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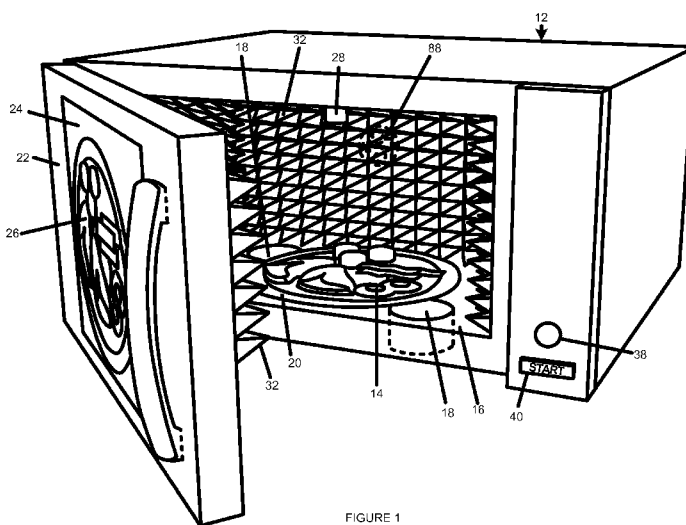


FIGURE 1

(57) Abstract: A selective heating device may comprise a chamber configured to contain a target to be at least partially heated, at least one heating element, and a controller. The at least one heating element may be configured to selectively heat a first portion of the target at a first energy level for a first period of time. The at least one heating element may also be configured to selectively heat a second portion of the target at a second energy level for a second period of time, wherein the second energy level and/or the second period of time are different from the first energy level and/or the first period of time; or refrain from heating a third portion of the target; or a combination thereof. The controller may be configured to receive a heating instruction and control the at least one heating element based on the heating instruction.

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## **System, Method, and Process for selective heating of materials in an electromagnetic oven**

### **CROSS REFERENCE TO RELATED APPLICATION**

This application is based on and derives the benefit of the filing date of U.S. Provisional Patent Application NO. 62/013,954, filed June 18, 2014, which is incorporated by reference in its entirety herein.

### **BACKGROUND**

Currently, conventional electromagnetic ovens, such as microwave ovens, bombard food placed in a cavity with electromagnetic energy that causes food to heat through the process of dielectric heating. For example, conventional microwave ovens use a magnetron to emit electromagnetic waves in a cavity. This creates standing waves inside the cavity that heat all food items within the cavity. Conventional infrared ovens use high frequency radiation to heat foods inside a space. Similarly, these ovens heat all food items within the cavity.

In microwave ovens, the standing wave pattern forms areas of high and low energy concentrations, thus creating non-uniform heating of foods or materials inside the conventional microwave ovens. Conventional microwave ovens attempt to mitigate uneven distribution through the use of a variety of methods, such as motorized rotating dishes or microwave stirrers that randomize the standing waves patterns.

**BRIEF DESCRIPTION OF THE DRAWINGS**

**FIG. 1** is a perspective view of a selective heating electromagnetic oven according to an embodiment of the disclosed systems and methods.

**FIG. 2** is a front view of a selective heating oven control panel according to an embodiment of the disclosed systems and methods.

**FIG. 3** is a perspective view of a selective infra-red heating based oven according to an embodiment of the disclosed systems and methods.

**FIG. 4** is a top down view of the inside of an oven cavity oven according to an embodiment of the disclosed systems and methods.

**FIG. 5** is a block diagram of an oven control circuit according to an embodiment of the disclosed systems and methods.

**FIG. 6** is a selective heating process according to an embodiment of the disclosed systems and methods.

**FIG. 7** is a portion of a selective heating oven control panel according to an embodiment of the disclosed systems and methods.

**FIG. 8** is a calorie determination process according to an embodiment of the disclosed systems and methods.

**FIG. 9** is a perspective view of a selective heating phase array-antenna microwave oven according to an embodiment of the disclosed systems and methods.

**FIG. 10** is a portion of a selective heating oven control panel according to an embodiment of the disclosed systems and methods.

**DETAILED DESCRIPTION OF SEVERAL EMBODIMENTS**

Previously cooked foods, leftovers, and frozen meals may contain several different foods or dishes, often on the same plate or in the same container. A user may wish to heat all of the foods or may prefer to only heat some of the foods, while leaving other foods unheated. Additionally, a user may wish to heat some foods more than others.

For example, a user may have a salad and potatoes on the same dish. In this instance, the user may wish to only heat the potatoes, and not the salad. The methods and systems described herein may enable selecting and directing energy to only specific areas within the cavity of an oven, thus allowing a user to selectively heat specific areas of a food item(s). Not only may a user save time and be provided more convenience through increased functionality and control, a user may also choose to heat different food items within the cavity of an oven to different temperatures without having to segregate food items or have the oven run multiple heat cycles. In addition, methods and systems described herein may prevent or reduce non-uniform heating by controlling where the heat is applied to the selected food items.

Using the methods and systems described herein, a frozen food item may be transformed into an entire meal that emerges from an oven that may include a salad or fruit medley served cold on the same tray as a meat-loaf that is steaming hot. Using the methods and systems described herein, a user may be able to place a dish containing fries and ketchup into an oven and only heat the fries and while leaving the ketchup untouched. Using the methods and systems described herein, a chef may be able to prepare multiple meals simultaneously within a single oven space although each meal has different temperature and time requirements. In

addition, instead of having to separate food into several containers or dishes and having to wait between each heating cycle, a user may be able to simultaneously place all the food on one container and selectively heat each item, thus reducing the amount of dishware and silverware needed, resulting in time, water, and energy savings.

The systems and methods described herein may perform selective heating of foods using electromagnetic energy. The term electromagnetic energy, as used herein, includes any or all portions of the electromagnetic spectrum, including, but not limited to, radio frequency (RF), infrared (IR), near infrared, visible light, ultraviolet, etc. In some cases, applied electromagnetic energy may include RF energy having wavelengths within a range of about 100 km to 1 mm, which corresponds to a frequency range of about 3 KHz to 300 GHz. In some cases, RF energy within a narrower frequency range, e.g., 1 MHz-100 GHz, may be applied. Applying energy in the RF portion of the electromagnetic spectrum is referred herein as applying RF energy. Microwave and ultra high frequency (UHF) energy, for example, are both within the RF range. In some other examples, the applied electromagnetic energy may fall only within one or more ISM frequency bands, for example, between 433.05 and 434.79 MHz, between 902 and 928 MHz, between 2400 and 2500 MHz, and/or between 5725 and 5875 MHz. Even though example embodiments are described herein in connection with the application of RF energy, these descriptions are provided as examples only, and are not intended to limit the scope of the described systems and methods to any particular portion of the electromagnetic spectrum.

In addition, the methods and systems described herein may include a machine readable code, or sticker, that could be attached to a food tray. The

sticker may contain information about the locations and temperatures to be heated. A smart oven may automatically read the code and heat the food per the specified heat map. Thus, dinner food manufactures may have more advanced control over how their food is heated, users may have a fully one-button automatic heating solution.

Furthermore, the methods and systems described herein may go beyond the kitchen and food space to include other industrial and commercial applications such as materials manufacturing.

Disclosed herein are systems and methods for allowing a user to selectively heat different food items or different areas of a food item to different temperatures inside an electromagnetic oven without having to go through several iterations of removing and placing food inside the oven. An electromagnetic oven may be configured to allow a user to heat food items or different areas of a food item to different temperatures in one operation. The oven may include a user interface and camera mounted inside the oven cavity that allow a user to select food items or areas of food items to be heated on a touch-screen display. The oven may include a system that captures the user's selections and utilizes the captured data to control a heating system capable of directing electromagnetic energy to any area of the food. Selectively directing the energy to certain areas may allow the heating system to only heat the selected areas. In addition, the systems and methods described herein may include a method for allowing food manufacturers to create and store heat maps on a printable sticker or other label that can later be read by the oven and used to heat the food.

Moreover, since food items may be placed in a space with a camera, controlled lighting, controlled cavity geometry, and a user interface that allows users to select and identify foods, the system may be utilized to determine calories of the food items. The oven of the systems and methods described herein may have a camera, a controlled lighting condition, and a user interface that allows users to select an area of food. The oven may also have a weight scale to measure to total weight of the food items being placed. Using the area of the user's selection, the total weight of the plate, and an average estimate of food height, the volume of the food may be calculated. The oven may allow the user to enter the food type via the interface, and the oven may return the calorie count. This data can be obtained from a database stored within the oven's memory or from an online database through an internet capable oven. Alternatively, the food identification and calorie data may be stored on the ID sticker discussed herein. Or, the oven may use currently available image food recognition methods and improve their accuracy by providing a controlled food image capture with controlled lighting and image setup. The design of the oven cavity and electromagnetic emitters or applicators may be dependent on the frequency of operation used. Food can be heated through several frequency ranges in the electromagnetic spectrum, ranging from low radio frequency heating in the tens of KHz to the hundreds of GHz range, all the way to the higher end the frequency spectrum in the Infra-Red THz range, for example. Different frequency ranges may result in different food heating outcomes, with the lower frequencies penetrating the food more, and the higher frequencies causing more surface based heating. This is primarily due to the dielectric properties of foods at different temperatures and frequencies. In addition, cooking times and food taste

may be altered based on the frequency of operation selected. For example, an oven operating in a very high frequency mode of operation in the infra-red range may only heat the surface of foods. The remaining volume of food is then heated through conduction of heat from the surface to the inner volume. Accordingly, high frequency cooking may produce more of a browning or crisping effect, but as heat conduction within foods is relatively slow, it may also result in increased heating time. This is similar to what happens in a convection based oven. On the other hand, an oven operating in the microwave frequency range may provide energy that is better able to penetrate foods. As such, the food volume may be heated much faster, but the crisping or browning effect is not produced. Thus, although a single frequency, or range of frequencies, may suffice to produce heating and a complete system, such as in the case of conventional microwave ovens, multiple methods or frequencies could be combined into a single system to produce various heating outcomes.

In one example embodiment, a number of RF electromagnetic applicators may be placed in specific stationary locations on the bottom floor of the oven. These applicators may create electromagnetic fields in their near vicinity and hence only heat food areas exposed to their near proximity. The applicators may be powered by a power source. The foods may be rotated on a plate, and the individual applicators' amplitudes may be increased (to heat) and decreased (not to heat) as the designated food areas to be heated move within proximity of the respective applicators. As such, different areas of the foods on the plate may be heated accordingly. The design and size of the applicators may define the heating area or "hot spot" of each applicator. The hot spot may also define the lowest heating resolution of the device. In addition, the physical size of the applicators

may limit the number of hot spots the oven can have within the cavity space. As such, the food may be placed on stage that could be shifted in the X or Y axis directions in addition to being rotated to ensure full coverage of all areas of the plate to be heated.

