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(54) Title: WIRELESS CULINARY PROBE CALIBRATION METHOD AND SYSTEM

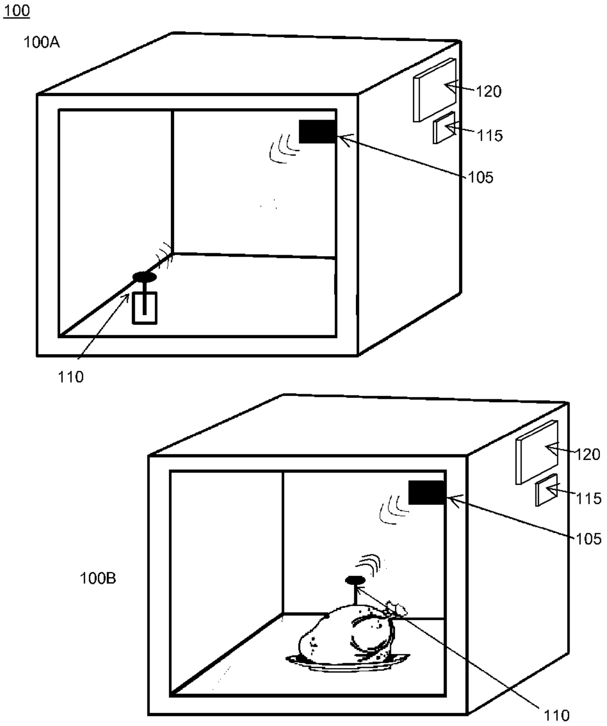

FIG. 1

(57) **Abstract**: A system and method to calibrate a temperature probe through immersion in a substance of known change of state temperature. The saturated Surface Acoustic Wave (SAW) probe temperature signal is calculated, overcoming oven reference temperature variability.

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WIRELESS CULINARY PROBE CALIBRATION METHOD AND SYSTEM

RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 61/828,803 filed 30 May, 2013. This application is herein incorporated in its entirety by reference.

FIELD OF THE INVENTION

[0002] The invention relates to a method and system for calibrating a wireless culinary temperature probe.

BACKGROUND OF THE INVENTION

[0003] A wide range of cooking appliances include heating elements, such as ovens, kettles, steamers, rice cookers, food processors, crock pots, etc. It is important that these appliances accurately control the temperature to which food is heated to ensure that it is neither undercooked nor overcooked. Therefore, heating appliances are typically provided with a temperature sensor to monitor a temperature of the heating element or food. The power supply to the heating element is controlled by the readings of the temperature sensor in order to maintain this temperature within a predetermined range. However, temperature sensors, especially for food in oven applications, often have a high variability or inaccuracy. This can lead to improperly cooked food. Variability or inaccuracy can be reduced, for example, by screening the food probes or temperature sensors, grouping food probes or temperature sensors to average values within a defined span, or calibrating the food probe using a reference temperature sensor in the oven. Applications require multiple sensors for calibration. This can be cumbersome and may not be reliable. Existing temperature sensor types include resistance (Pt100/Pt1000), thermocouple (NiCr/NiAl), and thermistor elements (NTC). Each requires wires, and some can be quite fragile. The combination of being low cost, inherently rugged, very sensitive, intrinsically reliable, wireless, and requiring no power is difficult to achieve.

[0004] What is needed is a system and method for establishing a reliable, accurate, fast reaction time temperature readout of wireless food probe temperatures sensors.

SUMMARY OF THE INVENTION

[0005] An embodiment provides an apparatus for calibrated control of a cooking oven comprising an oven heat source (120); a thermostat (115) providing temperature control signals to the heat source (120); a wireless temperature probe (110), the probe comprising a sensor body, at least one surface acoustic wave (SAW) temperature sensor (305), and at least one sensor antenna (310); a separate probe transceiver calibration unit (105, 325) receiving temperature information from the temperature sensor of the probe, the probe transceiver calibration unit comprising an antenna (330) electrically connected to the probe transceiver calibration unit (105, 325); a calibration material (315) in a calibration material container (320); the probe transceiver calibration unit (105, 325) configured to calculate a calibration factor to apply to a decoded uncalibrated temperature reading from the probe, producing a calibrated temperature from the probe; whereby the oven thermostat (115) receives calibrated temperature reading control input from the probe transceiver calibration unit (105, 325). Embodiments comprise a pre-calibration sequence (1110 - 1140). In other embodiments, the probe is calibrated without a reference temperature sensor. In subsequent embodiments the calibration is accomplished at a single temperature point (570, 615, 715), and calibration calculations are performed in the probe calibration unit (105, 325). For additional embodiments the probe (110) comprises a response time of at least about one second, an accuracy of about 0.5 degrees C, a precision of about at least 0.5 degrees C, a linearity of about 1% over a temperature range of about 0 to about 250 degrees C, and a drift of less than about 0.1 degree C per year. In another embodiment, the quantity of the calibration material is minimized. Yet further embodiments comprise ending a pre-calibration sequence when SAW sensor measured temperature varies by no more than approximately 0.5 degrees Celsius.

[0006] Another embodiment provides a method for calibrating a culinary probe comprising the steps of providing a calibration material (910); placing one sensor in the calibration material in an oven (915); beginning a heating operation by controlling a heat source by a thermostat (920); detecting a temperature plateau of the calibration material in a probe calibration unit (925); adjusting a reading of the sensor to correspond to a calibration temperature (930); saving settings (935); and controlling the heat source by the thermostat receiving calibrated temperature control input from the probe calibration unit (1195). A following embodiment comprises receiving information about heating power, thermal properties of the calibration material; probe unique identifier; and calibration material unique identifier at the probe calibration unit, and recording, at the probe calibration unit, time at which temperature of the calibration material does not increase. Subsequent embodiments comprise storing, in the probe calibration unit, the information about a correlation between the time at which the calibration material temperature does not increase and thermal properties of the calibration material; and the probe unique identifier. Additional embodiments comprise calculating, in the probe calibration unit, a calibration factor to apply to the decoded uncalibrated temperature reading from the probe producing a calibrated temperature from the probe. Included embodiments comprise a pre-calibration sequence comprising activating a SAW temperature sensor with an RF signal; decoding uncalibrated temperature and probe ID from a SAW response signal; saving the uncalibrated temperature associated with the probe and calibration material identifications and time; waiting for a measurement interval; repeating activating decoding and saving cycle; comparing consecutive uncalibrated temperatures from the SAW; checking to determine if temperature is unchanged, stable at ambient temperature; if not unchanged wait for measurement interval, if unchanged temperature is stable at ambient temperature, ending the pre-calibration sequence. Related embodiments comprise collecting approximately 300 data points for calibration calculation, and collecting data from the probe at about one second intervals. Further embodiments comprise immersing the probe in water calibration material. Ensuing embodiments comprise removing the calibration material from the oven after completion of calibration and cooking initiation.

[0007] A yet further embodiment provides a system for calibrating a culinary probe comprising activating a SAW temperature sensor with an RF signal (1110); decoding uncalibrated temperature and probe ID from a SAW response signal (1115); saving the uncalibrated temperature associated with the probe and calibration material identifications and time (1120); waiting for a measurement interval (1125); repeating activating decoding and saving cycle (1130); comparing consecutive uncalibrated temperatures from the SAW (1135); checking to determine if temperature is unchanged, stable at ambient temperature (1140); beginning energizing heat source controlled by a thermostat (1150); performing a sequence comprising activating the SAW sensor, decoding a SAW sensor response, saving the SAW response, probe and calibration material identifications, and time (1155); waiting for measurement interval (1160); comparing consecutive uncalibrated temperature sensor responses from SAW (1165); checking to determine if temperature reading has increased (1170); if temperature has increased repeat the activate decode save cycle (1155); if temperature has not increased, confirm that the heat source is on (1175); collecting a predetermined quantity of uncalibrated temperature reading repetitions at stable temperature (1180); calculating and saving calibration factor for SAW probe and material by the respective identifications (1185); de-energizing heat source (1190); ending calibration steps; and controlling the heat source by the thermostat receiving calibrated temperature control input from the probe calibration unit (1195).

[0008] The features and advantages described herein are not all-inclusive and, in particular, many additional features and advantages will be apparent to one of ordinary skill in the art in view of the drawings, specification, and claims. Moreover, it should be noted that the language used in the specification has been principally selected for readability and instructional purposes, and not to limit the scope of the inventive subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Figure 1 depicts a simplified calibration environment for an embodiment of the present invention.

[0010] Figure 2 depicts a SAW probe, receptacle, and calibration material for an embodiment of the present invention.

[0011] Figure 3 depicts components of a system overview for an embodiment of the present invention.

