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(54) **Heating apparatus with infrared temperature sensor measuring temperature of food**

(57) A heating apparatus such as a microwave oven includes a heating chamber (4) in which food to be cooked is accommodated, an infrared temperature sensor (16) including an infrared sensing element (19) measuring an amount of infrared radiated from the food accommodated in the heating chamber (4) and a sensor temperature measuring unit (20) for measuring a temperature of the infrared sensing element (19), a specifying unit (23) for specifying a temperature of the food

on the basis of data of measurement by the infrared sensing element (19) and data of measurement by the sensor temperature measuring unit (20), and a control device (23) for controlling a cooking operation on the basis of the temperature specified by the specifying unit (23) and carrying out a control manner on the basis of the data of measurement by the sensor temperature measuring unit (20) so that the cooking operation is normally carried out.

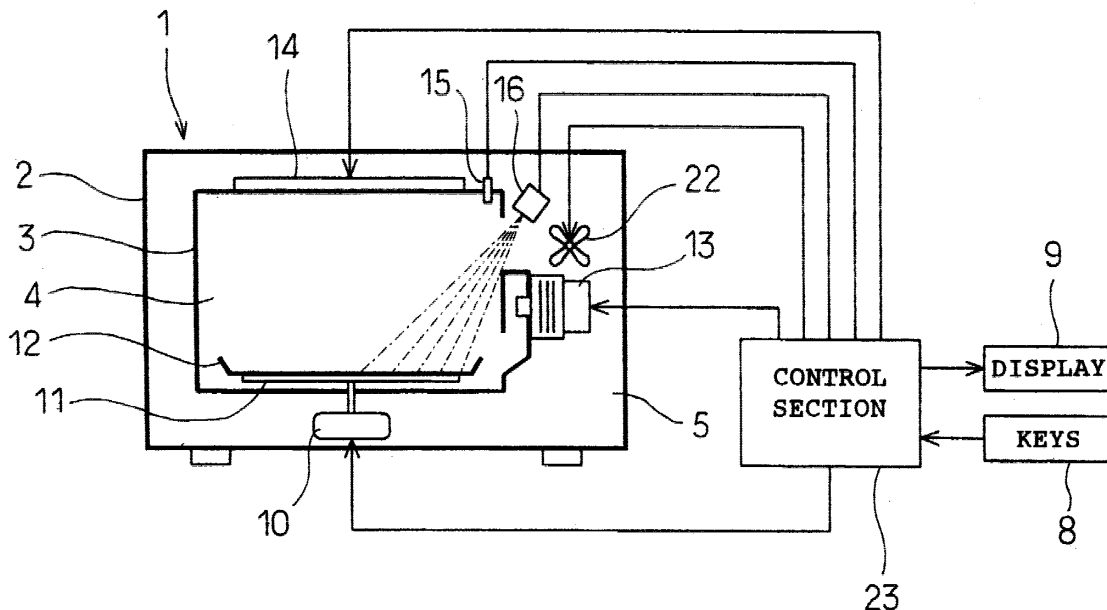


FIG. 3

Description

[0001] This invention relates to a heating apparatus provided with an infrared temperature sensor for measuring a temperature of food accommodated in a heating chamber.

[0002] Heating apparatuses such as microwave ovens have been provided which include an infrared temperature sensor serving as temperature detecting means provided on a side wall or ceiling of a heating chamber for measuring a temperature of food accommodated in the heating chamber. The infrared temperature sensor comprises an infrared sensing element such as a thermopile and a sensor temperature measuring element measuring a temperature of the infrared temperature sensor itself. The microwave oven includes a control section specifying the temperature of the food on the basis of data of measurement by the infrared temperature sensor and data of measurement by the sensor temperature measuring element. The control section controls a cooking operation on the basis of a specified temperature of the food.

[0003] Temperature detecting means, heating means, cooling means and equipment such as a turntable are required to be maintained in a normal state in order that the heating operation may be carried out normally. For example, since the infrared temperature sensor is an electronic component, a range of temperature at which the microwave oven is used is previously set. Accordingly, the temperature of the infrared temperature sensor needs to be maintained in the temperature range even during execution of the heating.