To control which areas to heat, an input device such as an LCD touch screen, for example, may display a live image taken by a camera mounted inside the oven facing the food. The user may select which food items to heat by drawing circles or shapes around the food they desire to be heated on the LCD screen. Using software and an embedded microcontroller, the shapes or areas selected by the user may be converted into timing and control signals that control power to the electromagnetic applicators inside the oven.

In another example embodiment, a number of infrared heaters may be placed within the oven cavity. The infrared heaters may be configured to be highly directional and thus create a focused a beam of infrared energy on a specific hot spot. These infrared heaters may be placed on the ceiling of the oven pointing downwards at the food plates. An array of infrared heaters may be placed such that each heater targets a specific small area to be heated. The hot spot formed on the food by the heaters may be configured such that it forms the focal point of a spherical cap reflector. As such, any electromagnetic reflections off of the food will be reflected back towards the hot spot, preventing other unintended areas of the food to be heated. The infrared heaters may be powered by a power source. The foods may be rotated on a plate, and the individual infrared heaters may switched on (to heat) and off (not to heat) as the designated food areas to be heated move within proximity of the respective applicators. The food plate may also shift in the X and Y direction to ensure all

areas of the plate to be heated are reachable. As such, different areas of the foods on the plate may be heated differently.

In another example embodiment, an antenna producing a highly directional focused beam of RF energy may be placed within the oven. The antenna may be a phased array antenna such that the focused beam produced may be steered in the desired direction to target a specific area of the food. The antenna may be mounted on the ceiling of the oven cavity such that the formed electromagnetic beam is aimed downwards at the food. In this example, the food may be stationary, as the RF beam direction may be controlled to reach all areas of the food. The cavity of the oven may also include a system of absorbers and reflectors to insure that any electromagnetic energy reflected off the food or other items in the oven does not get transmitted to other unintended areas of the food. In addition, the absorbers may be configured to absorb any electromagnetic energy produced by side lobe energy fields produced by the antennas (i.e., energy that is not part of the focused beam).

**FIG. 1** is a perspective view of a selective heating electromagnetic oven or other heating system according to an embodiment of the disclosed systems and methods. The heating system **12** may be configured for enabling a user to selectively heat food items **14**, or other materials, within a microwave oven cavity **16**. The system **12** may include stationary open ended RF applicators **18** that are placed underneath a rotating plate **20**, or any other high power low frequency electromagnetic applicators capable of generating fields that couple with materials only in close proximity to each applicator. The RF applicators may heat the food when fringing fields interact with the food, thereby producing heat. The user may interact with the system **12** through an interface **22**. Interface **22**

may include an LCD touch screen **24** that displays an image **26** of the food items **14** inside the cavity **16** of the system **12**, for example. The image **26** of the food items **14** that are inside the cavity **16** of the system **12** may be captured using a camera **28** located inside the system **12** or other device that may be used to measure and display to the user a graphical representation of the materials inside the system **12**. The food may be placed on a rotating platter **20**. As the platter rotates, the food items **14** may pass over the RF applicators **18**. To control which areas of the food **14** are heated, the RF applicators **18** may be switched on or off as the designated food items to be heated pass within each respective RF applicator **18** electromagnetic field. An embedded microcontroller (not shown) may capture the user's area selection **42** from the interface **22**. The controller may convert the user's heat drawing and time selections into a series of on/off sequences to the power sources (not shown) powering each individual RF applicator **18**. The timing sequence of on/off commands may correspond to the time at which a designed area to be heated moves within a respective RF applicator's electromagnetic field. For example, **FIG. 4** (described below) explains how this control may be accomplished in some embodiments

Conventional microwave ovens use the reflective inner walls of an oven cavity to create standing wave patterns at the cavity's resonant frequency. This is accomplished through specific tuning of the design and dimensions of the cavity. However, standing wave patterns may result in energy bouncing off the walls and striking areas of the food **14** that the user does not desire to be heated. As such, the cavity **16** may be lined with microwave absorbent materials **32** that create an anechoic chamber. When the RF applicators **18** generate electromagnetic radiation energy, most of it may be coupled with a particular

area of the food item **14**, causing it to heat, yet some radiation energy may escape into the cavity. As such, the wall lining and design of the interior cavity **16** may prevent the reflection of radiation energy off of the inside walls of the cavity **16**. The radiation energy may be prevented from bouncing back and heating other unintended areas of the food items **14** inside the cavity **16** by the high absorbency of the microwave absorbent materials **32** on the inner walls. Additionally, this feature may simplify the design of the oven cavity. The cavity's size need not conform to specific dimensions that achieve resonance at specific frequencies. Instead, the oven cavity may be designed to any shapes or dimensions. In order to further reduce and/or prevent inadvertent or incorrect heating of areas of the food **14** that are not to be heated, an exhaust fan **88** may be included to draw hot air from inside the cavity **16** to the outside of the cavity **16**. Air in the cavity **16** may be heated through contact with the heated food **14** and, unless removed from the cavity **16**, may heat colder areas of the food **14** through convection. Thus, the fan **88** may operate continuously during a heating operation, or after ambient temperature in the cavity **16** reaches some predetermined level, to draw hot air away from the food **14**.

**FIG. 3** is a perspective view of a selective infra-red heating based oven according to an embodiment of the disclosed systems and methods. This embodiment offers similar selective heating functionalities to other embodiments, however the heating is accomplished via infrared heating. This is a very high frequency method of heating that may result in more of a surface type heating of the food. This embodiment may include stationary highly directional beam infrared emitters **52** that are mounted on the ceiling of the oven cavity **16**. The infrared heaters may emit a narrow beam that only heats a

small area directly below the emitter. This area is called the hot spot. For example, the hot spot could be an inch in diameter or some other dimension. The hot spot size may determine the smallest heating area resolution. In addition, the infrared source may be one that has a fast heating response time, as described later. An infra-red spherical cap reflector **50** may be mounted on the ceiling. The spherical cap reflector **50** may be positioned such that the center of the imaginary sphere created by the cap may be where the hot spot is centered. In other words, the focal point of the reflector **50** may be where the infrared hot spot is created on the food below the infra-red emitter **52**. The spherical cap reflector **50** may be used to capture a portion of the electromagnetic energy that inadvertently reflects off the plate or shiny surfaces of food and reflect it back onto the hot spot. Otherwise, the energy would reflect back out into the cavity and dissipate into unintended food areas. Thus, the reflector **50** may improve the efficiency of the oven and the accuracy of the selective heating process. The user may interact with the system **12** through an interface **22** that may include an interface such as an LCD touch screen **24** that may display an image **26** of the food items **14** inside the cavity **16** of the system **12**. The image **26** of the food items **14** that are inside the cavity **16** of the system **12** may be captured using a camera **28** located inside the system **12** or other device that may be used to measure and display to the user a graphical representation of the materials inside the system **12**. The camera may be placed inside an electromagnetic shield structure to protect its circuitry from the electromagnetic radiation. The food may be placed on a rotating platter **20**. As the platter rotates, the food items **14** may pass below the infra-red emitters **52**. To control which areas of the food **14** are heated, the infrared emitters **52** may be switched on or off as the designated

food items to be heated pass below the hot spot. The infra-red emitters **52** may have a fast turn on time or low time to heat. This may reduce the overall heating time of the dish. An embedded microcontroller (not shown) may capture the user's area selection **42** from the interface **22**. The controller may convert the user's heat drawing and time selections into a series of on/off control signals to the power sources (not shown) powering each individual infrared emitter **52**. The timing sequence of on/off commands may correspond to the time at which a designed area to be heated moves within an infrared emitter's hot spot, as discussed below with respect to **FIG. 4**, for example. Although it is not shown, this embodiment may include a fan to draw hot air away from the food **14**, like the embodiment of **FIG. 1**.

**FIG. 9** is a perspective view of a selective phase array antenna microwave oven according to an embodiment of the disclosed systems and methods. The oven of **FIG. 9** is similar to the oven of **FIG. 1** described above, and certain details (e.g., camera **28**, display **24**, controls **38**, **40**, etc.) are omitted in the drawing, but may be present in the oven. For example, this embodiment may include a fan to draw hot air away from the food **14**, like the embodiment of **FIG. 1**. Also, instead of using the heating elements **18** of **FIG. 1**, the embodiment of **FIG. 9** may include one or more phase array antennas **82**. The phase array **82** may provide two or more focused beams that may be steered in the desired direction to target a specific area of the food **14**. The antenna may be mounted on the ceiling of the oven cavity such that the formed electromagnetic beam is aimed downwards at the food, as shown. There may be many possible locations to position the antenna. For example, the antenna may be placed on the top wall, the sidewalls, or placed as an array of antennas in multiple locations within the cooking cavity

**16.** In this example, the food may be stationary, as the RF beam direction may be controlled to reach all areas of the food. The antenna may produce a narrow beam of electromagnetic radiation creating a focused hot spot on the food items. Thus, unlike in **FIG. 1**, this embodiment may omit the rotating platter **20**. The cavity of the oven may also include a microwave absorbent materials **32** to insure that any electromagnetic energy reflected off the food or other items in the oven does not get transmitted to other unintended areas of the food. Another example may include several phase array antennas or other types of antennas able to direct and heat multiple spots simultaneously or non-simultaneously. For example, while an array **82** is shown in this example, an electromagnetic energy-emitting device may be configured to include an antenna, magnetron, waveguide, etc. or any other electromagnetic radiation producing or electromagnetic wave guiding device or combination of devices that may produce a directed radiation pattern. This focused energy-emitting device may be located inside the cavity **16** of the system and may direct radiation energy to a particular food item **14** or area within the cavity.

**FIG. 4** is a top down view of the inside of an oven cavity oven according to an embodiment of the disclosed systems and methods. The figure illustrates an example of how the heating devices **50** and **56** may be positioned inside the cavity in such an arrangement as to be able to reach all areas of the food dish. One constraint in the design of the heating device is the physical size and shape of the device. For some device sizes and/or shapes, it may not be possible to place enough stationary heating devices within a standard consumer appliance size cavity to target all possible areas of the dish. The heating devices, which may be any type, may occupy some space **50** and **56** but produce a hot spot of

size **52** and **58**. The plate (not shown) has food items **70** and **72**. A servo or stepper motor **62** may be provided at the center of the device to rotate the plate. Hot spot **52** can reach, and therefore heat, areas of the plate depicted by the circular track **54**. Similarly, hot spot **58** can reach, and therefore heat, areas of the plate depicted by the circular track **55**. However, as intentionally shown in this example, track **64** cannot be reached by any hot spots. This could be the case when the heating devices are too large to fit close to each other or as a design choice to restrict the total number of heating devices. To resolve this, the plate may be placed on a Y-stage, which may shift the plate by one track width in the Y direction. This may be accomplished using another servomotor **66** connected to the center pivot of the servomotor **62** via a geared rod **68**. By controlling the rotation of servomotor **66**, the entire food plate will shift in the +-Y direction (up/down in the figure) For example, if the plate shifts by one track width in the downward, -Y, direction, track **64** can now be heated by hotspot **58**. Using this method, all areas of the plate can be reached by at least one of the heaters. In some embodiments, second servomotors **66** may be connected to one or more of the heating devices instead of the servomotor **62**. In this case, the heating devices themselves may be shifted, rather than the plate. So, as the plate rotates in the counter clockwise direction, the food items **70** and **72** will approach the hotspots **52** and **58**. Assuming food item **70** is the item the user wants to heat, and food item **72** is the one the user does not want to heat, then as food item **70** passes over a hot spot **52** or **58**, heating devices **50** and **56** will turn on. Similarly, the heating devices **50** and **56** will switch off when food item **72** passes above them.