[0012] Figure 4 depicts a schematic of component operation for an embodiment configured in accordance with the present invention.

[0013] Figure 5 depicts a calibration material phase diagram for an embodiment of the present invention.

[0014] Figure 6 depicts a water liquid-vapor applied heat diagram for an embodiment of the present invention.

[0015] Figure 7 depicts a temperature reading curve for an embodiment of the present invention.

[0016] Figure 8 depicts a temperature curve for oven heating during calibration for an embodiment of the present invention.

[0017] Figure 9 is a system flow chart of an overview of a method for calibrating at least one wireless food probe configured in accordance with the present invention.

[0018] Figure 10 is a flow chart of a method for control unit operation for calibrating at least one wireless food probe configured in accordance with an embodiment of the present invention.

[0019] Figure 11 is a flow chart of details of a method for calibrating at least one wireless food probe configured in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

[0020] For oven application embodiments, the oven is heated to a temperature above the change of state temperature of the liquid, and the food probe temperature is observed. Liquid water as the calibration liquid changes state at 100°C. In embodiments, the calibration material may comprise a liquid, a solid, or a mixture of liquids and solids. Fast sensor reaction time means quick response to temperature changes both during calibration and cooking, reducing temperature overshoot and undershoot.

[0021] Once saturation (temperature plateau) of the food probe temperature (output signal) is detected, the calibration can be performed by taking the cooking temperature of the (calibration) liquid under consideration. By using this method, the oven reference temperature tolerance can be neglected.

[0022] The power supplied to the heating element during heating may be varied depending on the thermal inertia of the material being heated. For example, a material with a high specific heat capacity and low thermal conductivity will require more energy to be heated to a specific temperature, than a material with a low specific heat capacity and high thermal conductivity. To maintain a given time for calibration, more heat would need to be applied than for a material with a low specific heat capacity and / or a high thermal conductivity. The rate at which the power is supplied is dependent on the thermal inertia of the material being heated. The thermal inertia takes into account such factors as volume of material, specific heat capacity, and thermal conductivity. For example, a larger volume of water will have a higher thermal inertia than a smaller volume, since more energy is required to heat the larger volume to any given temperature. In embodiments, the quantity of the calibration material is minimized. A minimized quantity is a quantity sufficient to surround the sensor component and isolate the sensor component from the ambient environment so that the sensor component temperature matches the material temperature versus the ambient temperature of the oven.

[0023] In certain embodiments, the control unit may be arranged to wait until a predetermined number of data points have been recorded before calculating an estimated temperature. This ensures that the temperature is calculated with a desired degree of accuracy. As an example, the control unit may wait until several data points have been recorded after the temperature plateau. In an embodiment, the control unit is also configured to record data about the supplied heating power. The control unit records that the power is being supplied to the heating element. The control unit is further configured to begin calculating an estimated temperature after approximately one to hundreds of transmit cycles to the sensor once the temperature response from the SAW sensor varies no more than approximately 0.5 degrees C. In embodiments, these cycles have a period of approximately one second, meaning that the control unit waits until approximately one to hundreds of data points have been recorded before calculating a temperature. For embodiments, the control unit only calculates the temperature calibration in response to a calibration request. Alternatively, embodiments automatically calibrate the temperature at start-up.

[0024] **FIG. 1** depicts a simplified oven calibration environment **100**. Two steps are shown step one **100A** and step two **100B**. Step one **100A** is the calibration step, and step two **100B** is the cooking operation step. In step one **100A**, probe transceiver calibration unit **105** transmits signals to food probe **110** for calibration in, as an embodiment example, boiling water. To boil the water, thermostat **115** controls heat source **120**. Thermostat **115** turns on heat source **120** until the thermostat reads higher than the change of state (boiling point) of the calibration material (water). Thermostat **115** cycles heat source **120** on and off, above and below the boiling point of the water. The calibration unit performs the calibration process with food probe **110**. In step two **100b**, food probe **110**, after calibration, is inserted in food to be measured. During cooking, heat source **120** is controlled by thermostat **115** with input from probe transceiver calibration unit **105**.

[0025] **FIG. 2** depicts a SAW probe, receptacle, and calibration material **200**. Antenna end of probe **205** is opposite SAW device end of probe **210** for an embodiment. Probe is immersed in calibration material **215** in container **220**. As mentioned, for embodiments the quantity of calibration material **215** is minimized.

[0026] **FIG. 3** depicts simplified block diagram components of a system overview **300**. SAW sensor **305** electrically connected to probe antenna **310** is in calibration material **315** which is in container **320**. Probe transceiver calibration unit **325** is electrically connected to control unit antenna **330**. Probe transceiver calibration unit **325** is also connected **335** to heat source **340**. Heat source **340** radiates heat **345** to warm calibration material **315** in environment **350**. Before calibration, heat source **340** is controlled by thermostat **355** through connection **360**. In operation, probe transceiver calibration unit **325** antenna **330** radiates transmit signal **365** to be received **370** at probe sensor antenna **310**. After reception, SAW **305** of probe re-radiates received signal **375** which is received **380** at control unit antenna **330**. During calibration, thermostat **355** controls heat source **340**. Thermostat **355** turns on heat source **340** until the thermostat reads higher than the change of state of calibration material **315**. Thermostat **355** cycles heat source **340** on and off, above and below the boiling point of calibration material **315**. Probe transceiver calibration unit **325** performs the calibration process with food probe comprising saw sensor **305** and probe antenna **310**. Once calibration is complete, control of heat source **340** is transferred from thermostat **355** to probe transceiver calibration unit **325**. After calibration, the food probe is inserted in the food to be cooked and, with probe transceiver calibration unit **325**, controls heating by heat source **340**. For embodiments, system components are enclosed in oven **385**. For calibration, probe transceiver calibration unit **325** receives input for calibration material identification including physical properties of the calibration material, and other data about environment **345**. This can include altitude and other relevant parameters.

[0027] FIG. 4 depicts a schematic of component operation **400**. SAW temperature sensor device **405** is electrically connected **410** to sensor antenna **415** for transmit and receive. Probe calibration control unit **420** generates signals to be sent to SAW, and demodulates signal received from SAW sensor through control unit antenna **425**. Before and during calibration, thermostat **430** controls operation of heat source **435** receiving external power **440**. During calibration, probe calibration control unit **420** generates a signal for the temperature probe SAW sensor **405**, and transmits it **445** to be received by probe antenna **415**. After reception and acoustic wave interaction, the SAW probe signal is radiated back **445** to be received by control unit antenna **425**. Probe calibration control unit **420** then demodulates the signal from the temperature probe SAW sensor to determine the temperature of the SAW device. This bidirectional transmission process is repeated during cooking to determine the temperature of the probe inserted in the food being cooked. After calibration, during cooking, heat source **435** is controlled by thermostat **430** with input from probe calibration control unit **420**.

[0028] FIG. 5 depicts a calibration material phase diagram **500**. It presents a horizontal axis of temperature **505** versus a vertical axis of pressure **510**. Two values for temperature and pressure are given, critical temperature T_{cr} **515** and critical pressure P_{cr} **520**. Two points are given, triple point **525** and critical point **530**. Triple point **525** has a pressure designated P_{tp} and a temperature designated T_{tp}. Critical point **530** has values of critical temperature T_{cr} **515** and critical pressure P_{cr} **520**. The diagram delineates six phases. These six phases are solid **535**, compressible liquid **540**, liquid **545**, vapor **550**, gaseous **555**, and supercritical fluid **560**. As heat is applied to the calibration material, it passes **565** from liquid phase **545** to vapor phase **550** at boiling temperature point **570** for standard temperature and pressure conditions (STP) this is 100 degrees Celsius for water. A phase transition is the transformation of a thermodynamic system from one phase or state of matter to another. A phase of a thermodynamic system and the states of matter have uniform physical properties. During a phase transition of a given medium, certain properties of the medium change, often discontinuously, as a result of some external condition such as temperature, pressure, and others. For example, a liquid may become gas upon heating to the boiling point, resulting in an abrupt change in volume. The measurement of the external conditions at which the transformation occurs characterizes the phase transition. The enthalpy of vaporization, also known as the heat of vaporization or heat of evaporation, is the energy required to transform a given quantity of a substance from a liquid into a gas at a given pressure (typically atmospheric pressure). It is commonly measured at the normal boiling point of a substance. The heat of vaporization is temperature-dependent, though a constant heat of vaporization can be assumed for small temperature ranges and for $Tr<<1.0$. The heat of vaporization diminishes with increasing temperature and it vanishes completely at the critical temperature ($Tr=1$) because above the critical temperature the liquid and vapor phases no longer co-exist. Molecules in liquid water are held together by relatively strong hydrogen bonds, water's enthalpy of vaporization, 40.65 kJ/mol, is more than five times the energy required to heat the same quantity of water from 0 °C to 100 °C (cp = 75.3 J K−1 mol−1).