[0004] In view of the above problem, conventional microwave ovens have been designed so that a cooling structure for the infrared temperature sensor has a sufficient heat tolerance. However, a space for installation of the infrared temperature sensor is increased when the cooling structure for the infrared temperature sensor has the sufficient heat tolerance. Furthermore, since heat shield is required for the infrared temperature sensor, the size and cost of the microwave oven will be increased.

[0005] Therefore, an object of the present invention is to provide a heating apparatus which can maintain a desired working condition for normal execution of the heating.

[0006] The present invention provides a heating apparatus comprising a heating chamber in which food to be cooked is accommodated, an infrared temperature sensor provided for measuring a temperature of the food in the heating chamber, characterized in that the infrared temperature sensor includes an infrared sensing element measuring an amount of infrared radiated from the food accommodated in the heating chamber and sensor temperature measuring means for measuring a temperature of the infrared sensing element, and characterized by specifying means for specifying a temperature of the food on the basis of data of measurement by the infrared

sensing element and data of measurement by the sensor temperature measuring means, and control means for controlling a cooking operation on the basis of the temperature specified by the specifying means and carrying out a control manner on the basis of the data of measurement by the sensor temperature measuring means so that the cooking operation is normally carried out.

[0007] According to the above-described heating apparatus, the specifying means specifies a temperature of the food, using the data of measurement by the sensor temperature measuring means. Furthermore, the control means carries out a control so that the cooking operation is normally performed, using the data of measurement by the sensor temperature measuring means. In this case, the control includes controlling the equipment of the heating apparatus, for example, cooling means or heating means. Consequently, maintenance of the desired operating condition for normal execution of the heating operation can be carried out without addition of a special mechanical structure or special detecting means, for example, the infrared temperature sensor can properly be protected against an overheated condition.

[0008] The invention will be described, merely by way of example, with reference to the accompanying drawings, in which:

FIG. 1 is a flowchart showing control contents of a control section employed in a microwave oven of one embodiment in accordance with the present invention;

FIG. 2 is a perspective view of the microwave oven with a door being eliminated;

FIG. 3 schematically illustrates an electrical arrangement of the microwave oven;

FIG. 4 is a schematic view of an infrared temperature sensor;

FIG. 5 schematically illustrates a range of temperature measured by the infrared temperature sensor; FIG. 6 is a graph showing the changes in an interior temperature and the changes in a sensor temperature in a heater cooking mode; and

FIG. 7 is a graph showing determination of an abnormal condition of an interior temperature sensor and infrared temperature sensor.

[0009] One embodiment of the present invention will be described with reference to the drawings. The invention is applied to a microwave oven with an oven function. Referring first to FIGS. 2 and 3, the microwave oven serving as the heating apparatus comprises a body 1 including a horizontally long generally rectangular outer cabinet 2 and a generally rectangular inner casing 3 having an open front. The inner casing 3 has an interior serving as a heating chamber 4. A space on the right of the inner casing 3 serves as an electrical component chamber 5. A door 6 is rotatably mounted on the front

of the body 1 so as to close and open the front of the heating chamber 4. An operation panel 7 is provided on the front of the component chamber 5. The operation panel 7 includes a plurality of keys 8 and a display 9 constituting informing means.

[0010] A turntable 11 is mounted on the bottom of the heating chamber 4. The turntable 11 is turned by a drive motor 10. A cooking plate 12 is detachably attached to the turntable 11 so as to be turned with the latter. Right and left side walls of the inner casing 3 are formed with two plate supports 3a on which a square plate (not shown) used in an oven mode is supported, respectively, as shown in FIG. 2. A magnetron 13 constituting heating means is mounted on the side wall of the inner casing 3 at the component chamber 5 side in the component chamber 5. When actuated, the magnetron 13 supplies microwaves into the heating chamber 4 so that food accommodated in the heating chamber 4 is heated. A heater 14 for the oven mode is mounted on a ceiling of the inner casing 3. The heater 14 constitutes heating means. Furthermore, an interior temperature sensor 15 is also provided on the ceiling of the inner casing 3 for measuring a temperature in the heating chamber 4. The interior temperature sensor 15 comprises a thermistor, for example.