As discussed with respect to **FIG. 2** below, some embodiments may allow a user to select the items they desire to heat by drawing an outline around the food item or area within the oven. A microcontroller then may close the loop created by the outline and fill in the entire shape. The resulting shape may be made of cells or pixels that represent the finest resolution for heat control. Each pixel may have a polar coordinate made up of an angle and a distance from the center, or a radius. Each hotspot may have fixed polar coordinates. As the motor **62** rotates the dish, the shape's angle may be updated, but the distance parameter may be fixed. At every step in the rotation for which the angle is updated, the processor may compare the new coordinates of the shape's pixels with those of the hot spots. If a pixel coordinate matches that of the hotspot, that hotspot may be turned on until no more pixel coordinates match the hotspot's coordinates. For example, for the sake of simplicity of the discussion, assume the pixel size is very large. In this case, as large as food item **72**. If the user highlights item **72**, the assigned heating pixel will be Angle 300 degrees, Radius 10 cm. The angle is measured from the 3 o'clock position going counterclockwise in **FIG. 4**. Thus, heater **52** is at a coordinate of Angle 30 and Radius 10 cm. As the plate rotates, the angle of food item **72** slowly approaches angle 0 as it approaches the 3 o'clock position, then starts increasing as it passes the 3 o'clock position. After some time, the food item **72** will be at Angle 30 and Radius 10 which is the coordinate of the heater. Thus, the processor may turn on the heater and, using a similar logic, turn off the heater when the food item passes. The processor may know the angle of the plate as it may be repeatedly communicated by the servo motor **62** and/or a servo motor **62** controller (not shown). The following algorithm represents a simplified method for controlling the heaters. However,

in some embodiments further optimization may be done, such as controlling rotation speed and direction, compensating for heater turn on/off times, and/or adjusting the shape's dimensions to adjust for shape edges.

The heating region may be small enough to allow for the heating of specific areas of food items, but not so small as to require considerable additional time to heat the entire food item. The frequency, intensity, and amplitude of the electromagnetic radiation energy may be configured in a manner that is most optimal for the cavity design to produce a desired directed pattern and also within a range to produce dielectric heating of food items **14**.

There may be various methods and techniques to control where the energy is to be directed. For example, some embodiments of the system **12** may include a phase array antenna **82** that may steer the radiation beam to heat any area of the food items. Such a design may not require a moving platter, as the actual direction of the beam is altered and thus able to heat any area of the food item.

In some embodiments, the microwave source may be configured to maintain a constant radiation pattern, and the antenna **82** may be mounted upon an actuated mechanical platform that directs the antenna **82** in a desired direction.

Some embodiments may utilize a combination of the above methods to allow a user to direct radiation energy to only the food items or areas of a food item selected for heating.

Some embodiments of the system may allow a user to select which food items or areas of a food item will be heated, as well as what heat intensity to apply to the food item or area of a food item. **FIG. 2** illustrates a front view of an

example of a selective heating oven control panel **30** that may be located on the system and accessible by a user. The user may use handle **48** to open the door and place the food items in the cavity. The front panel **30** may include a touch screen display **24**, a knob **38** for adjusting the heating time or temperature, and a start button **40**. The touch screen display **24** may display an image **26** of a food item **14** and any other contents contained inside the cavity **16** of the system **12** and captured by the camera **28**.

A user may select the area to be heated by highlighting that area with their finger on the touch screen display **24**. The highlighted area, called the selected area **42**, corresponds to a physical area inside the cavity **16**. A user may use the knob **38** to adjust the amount of time **44** that a user desires for the selected area **42** to be heated.

A user may repeat this process for other food items **14** or areas of a food item **14**. Thus, different areas of a food item **14** can be heated for different periods of time, or temperatures, based on the desired selection of a user. The touch screen display **24** may display to a user the selected area time **44** and the total time **48** for all the food items **14** to be heated completely, based on the desired selection entered by a user. A user may then press the start button **40** in order to direct the system to begin heating the food items based on the user-specified configurations.

The system may be configured to utilize a variety of methods to enable a user to select food items **14** or areas of a food item **14** that are displayed on the image **26** of the touch screen display **24**. In one example embodiment, a user may select the area within the cavity of the system that is to be heated by the user coloring in or highlighting a food item or area of a food item displayed on a

screen of a user interface by the user pressing a finger or a pointing device to trace a desired heating area. The amount of heat applied by the system to the various areas may also be determined by the intensity of coloring applied by a user.

For example, a user may shade in a region by pressing their finger or a pointing device on a screen on the user interface that displays an image of the food items and other contents contained within the cavity of the system. A food item that is viewed on the screen of the user interface, for example, may transform from light red to dark red to indicate that a food item or area of a food item has been selected, and/or also to display the intensity that a user selected for a food item or area of a food item that a user desires to be heated and selects through the user interface. The darker the color the more radiation exposure time or radiation energy is applied to that area and thus more heat is to be generated at that area.

In another example embodiment, a user may draw a closed loop on a screen on a user interface using their finger to trace around a food item **14** displayed on the screen, in order for the user to indicate which food item(s) or areas of a food item to be heated. Once a user traces a closed figure around a food item(s) or area of a food item, the system **12** may identify the closed figure as an area to be heated and may display the registration of this selection on the screen, possibly by shading the enclosed area selected with another color, to the user. A user may then adjust the knob **38** to input a desired amount of time to heat the selected area. A user may draw as many areas as the user desires.

A user may select previously drawn areas by tapping on the area identifying the particular drawn area with their finger or pointing device in

order to adjust the time settings for the particular drawn area or to otherwise modify or delete the drawn area before the user directs the system to begin heating process. Once a user has selected the drawn areas, and selected the respective heating time and intensity settings, the user may press the start button **40** to begin the heating process. Data for the colored area and intensity may be captured by a processor unit inside the system **12** which may convert coordinates of the drawn region into data for directing the heating processes available to the system, as described herein.

Generally, operation of the system **12** may proceed as shown in **FIG. 6**. A user may place food inside the oven **202**, and the image of the food taken by the camera may be displayed on the display screen **204**. The user may choose to heat the entire plate or may choose selective heating mode **206**. If the entire plate is to be heated, the user may enter a heating time, power, and/or other settings and press start **208**. The system **12** controller may turn on all heating elements for the specified time **210**. When the time is elapsed, the heating operation may end **220**. If the user chooses selective heating mode **206**, the user may select heat areas and, in some cases, specify time and/or power for each area **212**. The user may start the heating cycle **214**. The controller may receive the user input and start the heating operation **216**. The controller may turn on specific heating elements at specific times as required by the user input heating areas **218**. When all areas are heated as desired, the heating operation may end **220**.

As noted above, the system **12** may also provide calorie estimates for food inside the chamber. **FIG. 7** illustrates a portion of a selective heating oven control panel according to an embodiment of the disclosed systems and methods,

wherein calorie estimating features are included. As in **FIG. 2**, the touch screen display **24** may display an image **26** of the contents contained inside the cavity **16** of the system **12** captured by the camera **28**. The user may input a selected area **42** corresponding to a physical area inside the cavity. The oven may also have a weight scale to measure to total weight of the food items being placed. Using the area of the user's selection, the total weight of the plate, and an average estimate of food height, the volume of the food may be calculated. The touch screen display **24** may include a food type menu **80** or other input interface allowing the user to enter the type of food that is highlighted. Based on the selected food type (e.g., broccoli in the illustrated example), the estimated food volume, and stored calorie data (available in device **12** memory or via the internet), the oven may return the calorie count. Because lighting conditions, camera angle and settings, motion, and other variables may be stable and/or easily controllable within the cavity **16**, the nutritional estimates provided by the oven may be consistent and repeatable.

**FIG. 8** is a calorie determination process according to an embodiment of the disclosed systems and methods. A user may place food inside the oven **802**, and the image of the food taken by the camera may be displayed on the display screen **804**. The user may select a portion of the food on the plate to be measured, for example by drawing an outline around it as described above **806**. The user may specify the type of food that has been selected, for example via menu **80** as described above **808**. The system **12** controller may capture the user inputted area and weight data from a weight sensor arranged to weigh the food inside the oven **810**. The system **12** controller may use the area, the total weight, and food type to estimate the volume of the food to be measured **812**. The

system **12** controller may access an internal database and/or a remote database (e.g., via the internet) to find nutritional information for the food type and estimated food volume **814**. The system **12** controller may use the touch screen display **24** to display nutritional information for the selected food **816**.

Since the oven may be able to selectively heat different areas of a food plate to different temperatures, it may be agreeable to allow manufacturers of dinner foods, microwavable foods, etc. to store information in the form of a QR Code or RFID tag regarding the heat regions and temperatures of the food dish. For example, a vendor may sell a frozen food tray of steak and salad. The vendor may attach a QR sticker to the packaging of the tray. When the tray is inserted into the oven, the camera **28** may detect and read the information off the QR sticker. The information may include a heat map for the dish. In addition, the QR code's orientation may be captured. As such, the oven may now have information on how to heat the dish exactly as the vendor recommends without requiring the user to input any more data. The user may be prompted hit the start button to begin the heating operation. The heating information stored in the sticker may be normalized to power levels and starting temperature of the food items in some embodiments. As such, the correct amount of power may always be delivered to the food items independent of the power level of the receiving oven and/or the initial starting temperature of the food. In other words, a low power oven may heat items longer than a high power oven to achieve the desired heat levels. Moreover, food that is heated starting from a cold temperature (e.g., from a fridge) may be heated using more power than food starting from room temperature.

Storage of data on a QR code, or a machine readable printed sticker, may be limited to several kilobytes of data. To enable storage of the heat map data, the information may be placed in a compressed format, such as a vector format. In the vector format method, each shape may be represented via a set of points. Each point's coordinates may be stored in a data file. When the system processor (e.g., microcontroller **104**, described below) receives the data, it may be able to rebuild the shape. For example, assume the following vector text stored on the QR code: "S 0,0 5,0 5,5 0,5 h25" This code represents a square shape starting at coordinates 0-0 and having corners at the other 3 coordinates. The heat level may be denoted by the "h25" (i.e., a heat level of 25). As shown, using 21 characters of space and consuming roughly 21 bytes, one may represent a square shaped heat region and its power level. The data size may be further reduced through data compression. The same methodology can be applied to incorporate complex shapes, denoted by points, and thus various heat maps. After the shapes are obtained, the orientation of the QR may be used to rotate the heat map image to match the food. This method is similar to the open standard Scalable Vector Graphics (SVG) specification developed by the World Wide Web Consortium (W3C). However, an SVG format file may have a larger file size than the example file, and SVG does not include orientation data. As such, although the QR code can only fit a small footprint of data, through efficient encoding techniques, the QR code may convey detailed heat map information to the oven. Vendors (e.g., vendors of frozen or reheatable meals) may create and store heat map data onto printable media that can be consumed by the oven's microprocessor through a camera.