[0029] **FIG. 6** depicts a water liquid-vapor applied heat diagram **600**. It depicts temperature **605** of calibration material including boiling point temperature **610** at 100 degrees Centigrade. Pressure is assumed fixed, at atmospheric pressure of about 14.696 psi or 101.325 kPa at sea level. For approximately every 500 feet of altitude, water's boiling point is lowered 1°F. Change of state is shown **615** where increasing heat energy transitions water from liquid to vapor phase without a change in temperature. The boiling point is the temperature at which the vapor pressure is equal to the atmospheric pressure around the water. This effect is employed to calibrate the SAW temperature sensor probe.

[0030] **FIG. 7** depicts a simplified temperature reading curve **700**. This graph of temperature versus time depicts the effect used for calibration. With a constant heat application, the ambient temperature of the air linearly increases **705**. In contrast, the calibration material temperature curve exhibits nonlinearity at change-of-state **710**. At the boiling point / change-of-state of the calibration material, the temperature plateaus **715**.

[0031] **FIG. 8** depicts a temperature curve **800** for oven heating during calibration. This graph of temperature versus time depicts the actual variation of oven environment temperature as controlled by the thermostat. Solid line **805** illustrates the saw tooth temperature profile as the heating element is turned on, points **810** and off, points **815** in an attempt to maintain a stable temperature. In addition, errors exist in the temperature shown by over-temperature dashed line **820** and under-temperature dashed line **825**. In some cases, thermostat inaccuracies can be from +/- 5 to 15 degrees Celsius. In contrast, SAW temperature sensors have fast time constants, high accuracy, high precision, high linearity, and little drift over time. Use of the calibrated food probe to measure actual food temperature to determine when the food is cooked to a certain point provides reliable cooking results in spite of actual oven temperature swings.

[0032] **FIG. 9** is a system flow chart of an overview of a method **900** for calibrating at least one wireless food probe. Steps comprise starting calibration cycle **905**; providing calibration material (at ambient temperature) **910**; placing at least one sensor in calibration material **915**; beginning heating operation **920**; detecting temperature plateau of calibration material **925**; adjusting the sensor reading to correspond to calibration temperature **930**; saving settings **935**; and ending calibration cycle **940**.

[0033] FIG. 10 is a flow chart of a method **1000** for probe transceiver calibration unit operation for calibrating at least one wireless food probe. Steps comprise requesting and initiating calibration **1005**; selecting calibration material **1010**; programming a controller with calibration material physical properties values including change-of-state temperature **1015**; identifying probe with RF signal **1020**; storing probe identity and calibration material identification **1025**; confirming saw temperature sensor operation with RF signal **1030**; performing calibration steps **1035**; ending calibration operation **1040**, transferring control of heating element to probe transceiver calibration unit **1045**.

[0034] FIG. 11 is a flow chart of details of a method **1100** for calibrating at least one wireless food probe. Steps comprise initiating calibration steps by providing a calibration material with the wireless food probe immersed in it **1105**; in a 'pre-calibration' sequence activating saw temperature sensor with RF signal **1110**; decoding uncalibrated temperature and probe ID from the SAW response signal **1115**; saving the uncalibrated temperature associated with the probe and calibration material identifications and time **1120**; waiting for measurement interval **1125**; repeating activating decoding and saving cycle **1130**; comparing consecutive uncalibrated temperatures from SAW **1135**; checking to determine if temperature is unchanged, stable at ambient temperature **1140**; if not unchanged – N, go to wait for measurement interval **1125**, if unchanged – Y, go to temperature stable (at ambient temperature - end of pre-calibration sequence), ready to begin calibration **1145**; next, begin energizing heat source controlled by a thermostat **1150**; perform activate (SAW sensor) / decode (SAW sensor response) / save (SAW response, probe and calibration material identifications, and time) cycle **1155**; waiting for measurement interval **1160**; comparing consecutive uncalibrated temperature sensor responses from SAW **1165**; checking to determine if temperature reading has increased **1170**; if temperature has increased – Y, go to activate / decode / save cycle **1155**, if temperature has not increased – N confirm that the heater is on **1175**; collecting quantity “n” uncalibrated temperature reading repetitions at the stable temperature **1180**; calculating and saving the calibration factor for the SAW probe and material by the respective identifications

1185; de-energizing the heat source **1190**; ending calibration steps and controlling heat source by thermostat with input from probe calibration control unit **1195**.

[0035] The foregoing description of the embodiments of the invention has been presented for the purposes of illustration and description. Each and every page of this submission, and all contents thereon, however characterized, identified, or numbered, is considered a substantive part of this application for all purposes, irrespective of form or placement within the application. This specification is not intended to be exhaustive or to limit the invention to the precise form disclosed. Many modifications and variations are possible in light of this disclosure. The embodiments may be modified, and all such variations are considered within the scope and spirit of the application. The components of the system may be integrated or separated. Moreover, the operations of the system may be performed by more, fewer, or other components. The methods may include more, fewer, or other steps. Additionally, steps may be performed in any suitable order. Many modifications and variations are possible in light of this disclosure.

CLAIMS

Among my claims are:

1. An apparatus for calibrated control of a cooking oven comprising:

an oven heat source (120);

a thermostat (115) providing temperature control signals to said heat source (120);

a wireless temperature probe (110), said probe comprising a sensor body, at least one surface acoustic wave (SAW) temperature sensor (305), and at least one sensor antenna (310);

a separate probe transceiver calibration unit (105, 325) receiving temperature information from said temperature sensor of said probe, said probe transceiver calibration unit comprising an antenna (330) electrically connected to said probe transceiver calibration unit (105, 325);

a calibration material (315) in a calibration material container (320);

said probe transceiver calibration unit (105, 325) configured to calculate a calibration factor to apply to a decoded uncalibrated temperature reading from said probe, producing a calibrated temperature from said probe;

whereby said oven thermostat (115) receives calibrated temperature reading control input from said probe transceiver calibration unit (105, 325).

2. The apparatus of claim 1 comprising a pre-calibration sequence (1110 - 1140).

3. The apparatus of any of the preceding claims wherein said probe is calibrated without a reference temperature sensor.

4. The apparatus of any of the preceding claims wherein said calibration is accomplished at a single temperature point (570, 615, 715), and calibration calculations are performed in said probe calibration unit (105, 325).

5. The apparatus of any of the preceding claims wherein said probe (110) comprises a response time of at least about one second, an accuracy of about 0.5 degrees C, a precision of about at least 0.5 degrees C, a linearity of about 1% over a temperature range of about 0 to about 250 degrees C, and a drift of less than about 0.1 degree C per year.

6. The apparatus of any of the preceding claims wherein quantity of said calibration material is minimized.

7. The apparatus of any of the preceding claims comprising ending a pre-calibration sequence when SAW sensor measured temperature varies by no more than approximately 0.5 degrees Celsius.

8. A method for calibrating a culinary probe comprising the steps of:

providing a calibration material (910);

placing one sensor in said calibration material in an oven (915);

beginning a heating operation by controlling a heat source by a thermostat (920);

detecting a temperature plateau of said calibration material in a probe calibration unit (925);

adjusting a reading of said sensor to correspond to a calibration temperature (930);

saving settings (935); and

controlling said heat source by said thermostat receiving calibrated temperature control input from said probe calibration unit (1195).

9. The method of claim 8 comprising:

receiving information about heating power, thermal properties of said calibration material; probe unique identifier; and calibration material unique identifier at said probe calibration unit, and

recording, at said probe calibration unit, time at which temperature of said calibration material does not increase.

10. The method of claims 8 through 9 comprising:

storing, in said probe calibration unit, said information about a correlation between said time at which the calibration material temperature does not increase and thermal properties of said calibration material; and

said probe unique identifier.

11. The method of claims 8 through 10 comprising:

calculating, in said probe calibration unit, a calibration factor to apply to said decoded uncalibrated temperature reading from said probe producing a calibrated temperature from said probe.

12. The method of claims 8 through 11 comprising a pre-calibration sequence comprising:

activating a SAW temperature sensor with an RF signal;

decoding uncalibrated temperature and probe ID from a SAW response signal;

saving said uncalibrated temperature associated with said probe and calibration material identifications and time;

waiting for a measurement interval;

repeating activating decoding and saving cycle;

comparing consecutive uncalibrated temperatures from said SAW;

checking to determine if temperature is unchanged, stable at ambient temperature;

if not unchanged wait for measurement interval, if unchanged temperature is stable at ambient temperature, ending said pre-calibration sequence.