[0011] An infrared temperature sensor 16 is provided on an upper portion of the side wall of the inner casing 3 at the component chamber 5 side. As shown in FIG. 4, the infrared temperature sensor 16 includes a casing 17 in which a wiring board 18 carrying an infrared sensing element 19 and a sensor temperature measuring element 20 thereon is provided. An imaging lens 21 is mounted on a front portion of the casing 17. The infrared sensing element 19 comprises eight thermopiles. A sensor temperature measuring element 20 is provided for measuring a temperature of the infrared temperature sensor 16 as sensor temperature measuring means.

[0012] The infrared temperature sensor 16 is composed into a line sensor in which the eight infrared sensing elements 19 are aligned horizontally. Eight areas 19a are set along the radius of the cooking plate 12 as shown in FIG. 5. The sensing elements 19 measure amounts of infrared radiated in the respective areas 19a. Accordingly, even when food A is placed any part on the cooking plate 12, the infrared temperature sensor 16 can measure the temperature of food A by rotation of the turntable 11.

[0013] A cooling fan 22 serving as cooling means is provided in the component chamber 5 as shown in FIG. 3. The magnetron 13, infrared temperature sensor 16, etc. disposed in the component chamber 5 are cooled upon drive of the cooling fan 22. A control section 23 including a microcomputer is provided at the rear of the operation panel 7. The control section 23 serves as food temperature specifying means and control means in the invention. The keys 8, the interior temperature sensor 15 and the infrared temperature sensor 16 deliver respective signals, which are supplied into the control sec-

tion 23. Regarding the infrared temperature sensor 16, signals delivered from the respective sensing elements 19 and a signal delivered from the single sensor temperature measuring element 20 are sequentially transmitted through a single signal line. The control section 23 controls the display 9, drive motor 10, magnetron 13, heater 14 and cooling fan 22 on the basis of the signals delivered from the keys 8, interior temperature sensor 15, infrared temperature sensor 16, and a program previously stored thereon.

[0014] When the above-described microwave oven is operated as a cooking range, food is placed on the cooking plate 12 and the door 6 is closed. Subsequently, the keys 8 are operated so that a range mode is set. The control section 23 then drives the motor 10 and oscillates the magnetron 13 so that the food on the plate 12 is cooked by means of microwaves while being rotated. In this case, the temperature of the food placed on the plate 12 is measured by the infrared temperature sensor 16. The control section 23 specifies the temperature of the food on the basis of data of measurement by the sensor 16, controlling the magnetron 13 on the basis of the specified temperature.

[0015] The measurement of the food temperature by the infrared temperature sensor will now be described. Data of measured temperature of the sensor 16 itself is required in order that the sensor 16 using the infrared sensing elements 19 comprising thermopiles respectively may measure a temperature of an object. For this purpose, the sensor 16 includes the single sensor temperature measuring element 20 as well as the eight infrared sensing elements 19. The sensing elements 19 measure amounts of infrared in a plurality of portions of the food placed on the plate 12. Furthermore, the element 20 measures a temperature of the infrared temperature sensor 16. Signals (data of measurement) delivered from the respective elements 19 and a signal (data of measurement) delivered from the element 20 are supplied into the control section 23. Based on the supplied measurement data, the control section 23 specifies a temperature of the food.

[0016] On the other hand, when the microwave oven is operated as a cooking oven, food is placed on a square plate (not shown), which is then supported on the plate supports 3a so that the food is accommodated in the heating chamber 4. The door 6 is then closed and the keys 8 are operated so that an oven mode is set. The control section 23 then energizes the heater 14 so that heat is generated. The food is heated by the heater 14 to be cooked. In this case, the temperature in the heating chamber 4 is measured by the interior temperature sensor 15. The control section 23 specifies the temperature in the heating chamber 4 on the basis of the data of measurement by the sensor 15 (hereinafter, "interior temperature"), controlling the heater 14 on the basis of the specified temperature.