In another example, heat map data may be obtained from stored heat map data on an online database. The camera inside the microwave oven may scan the QR code, or other identification codes, on the packaging. The internet connected oven may look up the QR code in an online database including heat maps and download the heat map data. For example, the QR code may be linked to a specific heat map in the database. The oven may use the orientation of the QR code to orient the downloaded heat map as described above. Then, the oven may heat the food per the vendor's specification. This selective heating capability coupled with the heat map sticker may allow manufactures to create a wide array of auto heating food combinations for use with the described ovens.

**FIG. 10** is a portion of a selective heating oven control panel according to an embodiment of the disclosed systems and methods. As described above, the device **12** may use the camera **28** to read a QR code **84** for heating instructions and determine food orientation based on the orientation of the QR code **84**. The touch screen display **24** may display an image of the QR code **84** and/or an image **86** of the orientation of the food inside the cavity **16** of the system **12** captured by the camera **28**. In some embodiments, cook time and power data as determined by the QR code may also be displayed. The oven may allow the user to confirm the information and/or to initiate the cooking process.

**FIG. 5** is a block diagram of an oven control circuit **100** according to an embodiment of the disclosed systems and methods. The circuit **100** may control the system to perform the functions described above. The circuit **100** may be powered by power supply **102**, which may be configured to supply power from a home AC circuit, a battery, or any other source. The circuit **100** may include a microcontroller **104**, which may be any kind of processor capable of interacting

with and/or controlling the other circuit **100** components. As discussed above, the microcontroller **104** may receive image data from a camera **108** and display the image on the touch screen interface **106**. Via the interface **106**, a user may enter heating instructions. The microcontroller **104** may use these instructions to selectively control amplifiers **110** to control amplitude and phase of the signals to the heating elements (EM emitters **112**) as described above. The microcontroller **104** may also control servomotor **114** to move the rotating plate **116** on which the food is placed as well as receive food location data based on the position of the servomotor **114**, as described above.

Examples of additional embodiments may allow a user to integrate the system **12** with other devices of the user or another user, including communication devices (e.g., smart phones, tablets, computers, etc.), to allow for increased functionality and ease of use, as well as the ability to share the contents or access rights to the system with another user. For example, using WiFi or Bluetooth protocols, the system may communicate with an application installed on the user's handheld smart phone and may display an image of the food inside the cavity on their smart phone. The camera **28** inside the oven may capture an image of the food that may be read by the microcontroller **104**. The microcontroller **104** may be configured to interface with a wireless module, such a Wifi module, which may be added to the circuit of **FIG. 5**, for example. Through the wireless module, the microcontroller **104** may communicate with an application installed on the user's smartphone. The application may display the image captured by the oven camera on screen. The user may then use his fingers to select the heating regions and heat settings and send this data back to the microcontroller **104** to start the oven heating operation. The data may get

transmitted back to the oven so the heating operation may begin. Upon completion of the heating cycle, the microcontroller **104** may transmit a message to the user that may serve as a notification that the food is ready. In addition, the smart phone application may notify the user when important events occur such as the food being left, or forgotten, in the oven for longer than some predetermined length of time. In another example, the microcontroller **104** may transmit calorie related information to a user's smartphone device. After completing the calorie tracking process described previously, the microcontroller **104** may send the resulting calorie calculation and nutritional value of food to the user's smartphone. In addition, the microcontroller **104** may also transmit an image captured of the food. As such, the user may now have a log of all food items and their nutritional information stored in a log on their smartphone device. This may be beneficial for users who keep track of their caloric intake or for users on a health management diet.

Additional example embodiments may include adjustments to the delivery method and intensity of heat that the system may apply to a food item. Additional example embodiments may include adjustments in the inside wall patterns of the anechoic chamber in order for the system **12** to specifically heat other items, including chemicals that require specific heating requirements or to accommodate for alternative heating patterns and wave patterns for heating particular items with specific heating requirements.

Additional example embodiments may include a variety of shapes and forms with respect to the exterior design and dimensions of the system. For example, a system **12** could be configured in an egg-like or circular shape. A system **12** may also be configured to be small enough for a user to have a

personal or travel-size microwave-oven, including specific embodiments designed for installation inside of a recreational vehicle or other vehicles where a user may also desire a system **12** for the specific heating of food items.

An additional example embodiment may be adapted for the heating of lunch trays specifically tailored for commercial cafeterias and/or restaurants or other places where food may be served. For example, a system **12** may be configured to accommodate lunch trays that may hold already-prepared trays of food that simply require heating to be ready to serve. A user, possibly a chef or restaurant employee, may use the system to selectively heat a food item that may require heating, while omitting a food item that does not require heating, like a salad or a fresh fruit medley.

In some embodiments trays, packaged food items **14**, and other similar devices may be specifically designed for the system **12** and may also allow a user to selectively heat a food item **14** or area within a food item **14**.

While various embodiments have been described above, it should be understood that they have been presented by way of example and not limitation. It will be apparent to persons skilled in the relevant art(s) that various changes in form and detail can be made therein without departing from the spirit and scope. In fact, after reading the above description, it will be apparent to one skilled in the relevant art(s) how to implement alternative embodiments.

In addition, it should be understood that any figures that highlight the functionality and advantages are presented for example purposes only. The disclosed methodology and system are each sufficiently flexible and configurable such that they may be utilized in ways other than that shown.

Although the term “at least one” may often be used in the specification, claims and drawings, the terms “a”, “an”, “the”, “said”, etc. also signify “at least one” or “the at least one” in the specification, claims and drawings.

Finally, it is the applicant's intent that only claims that include the express language "means for" or "step for" be interpreted under 35 U.S.C. 112(f). Claims that do not expressly include the phrase "means for" or "step for" are not to be interpreted under 35 U.S.C. 112(f).

**CLAIMS**

What is claimed is:

1. A selective heating device comprising:
  - a chamber configured to contain a target to be at least partially heated;
  - at least one heating element configured to selectively heat a first portion of the target at a first energy level for a first period of time; and:
    - selectively heat a second portion of the target at a second energy level for a second period of time, wherein the second energy level and/or the second period of time are different from the first energy level and/or the first period of time; or
    - refrain from heating a third portion of the target; or
    - a combination thereof; and
  - a controller configured to receive a heating instruction and control the at least one heating element based on the heating instruction.
2. The device of claim 1, further comprising a camera in communication with the controller, the camera configured to capture an image of the target inside the chamber and send the image to the controller.
3. The device of claim 2, further comprising a display in communication with the controller, the display configured to display the image of the target.
4. The device of claim 3, further comprising an input device in communication with the controller, the input device configured to receive a user selection of a portion of the image and send the user selection to the controller as the heating instruction.
5. The device of claim 4, wherein the user selection defines the first portion of the target, the second portion of the target, the third portion of the target, the first energy level, the first period of time, the second energy level, the second period of time, or a combination thereof.

6. The device of claim 2, wherein the controller is further configured to:
  - determine nutritional information for the target based on the image of the target, a weight of the target, an estimated volume of the target, an input target type and data about the input target type retrieved from a database, an input target area, or a combination thereof; and
  - cause the nutritional information to be displayed.
  
7. The device of claim 2, wherein the controller is further configured to:
  - read heating instruction data from the image;
  - determine a target orientation from the image; and
  - generate the heating instruction from the heating instruction data and the target orientation.
  
8. The device of claim 7, wherein the heating instruction data from the image comprises a heat map for the target.
  
9. The device of claim 7, wherein the controller is configured to read the heating instruction data from the image by decoding a QR code in the image.
  
10. The device of claim 1, wherein the controller is further configured to:
  - receive the heating instruction via a network;
  - send information about the target to a remote device via the network; or
  - a combination thereof.
  
11. The device of claim 1, further comprising a motor configured to rotate the target within the chamber, wherein:
  - the at least one heating element comprises a plurality of heating elements configured to heat separate portions of the chamber and configured to be selectively turned on and off; and
  - the controller is configured to control the plurality of heating elements based on the heating instruction by:

turning on at least one of the heating elements when the first portion of the target, the second portion of the target, or a combination thereof passes into the portion of the chamber which the at least one heating element is configured to heat; and

turning off the at least one of the heating elements when:

the first portion of the target, the second portion of the target, or a combination thereof is outside of the portion of the chamber which the at least one heating element is configured to heat,

the third portion of the target passes into the portion of the chamber which the at least one heating element is configured to heat, or

a combination thereof.

12. The device of claim 11, further comprising a second motor configured to shift the target along an axis within the chamber, wherein the controller is configured to:

control the second motor to shift the target so that the first portion of the target, the second portion of the target, or a combination thereof is shifted into the portion of the chamber which the at least one heating element is configured to heat; and

turn on the at least one heating element when the first portion of the target, the second portion of the target, or the combination thereof is shifted into the portion of the chamber which the at least one heating element is configured to heat.

13. The device of claim 11, further comprising a second motor configured to shift at least one of the heating elements along an axis within the chamber, wherein the controller is configured to:

control the second motor to shift the at least one heating element so that the first portion of the target, the second portion of the target, or a combination thereof is positioned in an area which the at least one heating element is configured to heat; and

turn on the at least one heating element when the at least one heating element is positioned to heat the first portion of the target, the second portion of the target, or the combination thereof.

14. The device of claim 1, wherein:

the at least one heating element is configured to send directed energy to a plurality of areas within the chamber; and

the controller is configured to control the at least one heating element based on the heating instruction by causing the at least one heating element to send the directed energy to the first portion of the target, the second portion of the target, or a combination thereof.

15. The device of claim 1, wherein the at least one heating element comprises at least one steerable antenna, a phase array antenna, a microwave heating element, an infrared heating element, an electromagnetic heating element, or a combination thereof.

16. The device of claim 1, wherein the chamber comprises a chamber wall configured to absorb radiation that is not being emitted from the at least one heating element to the first portion of the target or the second portion of the target.

17. The device of claim 1, further comprising a reflector configured to reflect stray radiation toward the first portion of the target or the second portion of the target or a combination thereof.

18. A selective heating method comprising:

receiving, with a controller, a heating instruction;

selectively heating, with at least one heating element, a first portion of a target to be at least partially heated at a first energy level for a first period of time, the target being contained within a chamber; and

selectively heating, with the at least one heating element, a second portion of the target at a second energy level for a second period

of time, wherein the second energy level and/or the second period of time are different from the first energy level and/or the first period of time;  
refraining from heating a third portion of the target; or  
a combination thereof;  
wherein the controller controls the at least one heating element based on the heating instruction.