13. The method of claims 8 through 12 comprising:

collecting approximately 300 data points for calibration calculation, and collecting data from said probe at about one second intervals.

14. The method of claims 8 through 13 comprising:

immersing said probe in water calibration material, and removing said calibration material from said oven after completion of calibration and cooking initiation.

15. A system for calibrating a culinary probe comprising:

activating a SAW temperature sensor with an RF signal (1110);

decoding uncalibrated temperature and probe ID from a SAW response signal (1115);

saving said uncalibrated temperature associated with said probe and calibration material identifications and time (1120);

waiting for a measurement interval (1125);

repeating activating decoding and saving cycle (1130);

comparing consecutive uncalibrated temperatures from said SAW (1135);

checking to determine if temperature is unchanged, stable at ambient temperature (1140);

beginning energizing heat source controlled by a thermostat (1150);

performing a sequence comprising activating said SAW sensor, decoding a SAW sensor response, saving said SAW response, probe and calibration material identifications, and time (1155);

waiting for measurement interval (1160);

comparing consecutive uncalibrated temperature sensor responses from SAW (1165);

checking to determine if temperature reading has increased (1170);

if temperature has increased repeat said activate decode save cycle (1155);

if temperature has not increased, confirm that said heat source is on (1175);

collecting a predetermined quantity of uncalibrated temperature reading repetitions at stable temperature (1180);

calculating and saving calibration factor for SAW probe and material by the respective identifications (1185);

de-energizing heat source (1190);

ending calibration steps; and

controlling said heat source by said thermostat receiving calibrated temperature control input from said probe calibration unit (1195).