[0017] In the above-described oven mode, the temperature in the heating chamber 4 is increased to a high

temperature, for example, about 250°C and accordingly, the temperature of the sensor 16 mounted on the side wall of the inner casing 3 at the component chamber 5 side is also increased. The sensor 16 which is an electronic component has a predetermined temperature range thereof. An excessive temperature may result in a failure in the sensor 16. FIG. 6 shows the changes in an interior temperature in the heating chamber 4 and the changes in a sensor temperature in the oven mode. The control section 23 initially sets a target interior temperature at 250°C and performs a temperature control. However, the temperature of the sensor 16 is also increased due to the heating by the heater 14. Accordingly, when the temperature control is continued with the target temperature being maintained at 250°C, there is a possibility that the temperature of the sensor 16 may exceed a proof upper limit temperature of 90°C. In view of this problem, the control section 23 carries out a routine for protection of the sensor 16 and determination of abnormal condition as shown in FIG. 1 at predetermined intervals in the execution of the oven mode. At step S1 in FIG. 1, the control section 23 determines whether a temperature of the sensor 16 measured by the measuring element 20 (sensor temperature) is higher than a preset temperature of 85°C for determination of the abnormal condition. When the sensor temperature is at or below 85°C, the control section 23 determines in the negative (NO), advancing to step S2. The control section 23 detects changes in the sensor temperature with lapse of time or a change rate of the sensor temperature to determine whether the sensor temperature has increased 30°C or more in 5 seconds or whether a reference change rate has been exceeded. When the sensor temperature has not increased 30°C or more in 5 seconds, the control section 23 determines in the negative (NO), advancing to step S3.

[0018] At step S3, the control section 23 determines whether the sensor temperature is higher than $(\text{interior temperature} \times 0.3 + 20)^\circ\text{C}$. When the sensor temperature is equal to or lower than $(\text{interior temperature} \times 0.3 + 20)^\circ\text{C}$, the control section 23 determines in the negative, advancing to step S4. The control section 23 determines at step S4 whether the sensor temperature is lower than $(\text{interior temperature} \times 0.25 - 20)^\circ\text{C}$. when the sensor temperature is equal to or higher than $(\text{interior temperature} \times 0.25 - 20)^\circ\text{C}$, the control section 23 determines in the negative, advancing to step S5. When both measuring element 20 and sensor 15 are normal, there is a correlation between the measurement data (sensor temperature) of the measuring element 20 and the measurement data (interior temperature) of the sensor 15 as shown in FIG. 7. When both measurement data are within a range shown by slashes in FIG. 7, the measuring element 20 and the sensor 15 are determined to be normal. When both measurement data are outside the range, either one or both of the element 20 and the sensor 15 are determined to be abnormal. The control section 23 determines at step S5 whether the sensor

temperature is equal to or higher than a predetermined temperature of 70°C. When the sensor temperature is equal to or lower than the predetermined temperature, the control section 23 determines in the negative, returning to step S1. When the sensor temperature is higher than 70°C, the control section 23 determines in the affirmative, advancing to step S6. At step S6, the control section 23 starts the cooling fan 22 and changes the target interior temperature from 250°C to 200°C, for example. The infrared temperature sensor 16 is cooled upon drive of the cooling fan 22. As a result, an increase in the temperature of the sensor 16 is limited. Consequently, the temperature of the sensor 16 drops and can accordingly be prevented from exceeding the proof upper limit temperature.

[0019] When determining at step S1 that the sensor temperature has exceeded 85°C, the control device 23 advances to step S7 to interrupt the heating. Also when determining at step S2 that the sensor temperature has changed by 30°C in 5 seconds, the control section 23 advances to step S7 to interrupt the heating. Further when determining at step S3 that the sensor temperature is higher than $(\text{interior temperature} \times 0.3 + 20)^\circ\text{C}$ and when determining at step S4 that the sensor temperature is lower than $(\text{interior temperature} \times 0.25 - 20)^\circ\text{C}$, the control section 23 also advances to step S7 to interrupt the heating. In each of the aforesaid cases, the control section 23 further advances to step S8 to display occurrence of an abnormal condition and the contents of the abnormal condition on the display 9.

[0020] The measuring element 20 is provided for specifying the temperature of food. The measurement data (sensor temperature) of the measuring element 20 is used for other purposes, that is, for controlling the cooling fan 22 and for changing the target interior temperature. Consequently, the infrared temperature sensor 16 is protected from an increase in the temperature thereof upon the heating operation by the heater 14 and can accordingly be maintained in a predetermined temperature range.