19. The method of claim 18, further comprising:

capturing, with a camera in communication with the controller, an image of the target inside the chamber; and  
sending, with the camera, the image to the controller.

20. The method of claim 19, further comprising displaying, with a display in communication with the controller, the image of the target.

21. The method of claim 20, further comprising:

receiving, with an input device in communication with the controller, a user selection of a portion of the image; and  
sending, with the input device, the user selection to the controller as the heating instruction.

22. The method of claim 21, wherein the user selection defines the first portion of the target, the second portion of the target, the third portion of the target, the first energy level, the first period of time, the second energy level, the second period of time, or a combination thereof.

23. The method of claim 19, further comprising:

determining, with the controller, nutritional information for the target based on the image of the target, a weight of the target, an estimated volume of the target, an input target type and data about the input target type retrieved from a database, an input target area, or a combination thereof; and

causing, with the controller, the nutritional information to be displayed.

24. The method of claim 19, further comprising:

reading, with the controller, heating instruction data from the image;

determining, with the controller, a target orientation from the image; and

generating, with the controller, the heating instruction from the heating instruction data and the target orientation.

25. The method of claim 24, wherein the heating instruction data from the image comprises a heat map for the target.

26. The method of claim 24, wherein reading the heating instruction data from the image comprises decoding a QR code in the image.

27. The method of claim 18, further comprising:

receiving, with the controller, the heating instruction via a network;

sending, with the controller, information about the target to a remote device via the network; or

a combination thereof.

28. The method of claim 18, wherein the at least one heating element comprises a plurality of heating elements configured to heat separate portions of the chamber and configured to be selectively turned on and off, the method further comprising:

rotating, with a motor, the target within the chamber; and

controlling, with the controller, the plurality of heating elements based on the heating instruction by:

turning on at least one of the heating elements when the first portion of the target, the second portion of the target, or a

combination thereof passes into the portion of the chamber which the at least one heating element is configured to heat; and

turning off the at least one of the heating elements when:

the first portion of the target, the second portion of the target, or a combination thereof is outside of the portion of the chamber which the at least one heating element is configured to heat,

the third portion of the target passes into the portion of the chamber which the at least one heating element is configured to heat, or

a combination thereof.

29. The method of claim 28, further comprising:

controlling, with the controller, a second motor to shift the target along an axis within the chamber so that the first portion of the target, the second portion of the target, or a combination thereof is shifted into the portion of the chamber which the at least one heating element is configured to heat; and

turning on, with the controller, the at least one heating element when the first portion of the target, the second portion of the target, or the combination thereof is shifted into the portion of the chamber which the at least one heating element is configured to heat.

30. The method of claim 28, further comprising:

controlling, with the controller, a second motor to shift at least one of the heating elements along an axis within the chamber so that the first portion of the target, the second portion of the target, or a combination thereof is positioned in an area which the at least one heating element is configured to heat; and

turning on, with the controller, the at least one heating element when the at least one heating element is positioned to heat the first portion of the target, the second portion of the target, or the combination thereof.

31. The method of claim 18, further comprising:
- sending, with the at least one heating element, directed energy to a plurality of areas within the chamber; and
  - controlling, with the controller, the at least one heating element based on the heating instruction by causing the at least one heating element to send the directed energy to the first portion of the target, the second portion of the target, or a combination thereof.
32. The method of claim 18, wherein the at least one heating element comprises at least one steerable antenna, a phase array antenna, a microwave heating element, an infrared heating element, an electromagnetic heating element, or a combination thereof.
33. The method of claim 18, wherein the chamber comprises a chamber wall configured to absorb radiation that is not being emitted from the at least one heating element to the first portion of the target or the second portion of the target.
34. The method of claim 18, further comprising reflecting, with a reflector, stray radiation toward the first portion of the target or the second portion of the target or a combination thereof.