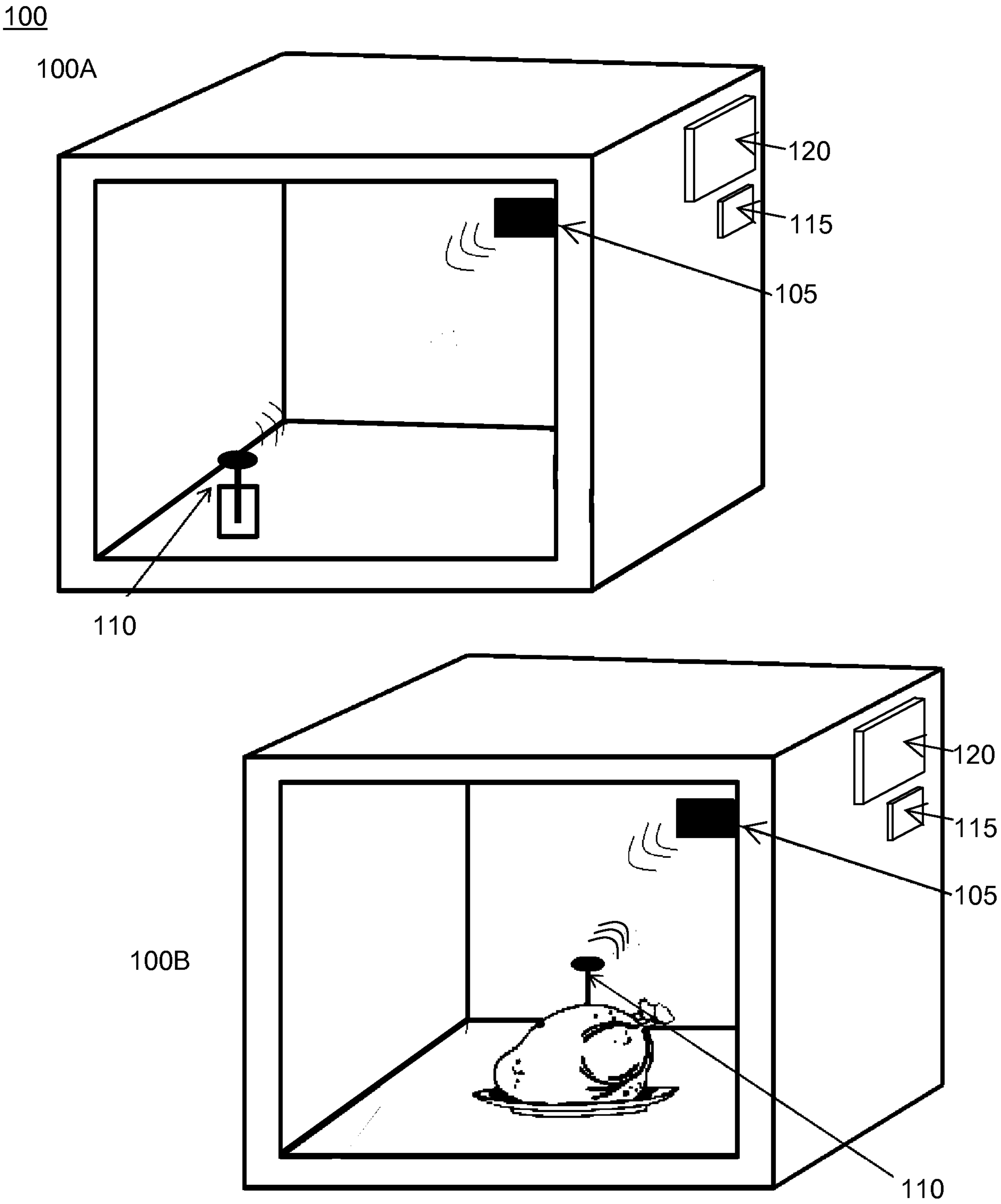

FIG. 1

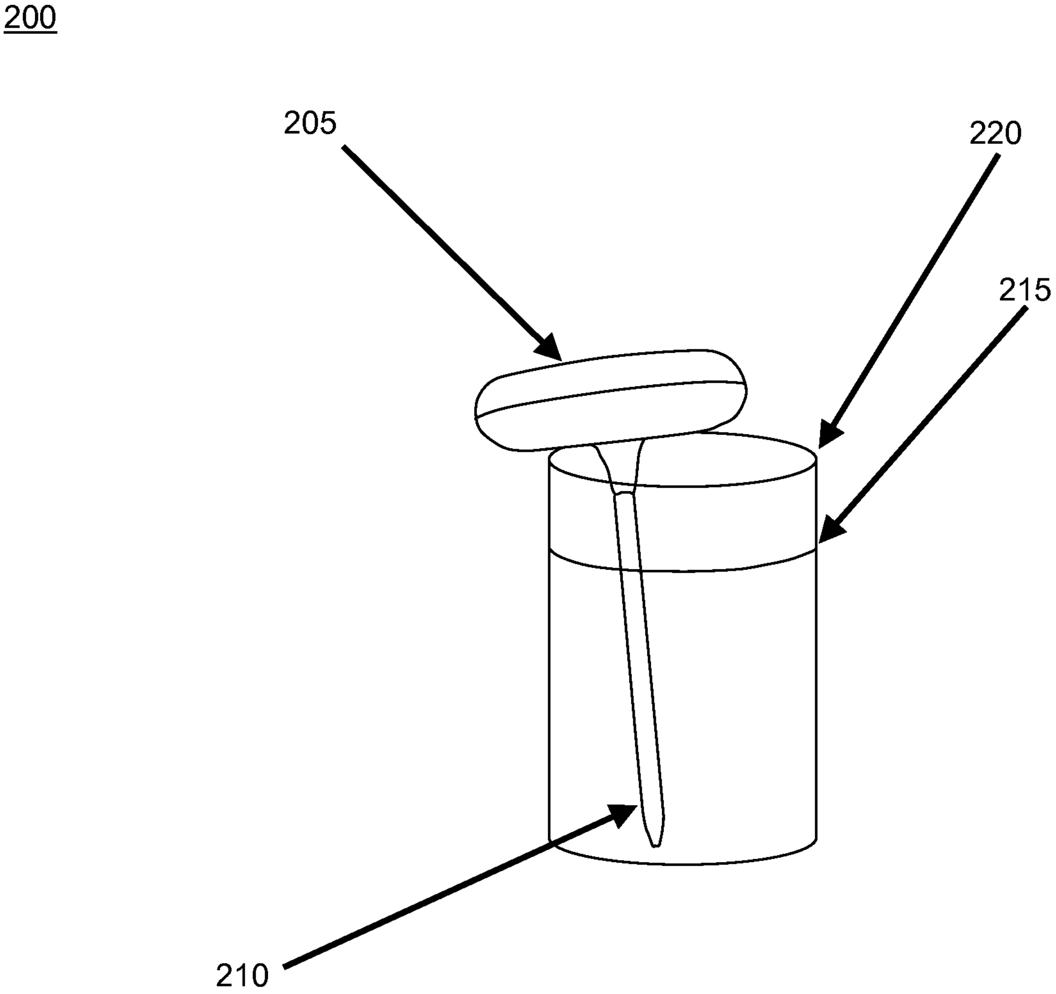

FIG. 2

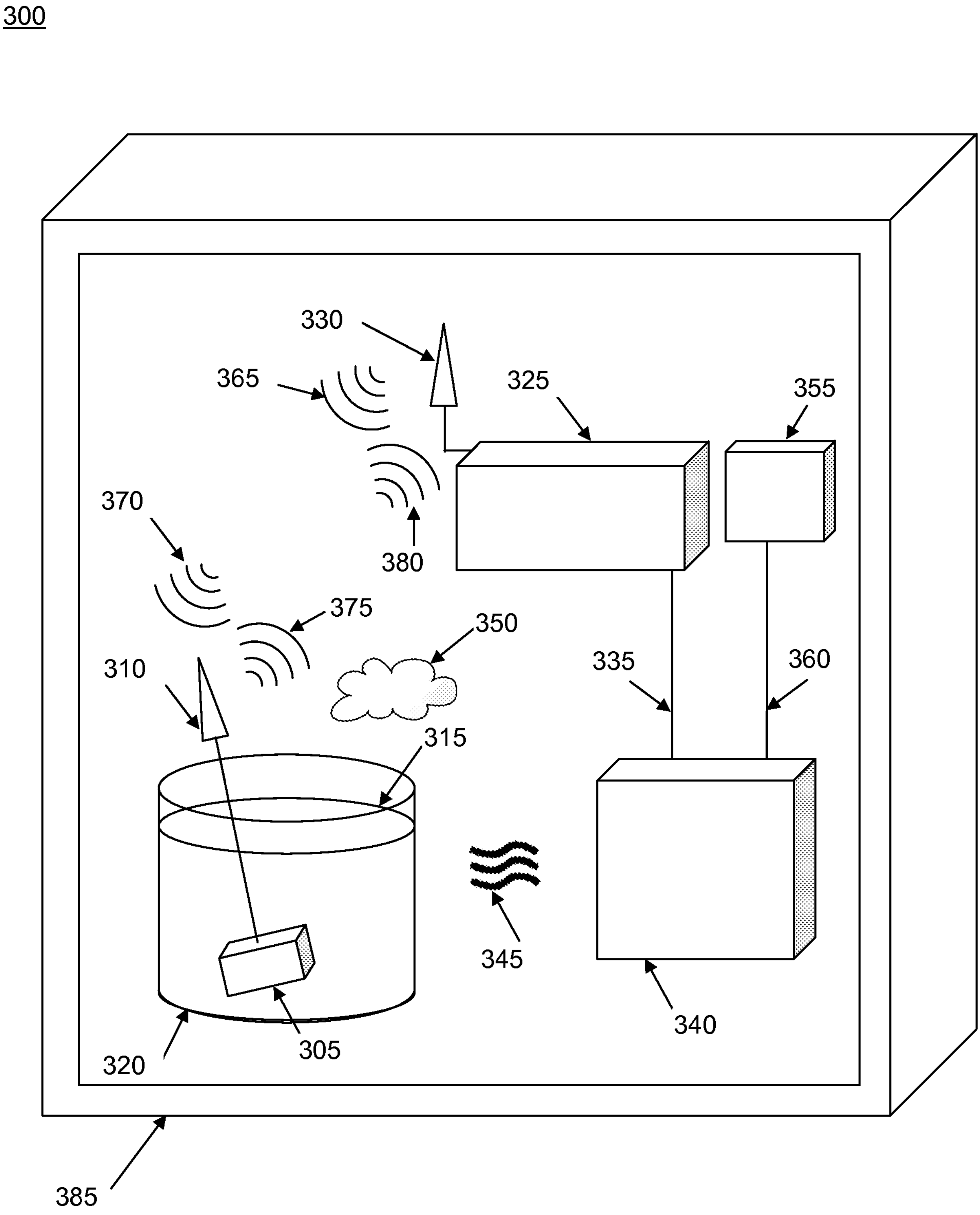
300
330
365
325
355
370
380
375
350
310
335
360
315
345
340
320
305
385