[0021] Thus, the measurement data of the measuring element 20, which is conventionally used only for specifying the temperature of food to be cooked, is also used for protection of the infrared temperature sensor 16. Consequently, the cooling structure for the sensor 16 need not be designed so as to have a sufficient heat tolerance. Since this reduces an installation space for the sensor 16 and no heat shielding means is required for the sensor 16, increases in the size and cost of the microwave oven can be prevented and the sensor 16 can desirably be used in the predetermined temperature range.

[0022] In the oven mode with the heater 14 used, the control section 23 compares the measurement data (sensor temperature) of the measuring element 20 and the measurement data (interior temperature) of the sensor 15, thereby determining whether at least one of the sensors 15 and 16 is in an abnormal condition. Further-

more, the control section 23 determines whether the measurement data (sensor temperature) of the measuring element 20 has reached a predetermined temperature (85°C) for determination of an abnormal condition, thereby determining whether the sensor 16 is in an abnormal condition. The temperature of the side wall of the heating chamber 4 is increased during the heating operation and accordingly, the temperature of the sensor 16 is also increased. After completion of the cooking, the interior of the heating chamber 4 is cooled such that the temperature of the sensor 16 is gradually reduced. If the sensor 16 should fail such that the temperature thereof could not be detected, the temperature of the sensor would take a value differing from the measurement data obtained before the failure with high possibility. Then, if the change rate of the measurement data (sensor temperature) of the element 20 is previously detected, a sudden change can be seen in the measurement data. Accordingly, based on the change rate of the measurement data, the control section 23 can determine whether the sensor 16 is in an abnormal condition. [0023] Furthermore, since the control section 23 interrupts the cooking when determining that the sensor 15 or 16 is in an abnormal condition, the safety of the microwave oven can be improved. Additionally, since the display 9 displays an indication of occurrence of abnormal condition, the user can easily understand the occurrence of the abnormal condition.

[0024] The measurement data (sensor temperature) of the element 20 may be used for purposes other than protecting the sensor 16. For example, the element 20 may be used instead of the sensor 15 or as a spare sensor in case of failure of the sensor 15 in the oven mode. Furthermore, the drive motor 10 may be controlled on the basis of the measurement data of the element 20.

[0025] The foregoing description and drawings are merely illustrative of the principles of the present invention and are not to be construed in a limiting sense. Various changes and modifications will become apparent to those of ordinary skill in the art. All such changes and modifications are seen to fall within the scope of the invention as defined by the appended claims.

Claims

1. A heating apparatus comprising a heating chamber (4) in which food to be cooked is accommodated, an infrared temperature sensor (16) provided for measuring a temperature of the food in the heating chamber (4), **characterized in that** the infrared temperature sensor (16) includes an infrared sensing element (19) measuring an amount of infrared radiated from the food accommodated in the heating chamber (4) and sensor temperature measuring means (20) for measuring a temperature of the infrared sensing element (19), and **characterized by** specifying means (23) for specifying a temperature

of the food on the basis of data of measurement by the infrared sensing element (19) and data of measurement by the sensor temperature measuring means (20), and control means (23) for controlling a cooking operation on the basis of the temperature specified by the specifying means (23) and carrying out a control manner on the basis of the data of measurement by the sensor temperature measuring means (20) so that the cooking operation is normally carried out.

2. A heating apparatus according to claim 1, further **characterized by** an electrical component chamber (5) and cooling means (22) for cooling an atmosphere in the component chamber (5), and in that the infrared temperature sensor (16) is disposed in the electrical component chamber (5), and the control means (23) controls the cooling means (22) on the basis of the data of measurement by the sensor temperature measuring means (20).

3. A heating apparatus according to claim 1, further **characterized by** heating means (13; 14) for heating the food, wherein the control means (23) controls the heating means (13; 14) on the basis of the data of measurement by the sensor temperature measuring means (20).

4. A heating apparatus according to claim 1, further **characterized by** heating means (13; 14) for heating the food, an electrical component chamber (5) and cooling means (22) for cooling an atmosphere in the electrical component chamber (5), and in that the infrared temperature sensor (16) is disposed in the electrical component chamber (5) and the control means (23) controls the cooling means (22) and the heating means (13; 14) on the basis of the data of measurement by the sensor temperature measuring means (20).