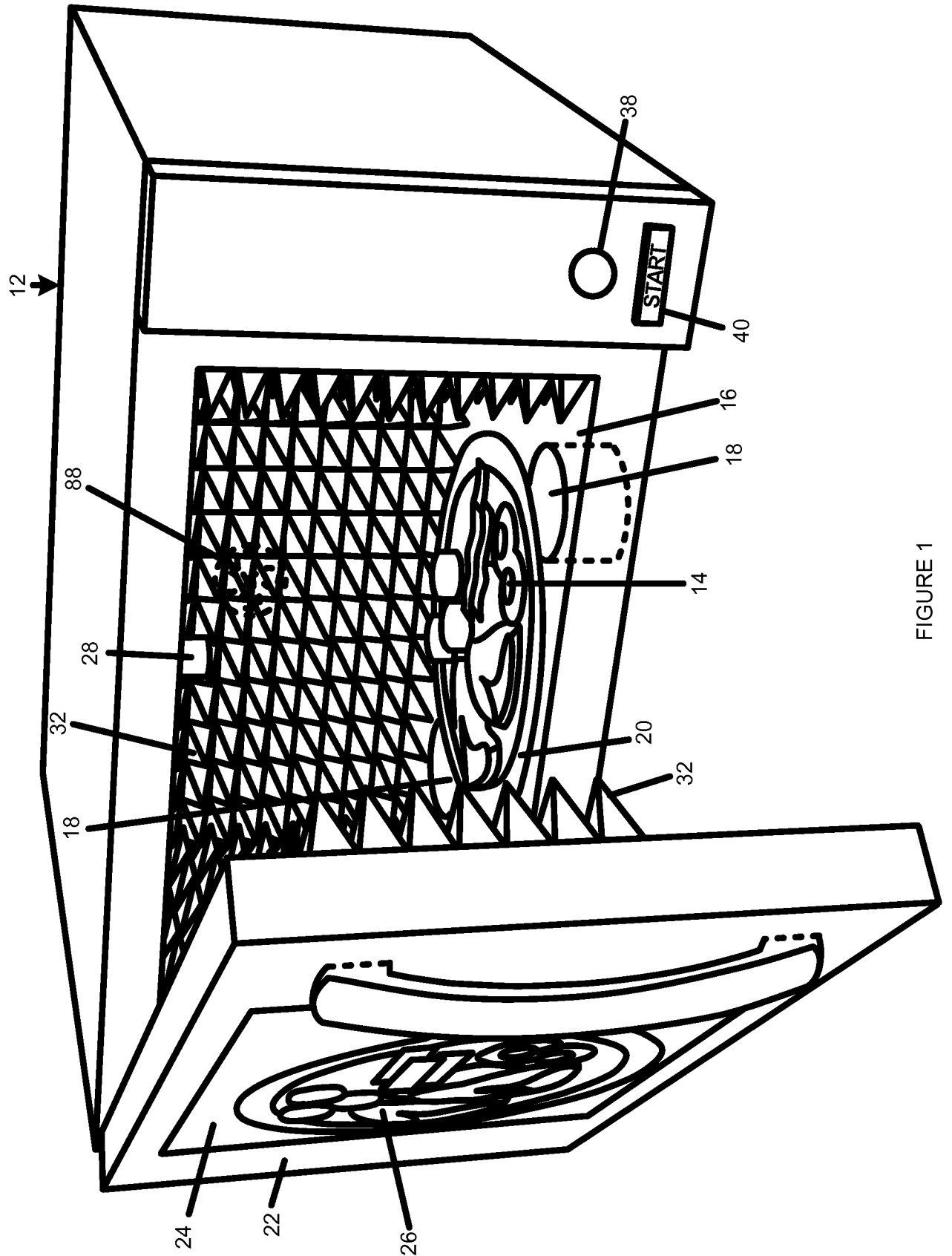


FIGURE 1

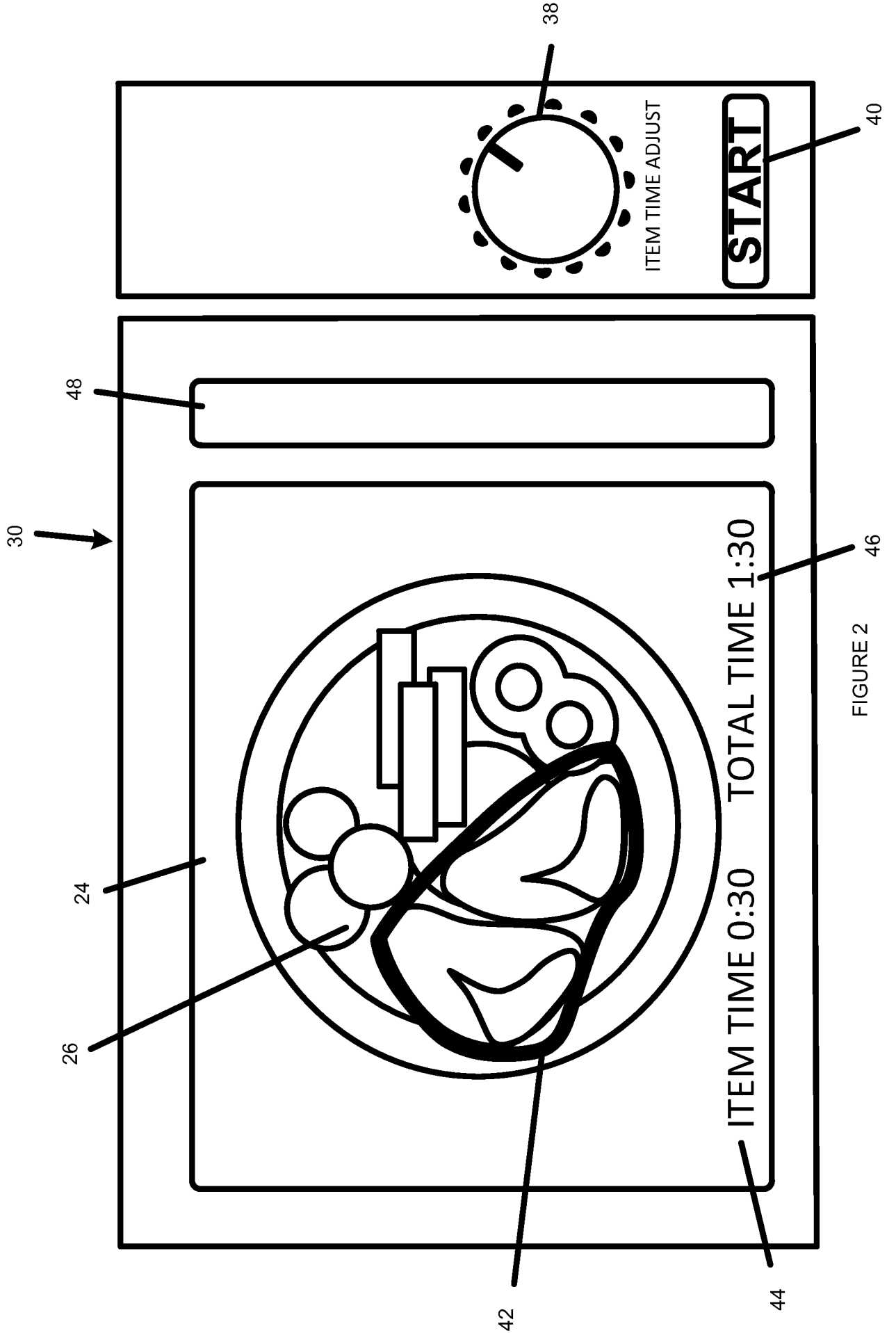


FIGURE 2

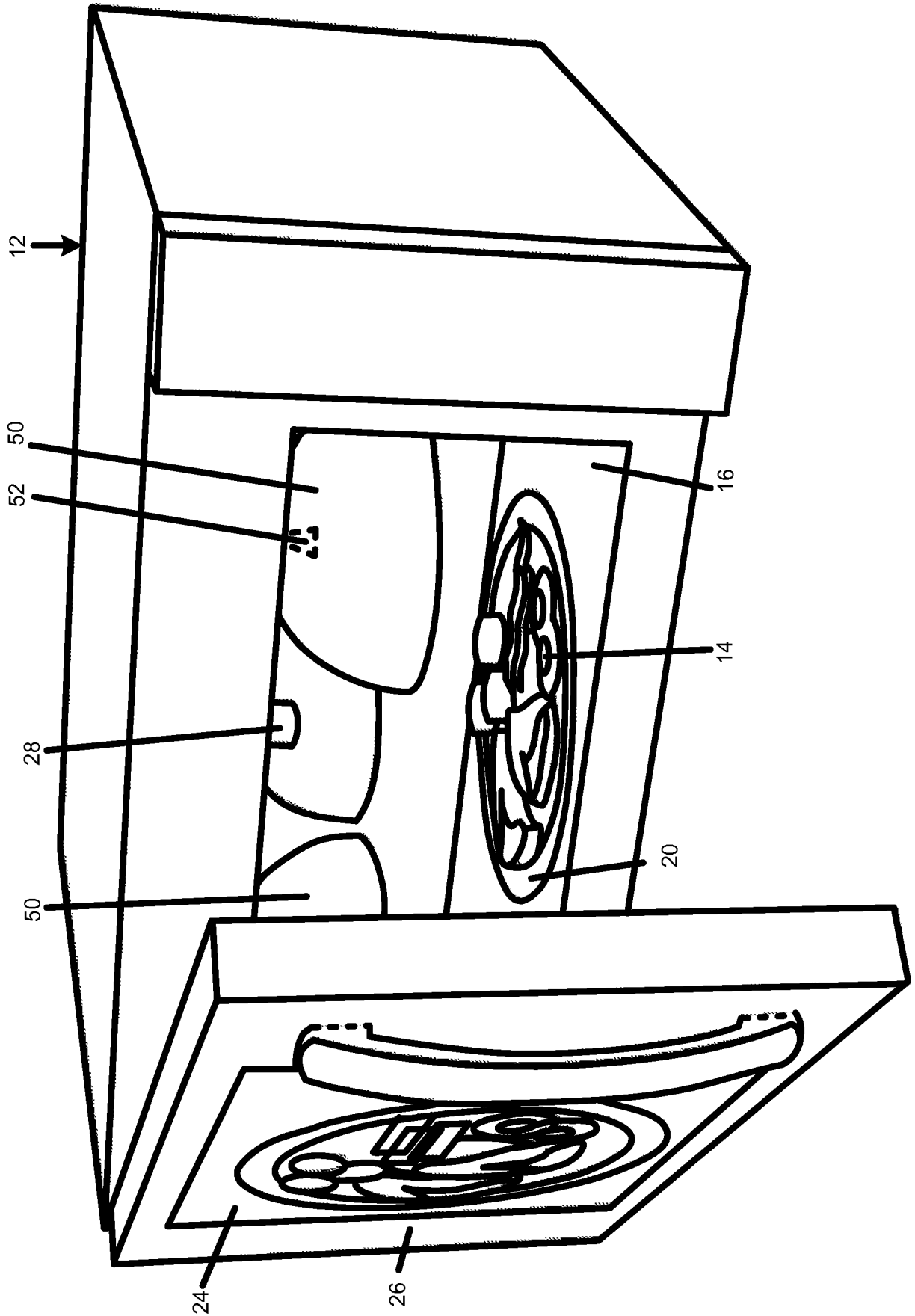


FIGURE 3

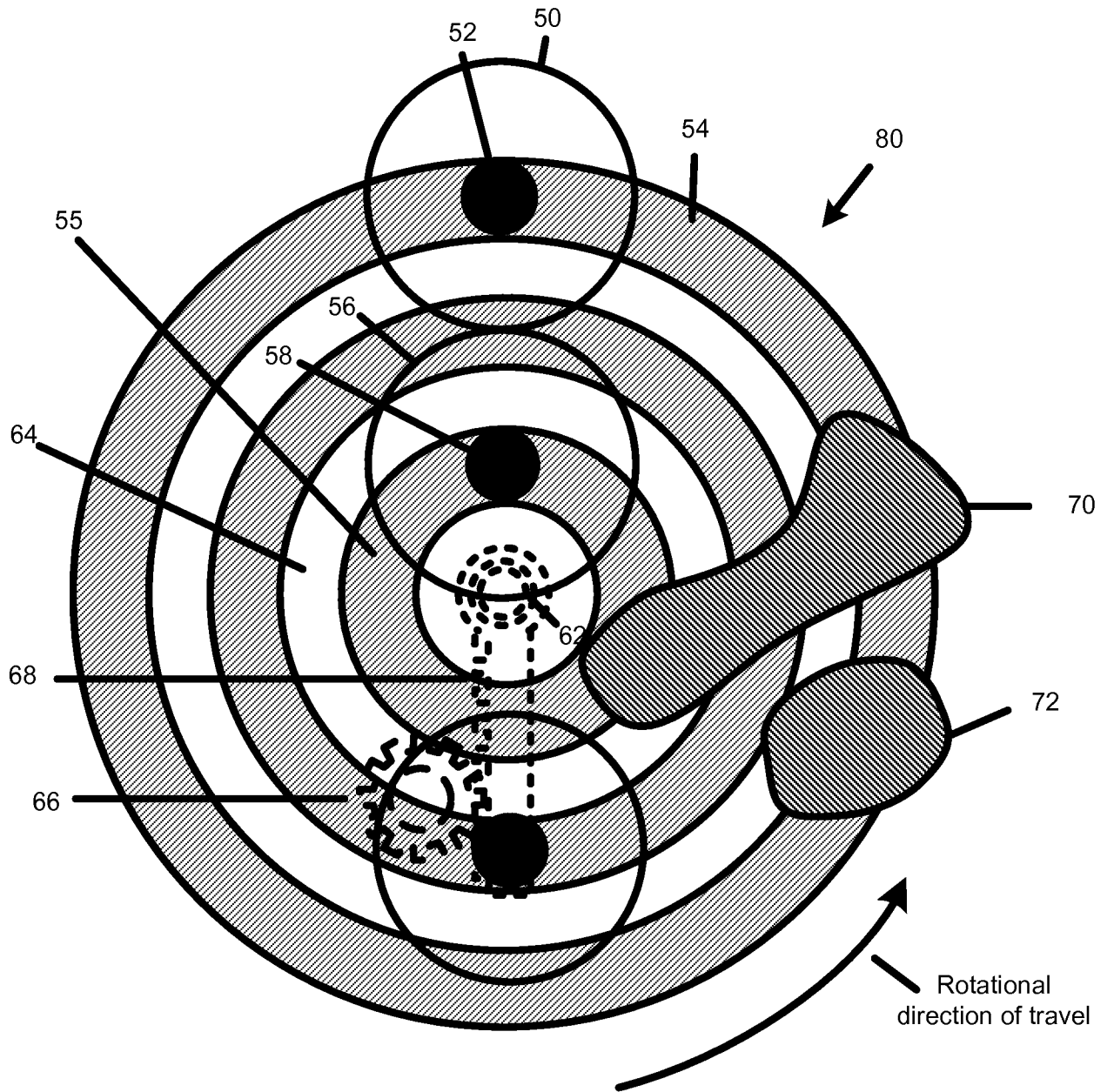


FIGURE 4

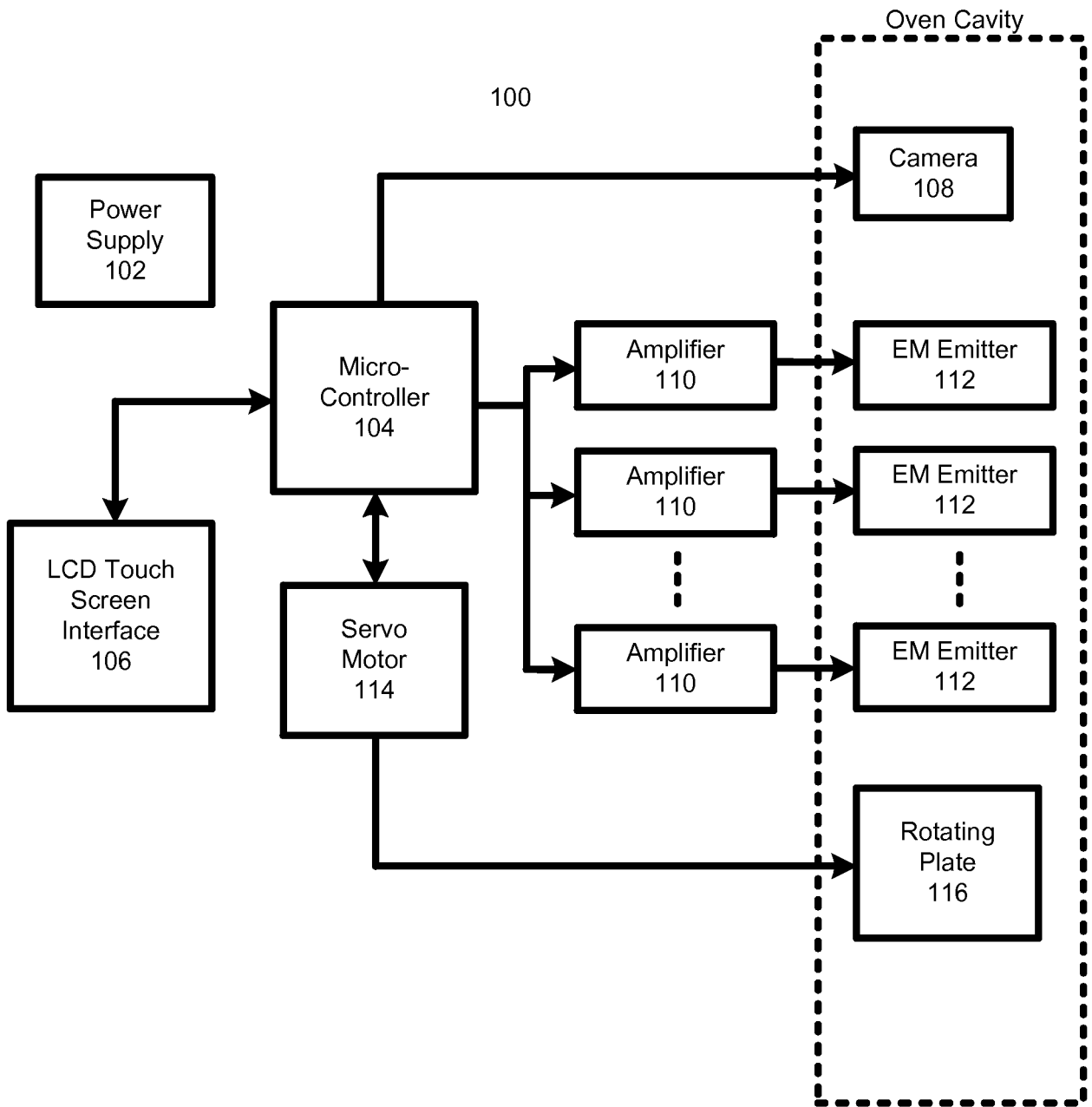


FIGURE 5

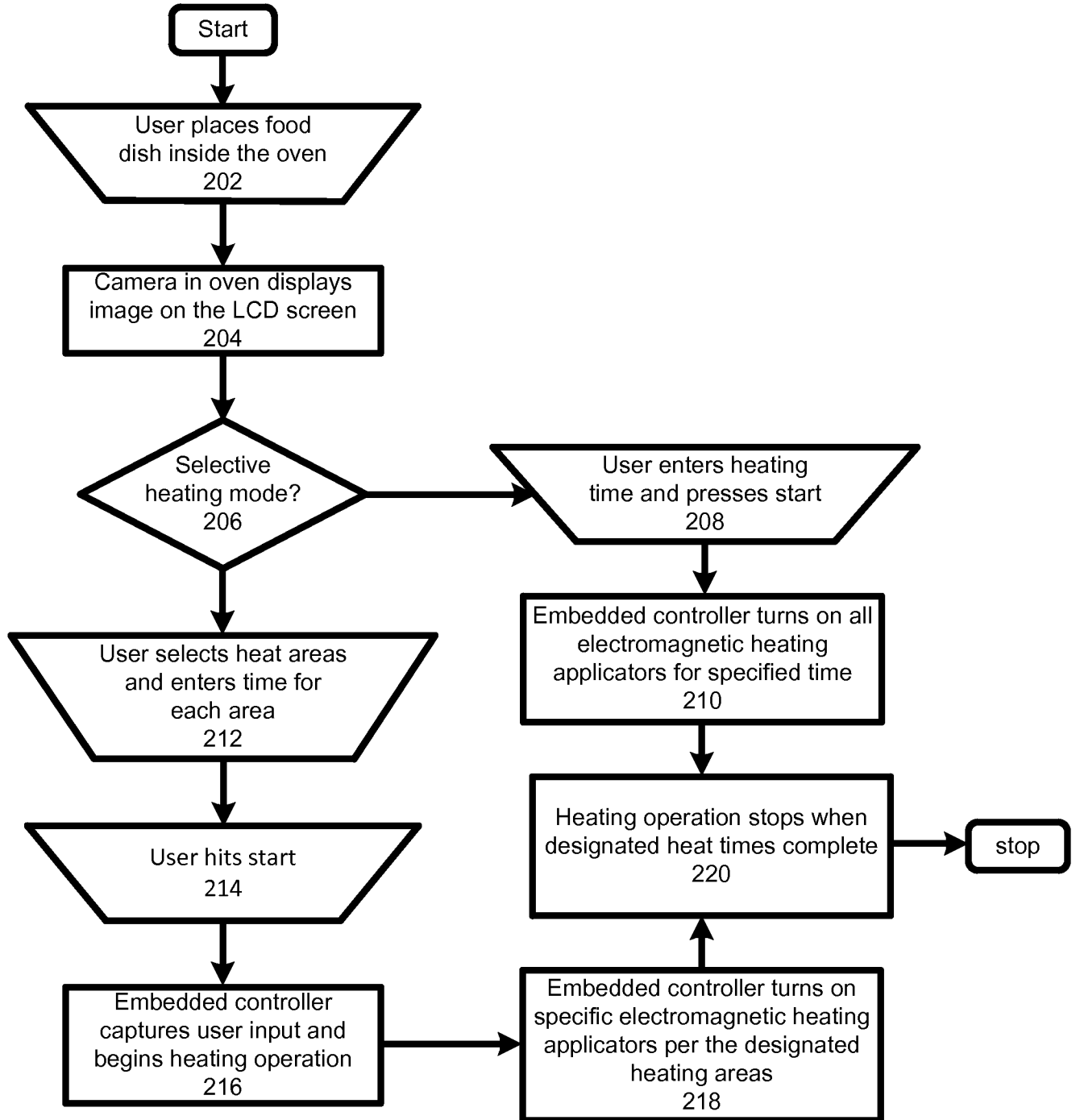


FIGURE 6

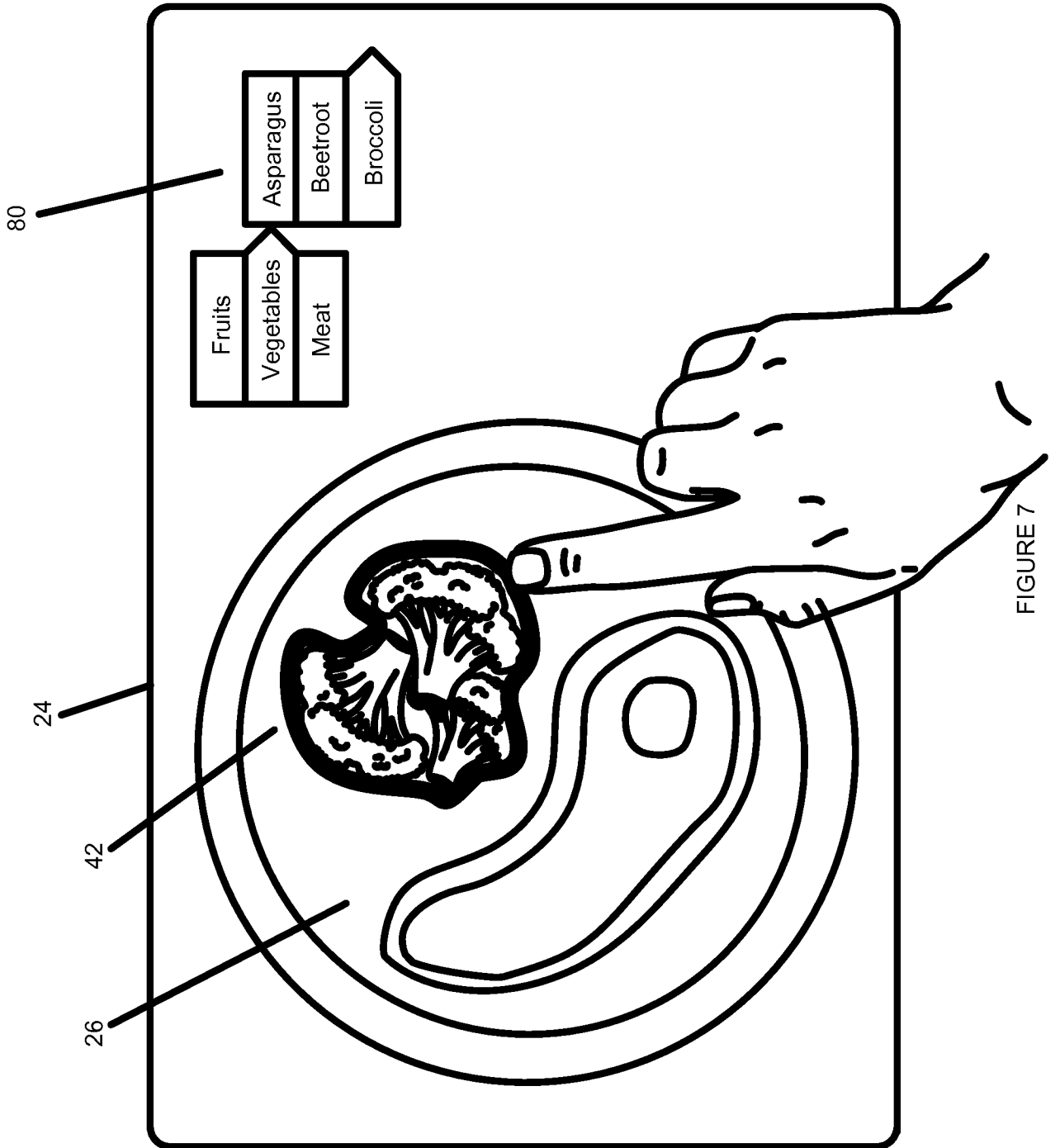


FIGURE 7

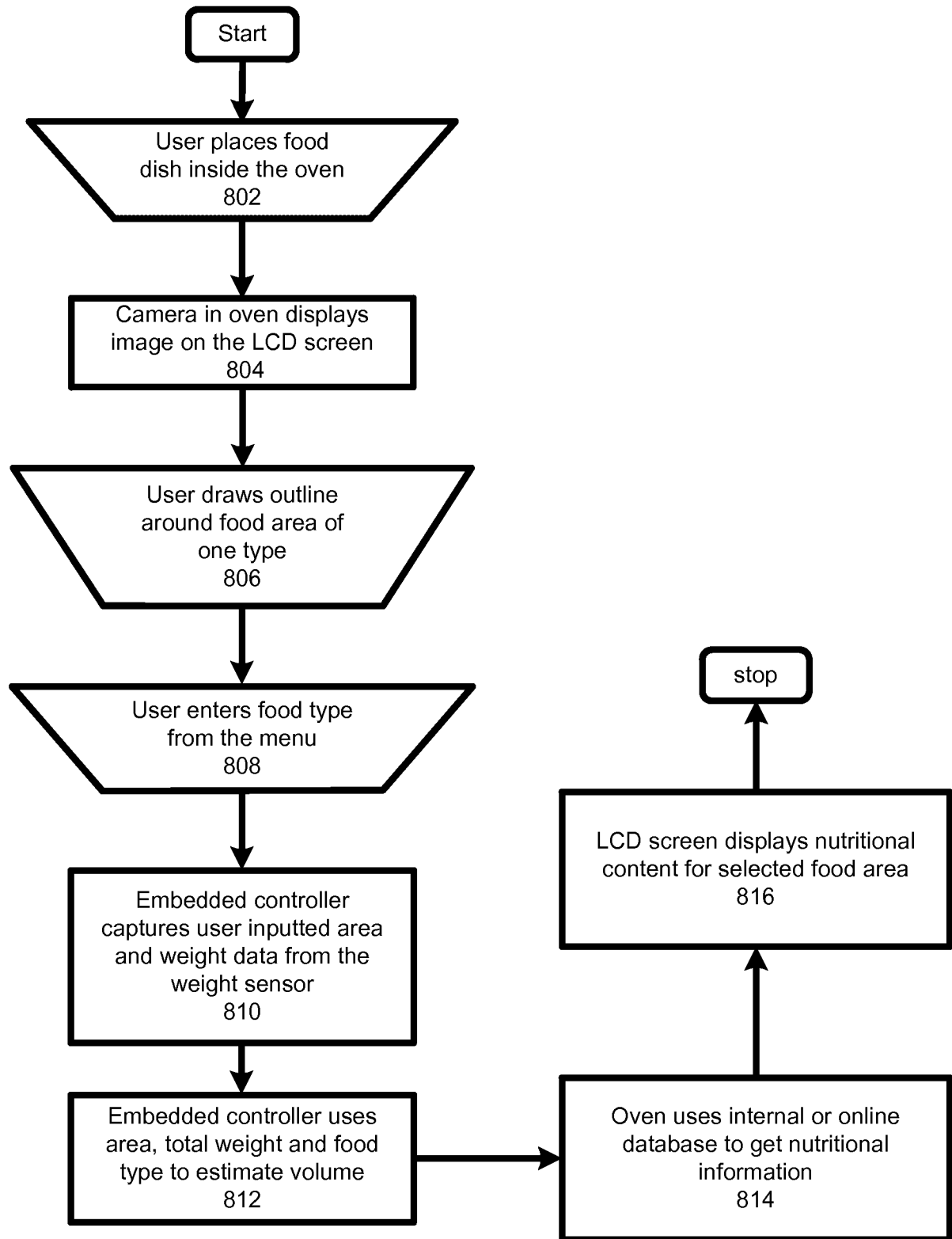


FIGURE 8

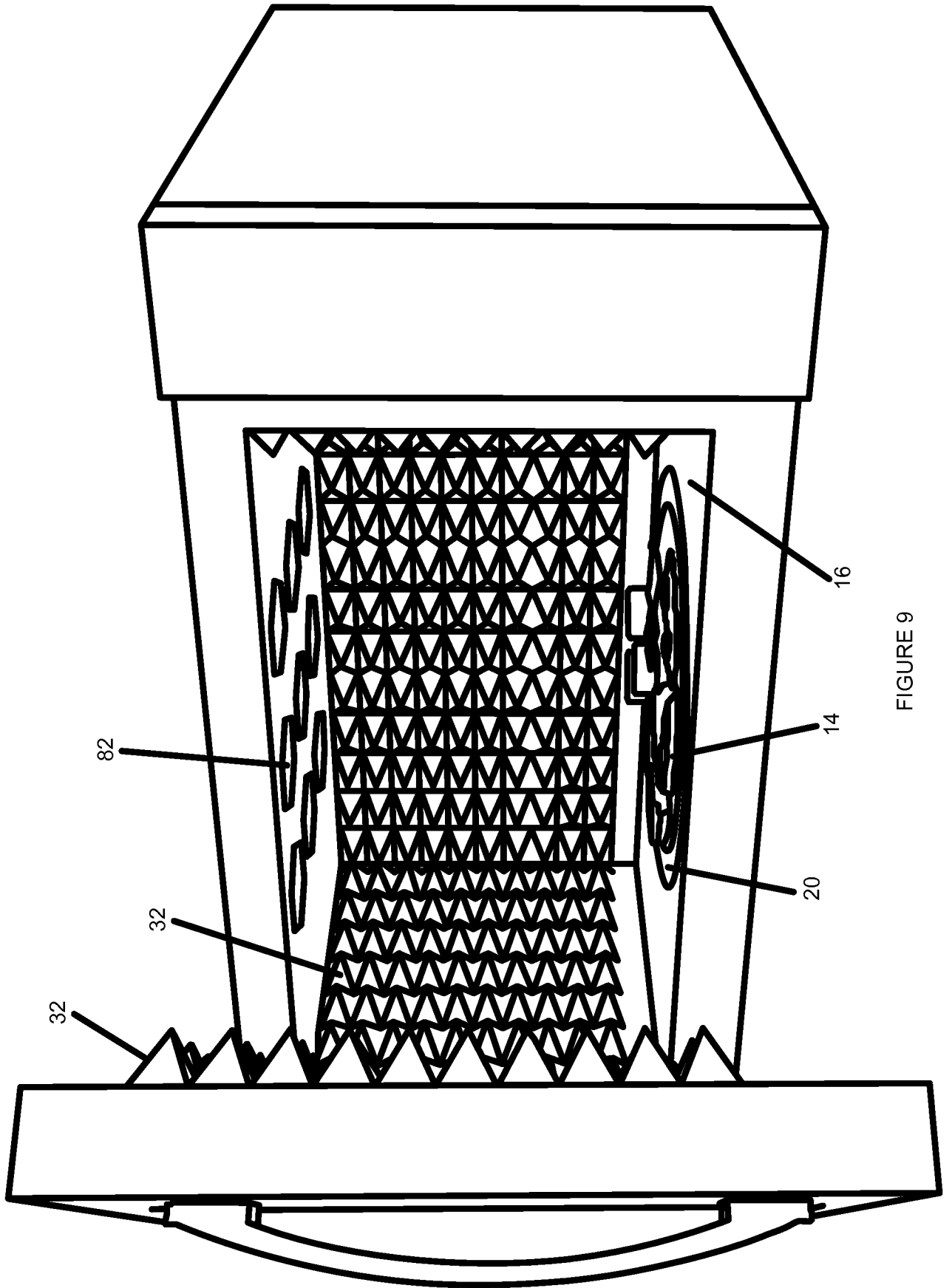


FIGURE 9

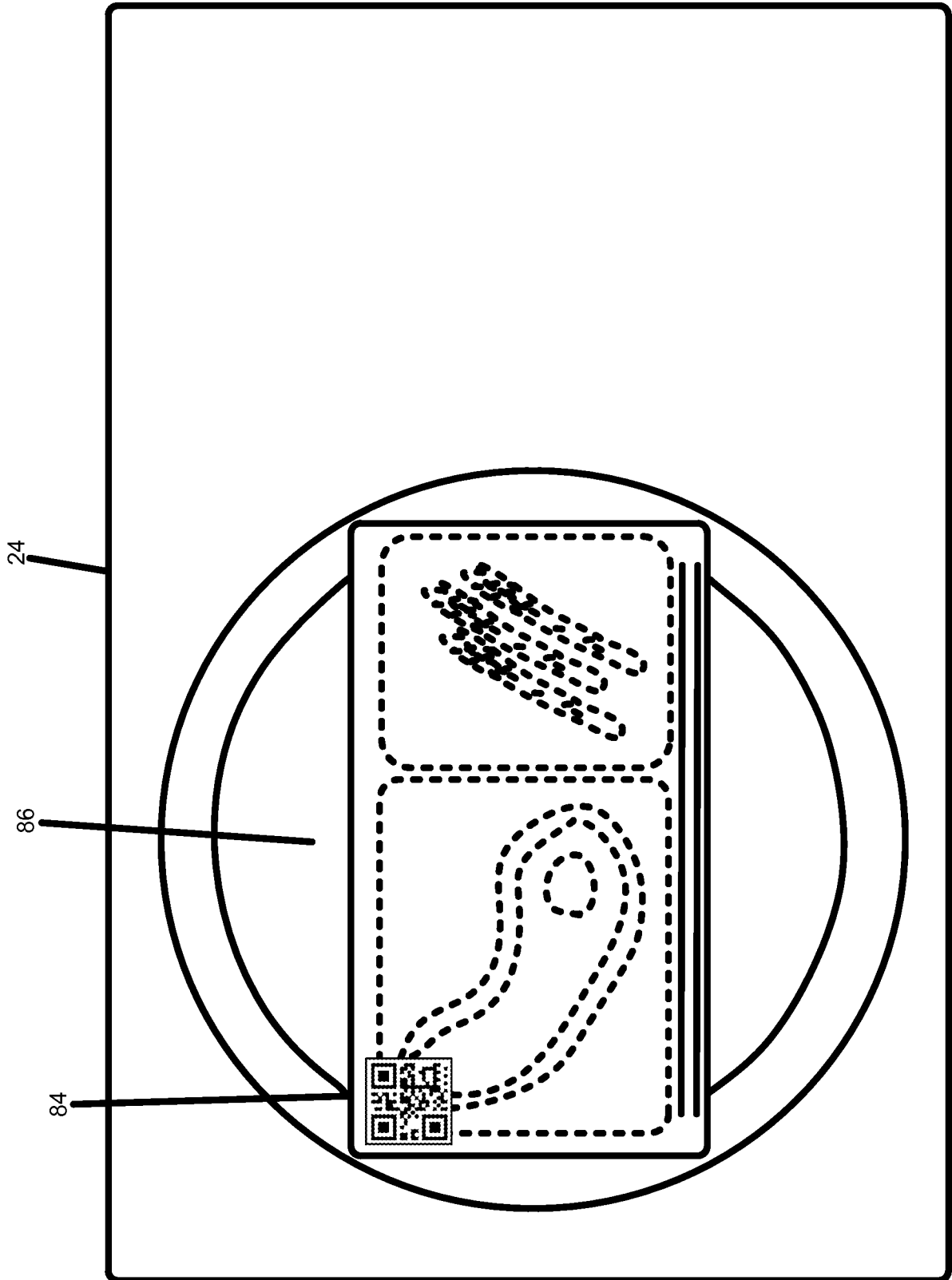


FIGURE 10

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2015/045744