FIG. 3

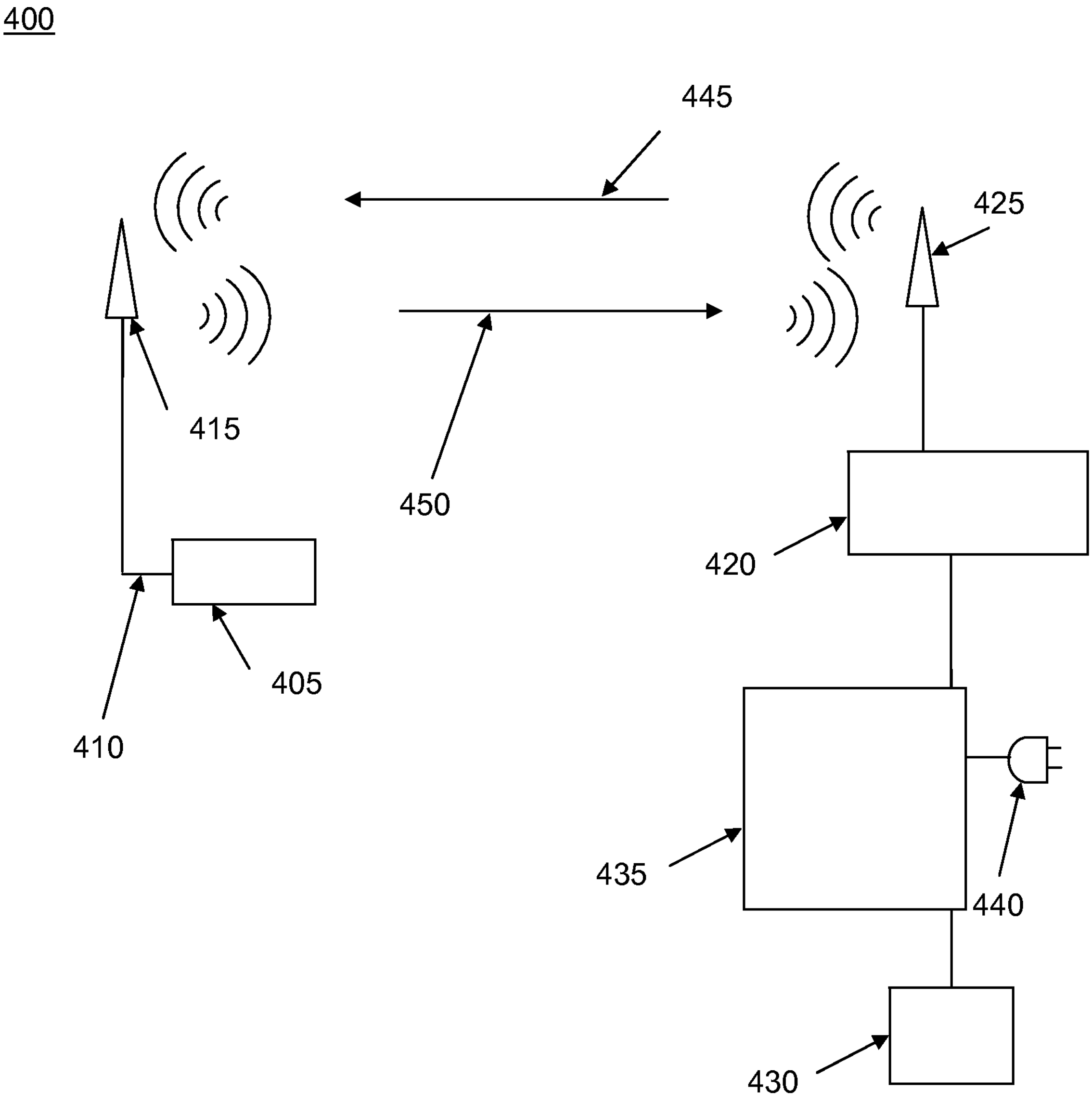

FIG. 4

500

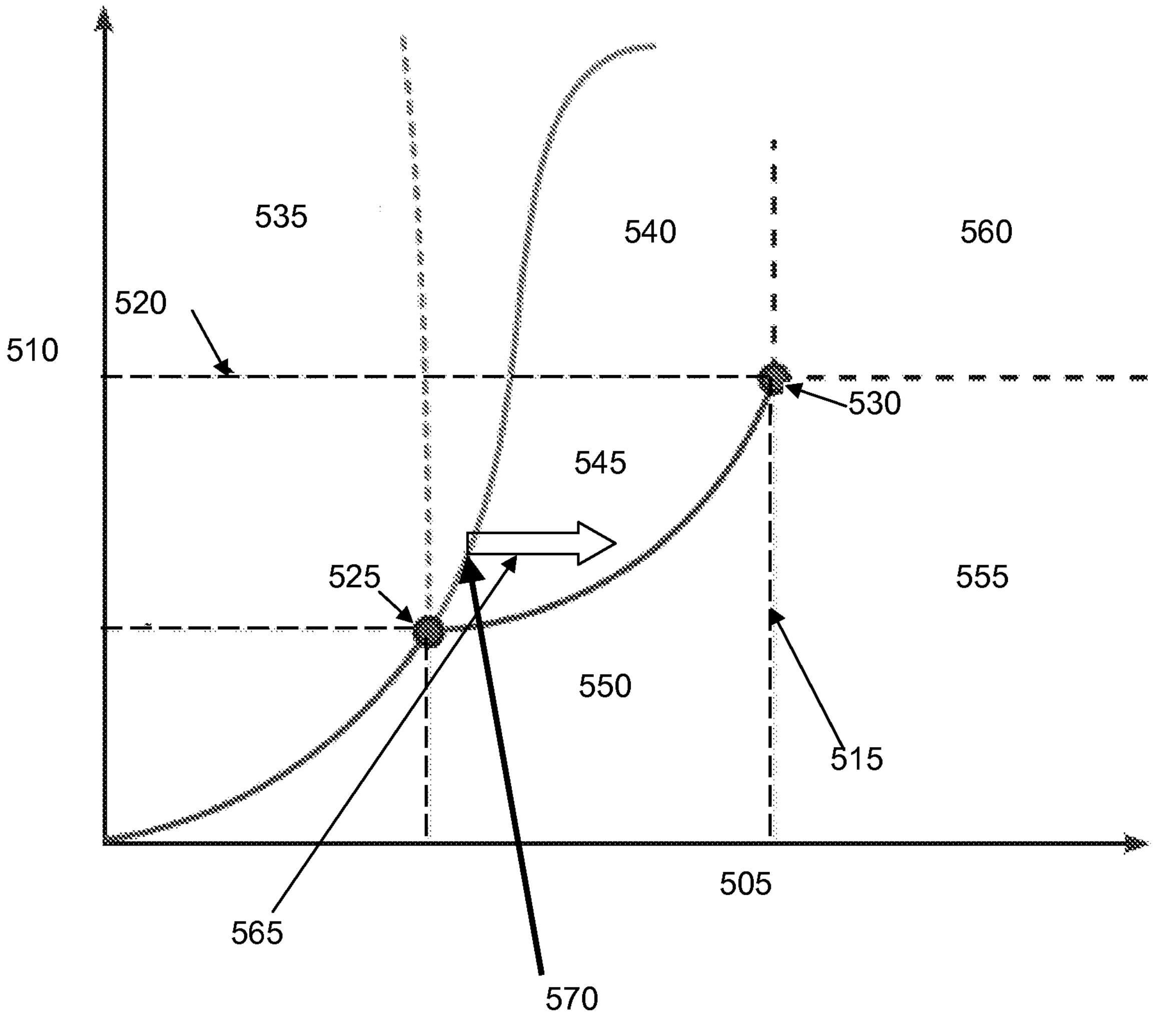

FIG. 5

600

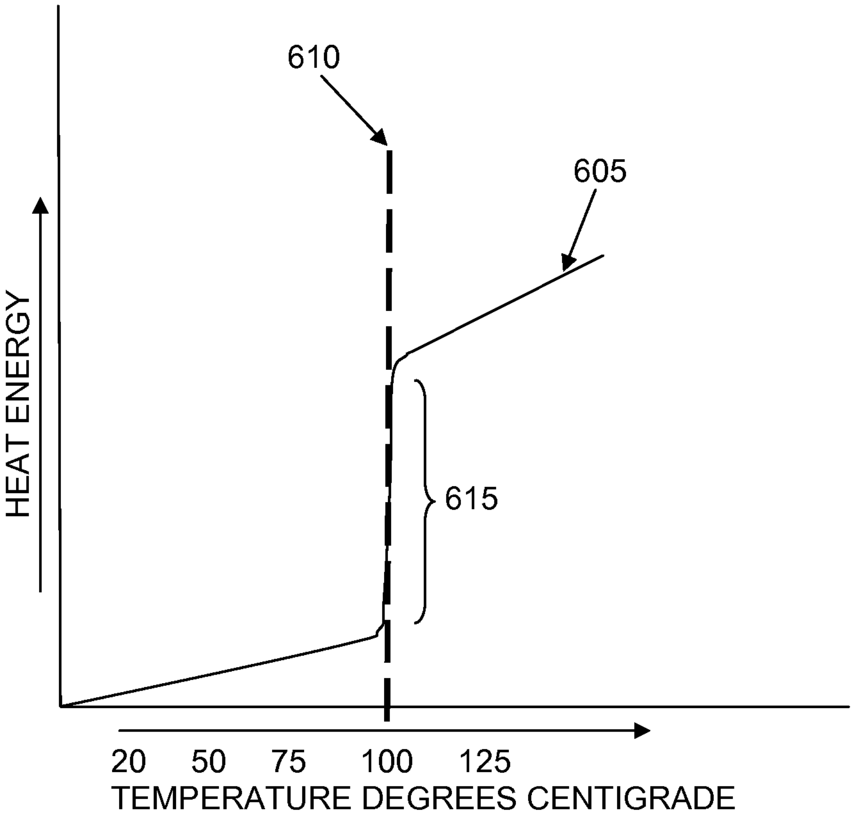
610
605
615
HEAT ENERGY
20
50
75
100
125
TEMPERATURE DEGREES CENTIGRADE