5. A heating apparatus according to claim 1, **characterized in that** the control means (23) carries out a protecting control for the infrared temperature sensor (16) so that the cooking operation is normally carried out.

6. A heating apparatus according to claim 2, **characterized in that** the control means (23) controls the cooling means (22) so that the infrared temperature sensor (16) is protected.

7. A heating apparatus according to claim 3, **characterized in that** the control means (23) controls the heating means (13; 14) so that the infrared temperature sensor (16) is protected.

8. A heating apparatus according to claim 1, further **characterized by** a heater (14) for heating the food

and an interior temperature sensor (15) for measuring a temperature in the heating chamber (4), and **characterized in that** the control means (23) controls the heater (14) on the basis of data of measurement by the interior temperature sensor (15) and determines whether at least one of the infrared temperature sensor (16) and interior temperature sensor (15) is in an abnormal condition, on the basis of the data of measurement by the sensor temperature measuring means (20) and the data of measurement by the interior temperature sensor (15).

9. A heating apparatus according to claim 8, further **characterized by** informing means (9), and in that when determining that at least one of the infrared temperature sensor (16) and interior temperature sensor (15) is in an abnormal condition, the control means (23) interrupts the cooking operation and operates the informing means (9) so that an abnormal condition is informed.
10. A heating apparatus according to claim 1, **characterized in that** the control means (23) determines that the infrared temperature sensor (16) is in an abnormal condition, when the data of measurement by the sensor temperature measuring means (20) reaches a predetermined temperature for determination of the abnormal condition.
11. A heating apparatus according to claim 10, further **characterized by** informing means (9), and in that when determining that the infrared temperature sensor (16) is in an abnormal condition, the control means (23) interrupts the cooking operation and operates the informing means (9) so that an abnormal condition is informed.
12. A heating apparatus according to claim 1, **characterized in that** the control means (23) detects a rate of change in the data of measurement by the sensor temperature measuring means (20) and determines that the infrared temperature sensor (16) is in an abnormal condition, when the detected rate of change exceeds a reference rate of change.
13. A heating apparatus according to claim 12, further **characterized by** informing means (9), and in that when determining that the infrared temperature sensor (16) is in an abnormal condition, the control means (23) interrupts the cooking operation and operates the informing means (9) so that an abnormal condition is informed.