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> IPC(8) - H05B 6/68 (2015.01) CPC - H05B 6/68 (2015.04) According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b> Minimum documentation searched (classification system followed by classification symbols) IPC(8) - H05B 6/00, 6/64, 6/66, 6/68 (2015.01) USPC - 219/678, 701, 702, 708		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched CPC - H05B 6/00, 6/64, 6/6438, 6/6447, 6/66, 6/68, 6/687, 6/688; Y02B 40/00 (2015.04) (keyword delimited)		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) Orbit, Google Patents, Google, ProQuest Search terms used: microwave oven, selective heating, image, heat map, infrared, portion, differential heating		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X		1-8,11,12,14,15,17-25,28, 29,31,32,34
---	US 2009/0321427 A1 (HYDE et al) 31 Dec 2009 (31.12.2009) entire document	---
Y		9,10,13,16,26,27,30,33
Y	US 2002/0059175 A1 (NAKANO) 16 May 2002 (16.05.2002) entire document	9,10,26,27
Y	US 5,693,246 A (HAN et al) 02 December 1997 (02.12.1997) entire document	13,30
Y	US 4,868,358 A (YAMASAKI) 19 September 1989 (19.09.1989) entire document	16,33
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 16 October 2015		Date of mailing of the international search report <b>13 NOV 2015</b>
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