FIG. 6

700

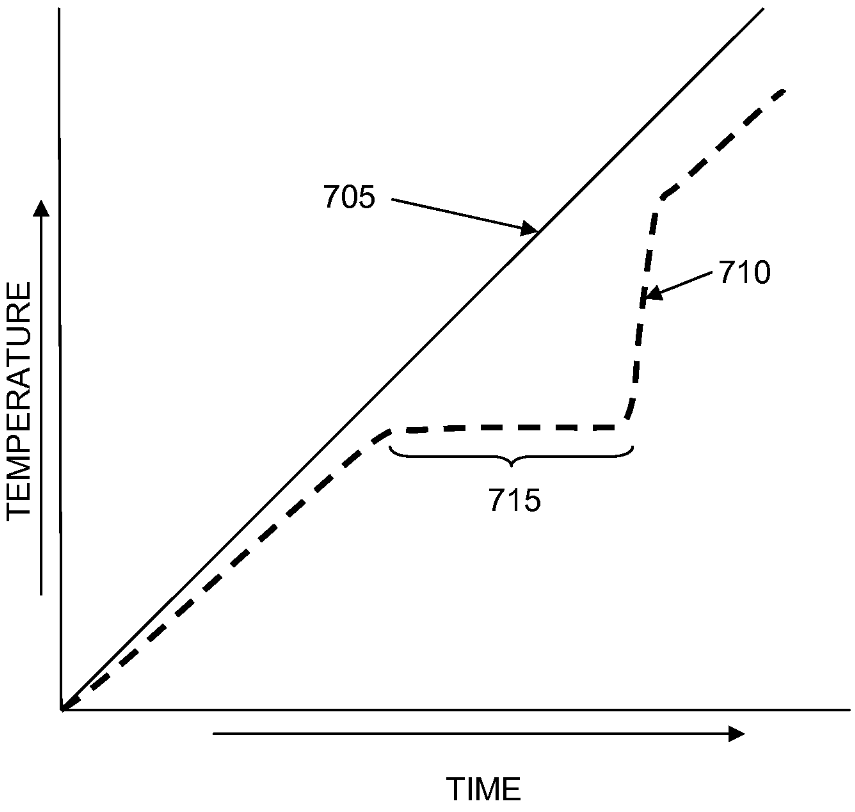

FIG. 7

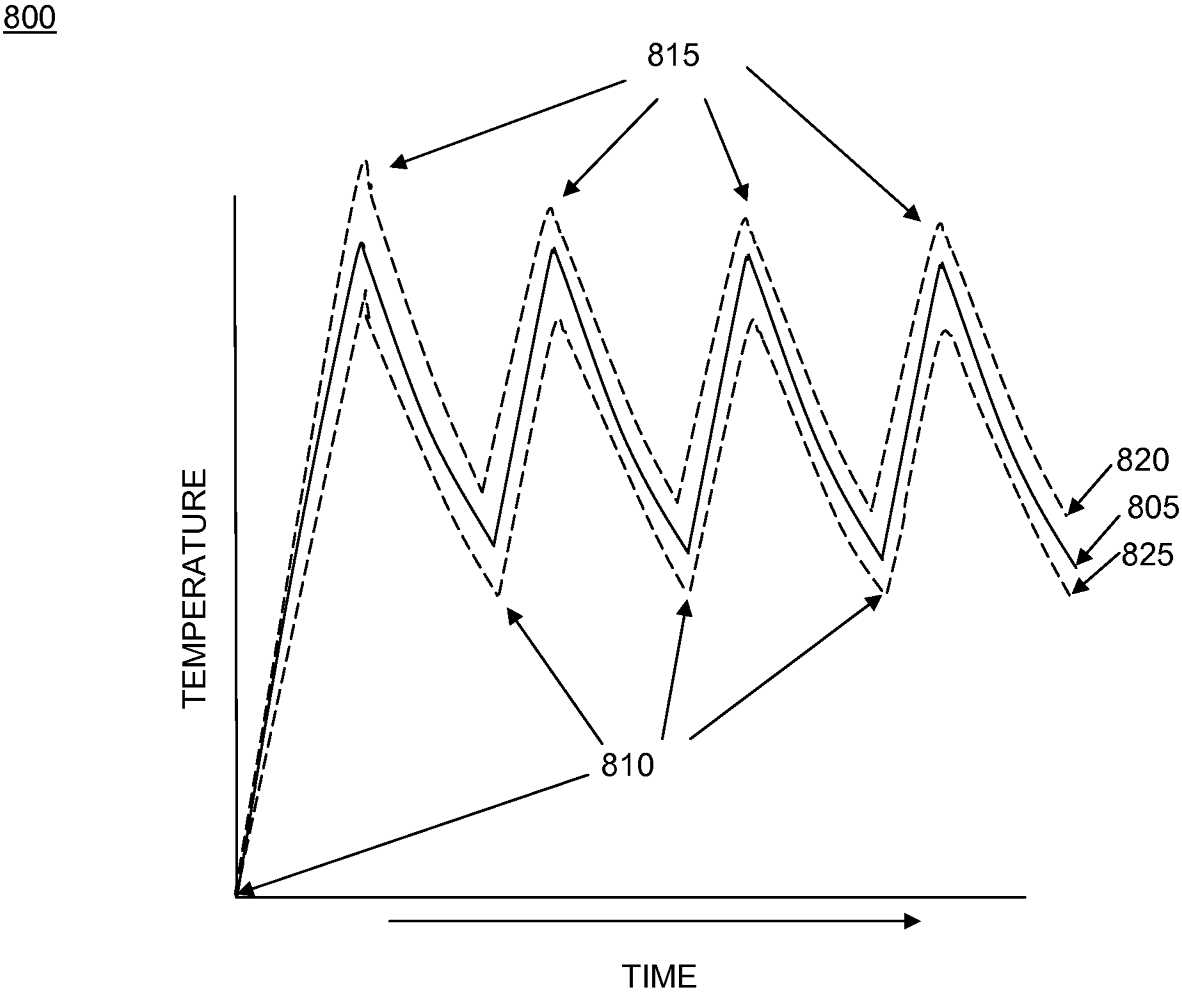

FIG.8

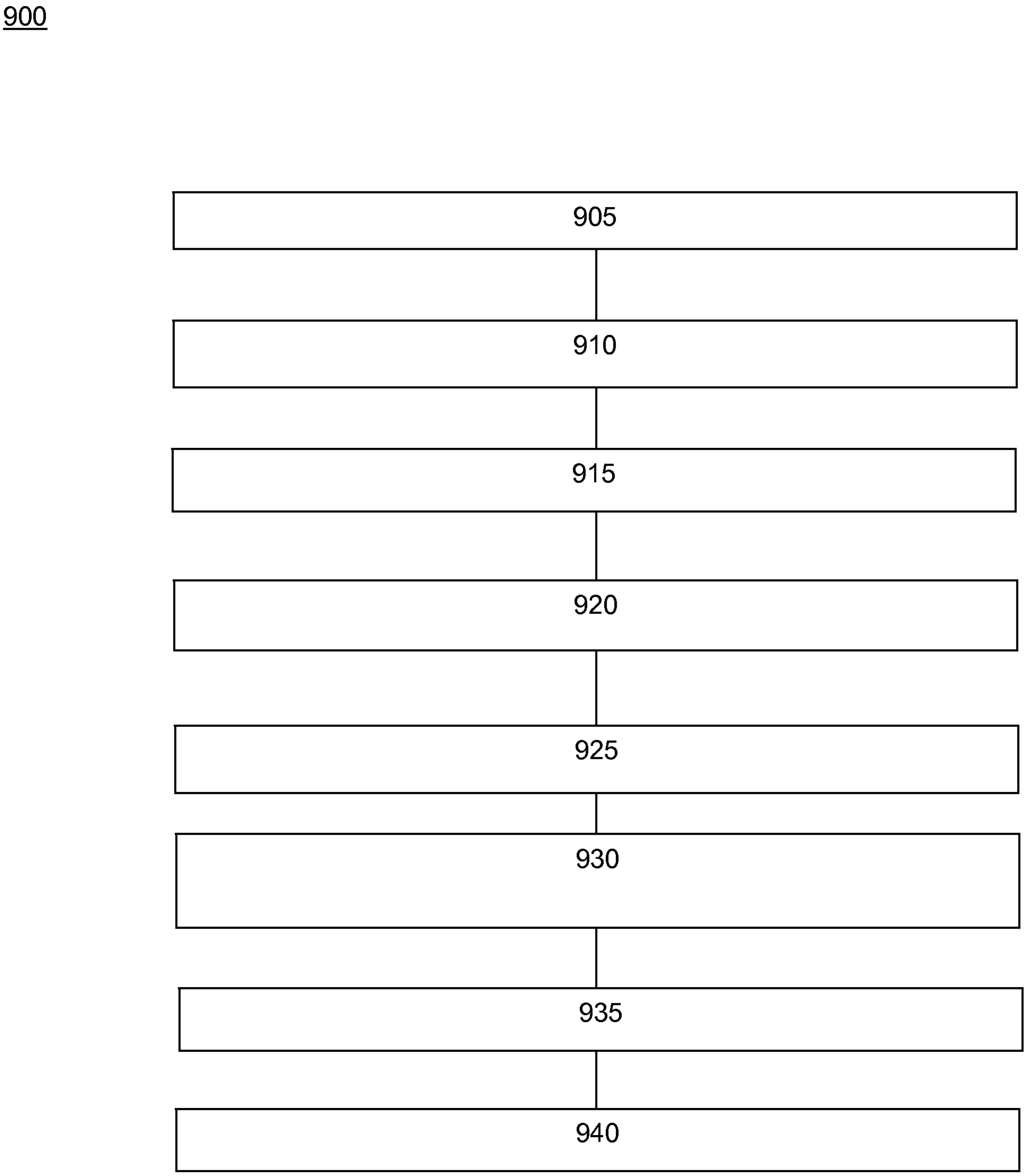

FIG. 9

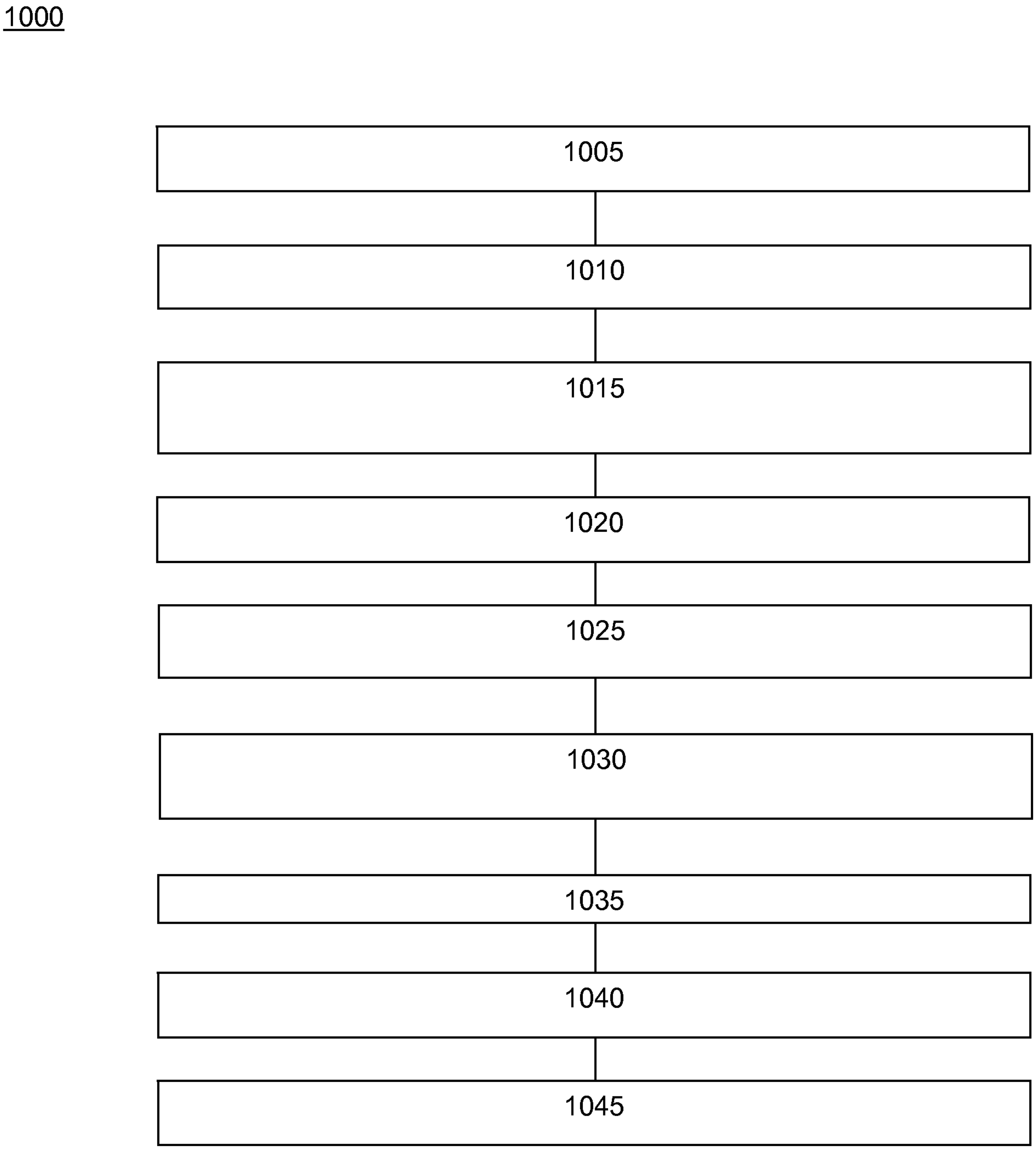

FIG. 10

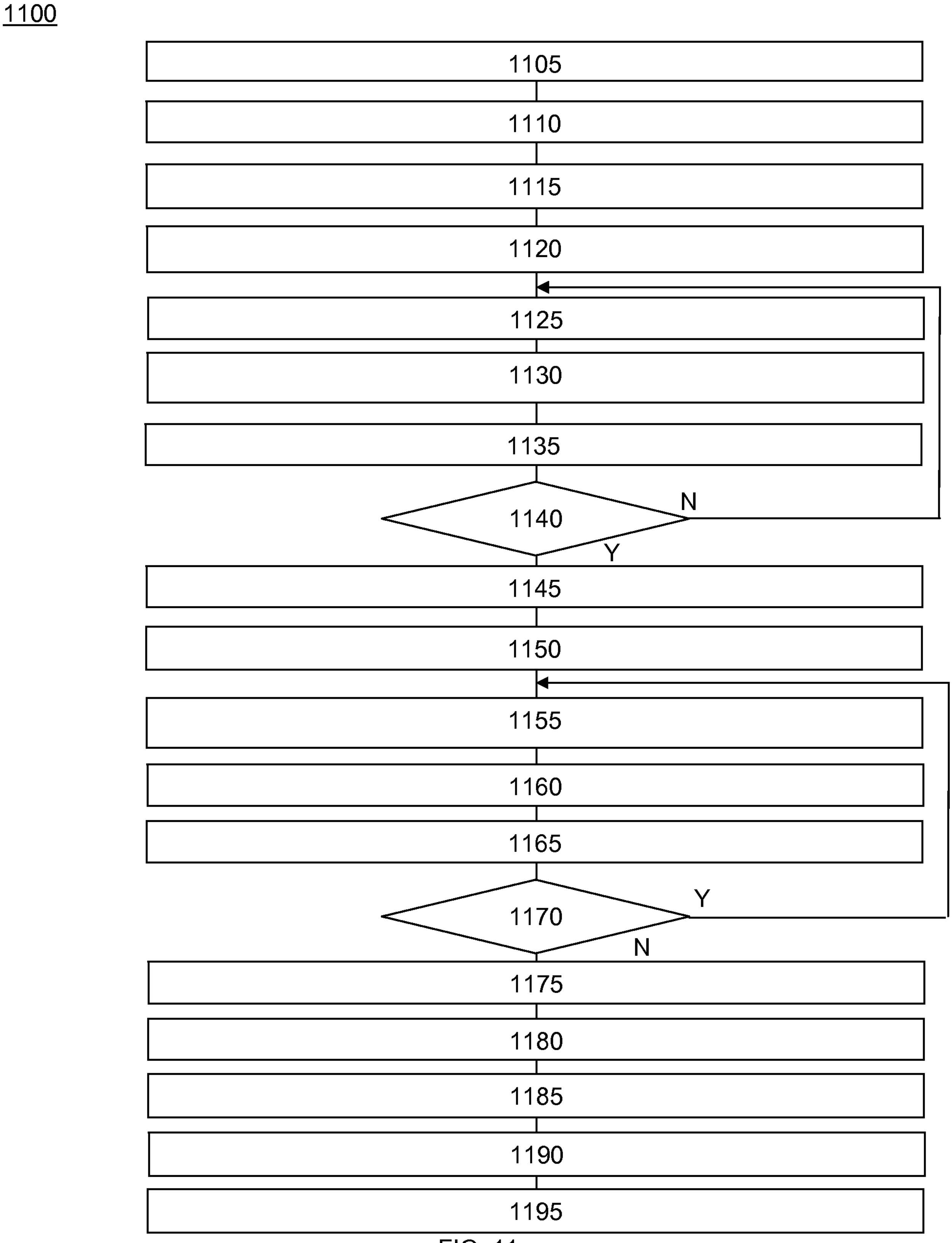
1100
1105
1110
1115
1120
1125
1130
1135
1140
N
Y
1145
1150
1155
1160
1165
1170
Y
N
1175
1180
1185
1190
1195

FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/040184

A. CLASSIFICATION OF SUBJECT MATTER

F24C 7/08(2006.01)i, F24C 15/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F24C 7/08; A21B 1/00; A23L 1/00; G01K 1/20; G01K 15/00; A47J 37/04; F24C 3/12; F24C 15/18; G05D 23/00; F24C 15/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & keywords: cooking oven, calibration, wireless temperature probe, thermostat, calibration material

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2002-0189462 A1 (WILLIAM YOUNGER GUESS) 19 December 2002 See paragraphs [0039]-[0042], [0077]; figures 1-4; and claim 1.	1-3,8
A		9,15
Y	US 6854883 B2 (RICHARD RUND et al.) 15 February 2005 See column 5, line 59 - column 7, line 19; and figures 3-5.	1-3,8
A	US 2011-0232624 A1 (ENRICO FRANZOLIN) 29 September 2011 See paragraphs [0010]-[0016]; and figure 1.	1-3,8,9,15
A	US 2008-0110999 A1 (DAVID ALAN JEROVSEK) 15 May 2008 See paragraphs [0017]-[0027]; and figure 1.	1-3,8,9,15
A	KR 10-2006-0013783 A (LG ELECTRONICS INC.) 14 February 2006 See pages 3, 4; and figures 4, 5.	1-3,8,9,15

☐ Further documents are listed in the continuation of Box C. ☒ 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
29 September 2014 (29.09.2014)

Date of mailing of the international search report
29 September 2014 (29.09.2014)

Name and mailing address of the ISA/KR
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/040184

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 4-7,10-14
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required addtional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of any additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/040184

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2002-0189462 A1	19/12/2002	US 2005-0160920 A1	28/07/2005
US 6854883 B2	15/02/2005	US 2004-0170213 A1	02/09/2004
US 2011-0232624 A1	29/09/2011	DE 102011014669 A1	10/05/2012
		IT PD20100093 A1	24/09/2011
US 2008-0110999 A1	15/05/2008	US 7608803 B2	27/10/2009
		WO 2008-060856 A2	22/05/2008
		WO 2008-060856 A3	21/08/2008
KR 10-2006-0013783 A	14/02/2006	None	