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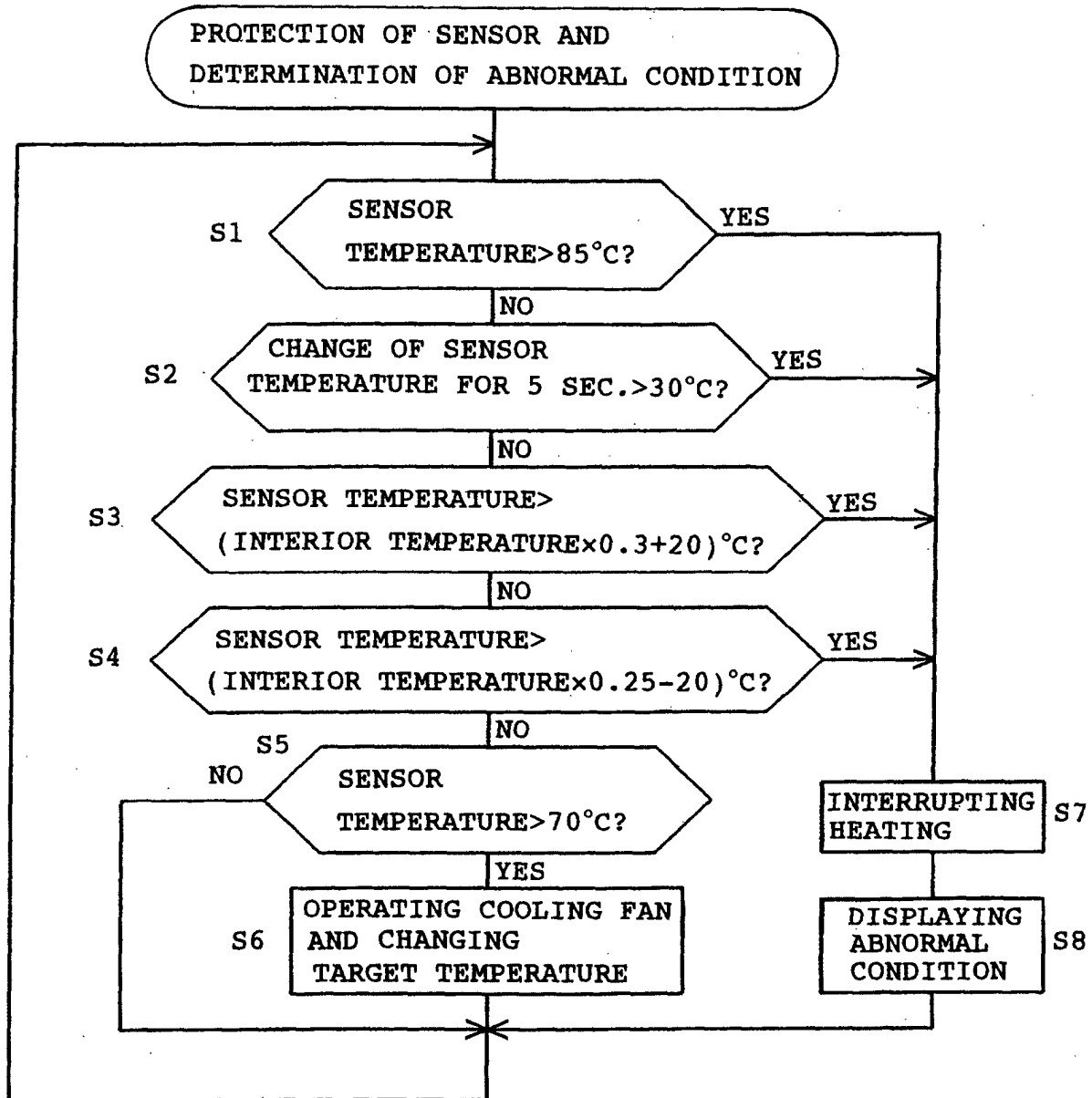


