooking device and to emit the radiation to a cooking cavity of the food cooking device suitable heat a food item in the cooking cavity.
11. The heating assembly of claim 8, wherein the visible light has a luminous flux of at least 100 lumens.
12. A cooking device comprising: a housing defining an interior area including a cooking space; and an electrical resistance heating element including a plurality of heating elements located in the housing and associated with the cooking space, each heating element having a first and second terminal ends and electrically conductive portions between the first and second terminal ends, the electrically conductive portions defining a sheet with a plurality of openings and first and second opposed faces, the plurality of heating elements being arranged with first faces oriented toward the cooking space and each of the heating elements having a radiating area arranged to emit radiation in a wavelength range of 0.75 to 10 microns along with visible light in a wavelength range of 570

to 800 nanometers toward the cooking space, and wherein a ratio of a total radiating area of the plurality of heating elements to an area of the cooking space receiving the radiation is 1% to 20%.

13. The cooking device of claim 12, wherein the sheet of each heating element has a total area, and a ratio of the radiating area of each heating element to the total area of the heating element is 5% to 25%.

14. The cooking device of claim 13, wherein a ratio of a sum of the total areas of the heating elements to the area of the cooking space is 15% to 70%.

15. The cooking device of claim 12, wherein each heating element has a radiating area of 0.5 sq.cm to 3.5 sq.cm.

16. The cooking device of claim 12, wherein the plurality of heating elements are arranged to emit the radiation with a radiative flux of 3,000 to 5,000 Watts/sq.cm and/or for a period of time of at least 50 seconds to 5 minutes seconds.

17. The cooking device of claim 12, wherein the visible light has a luminous flux of at least 100 lumens.

18. The cooking device of claim 12, wherein the plurality of heating elements are attached to a reflector such that the second faces of each of the plurality of heating elements are oriented toward the reflector, and wherein the reflector has a surface that spans across the second faces of the plurality of heating elements.

19. The cooking device of claim 18, wherein each of the heating elements is arranged to have an elongated rectangular shape having a length and a width, and the plurality of heating elements are arranged on the reflector so that the lengths of the plurality of heating elements extend in a same direction.

20. The heating assembly of claim 8, wherein the ratio of the radiating area to the total area of each heating element is 5% to 10%.

21. The cooking device of claim 12, wherein the ratio of the total radiating area of the plurality of heating elements to the area of the cooking space receiving the radiation is 1% to 10%.