FIG. 1

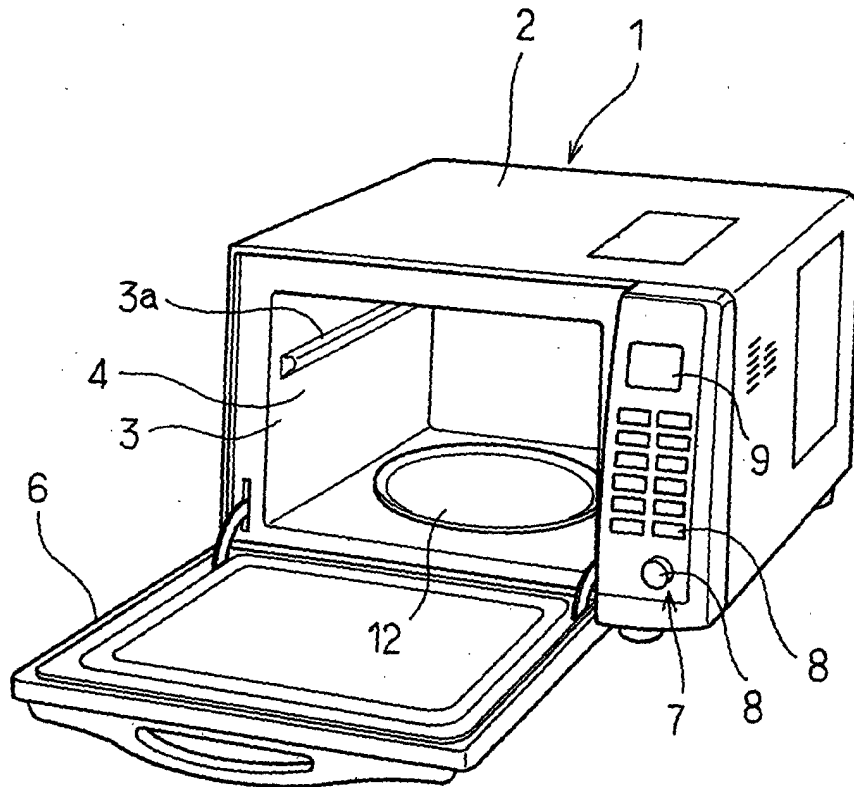


FIG. 2

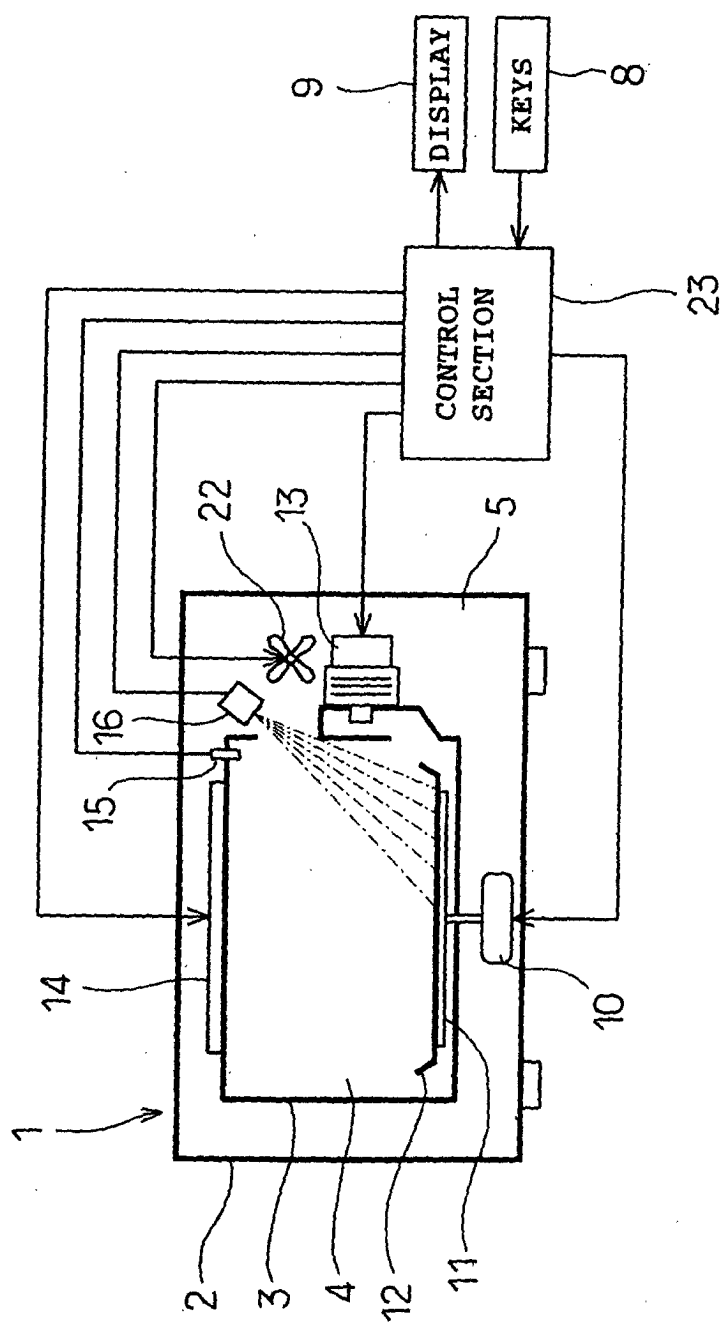


FIG. 3

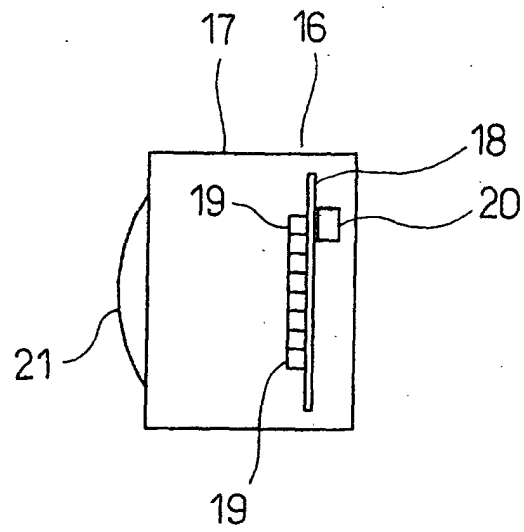


FIG. 4

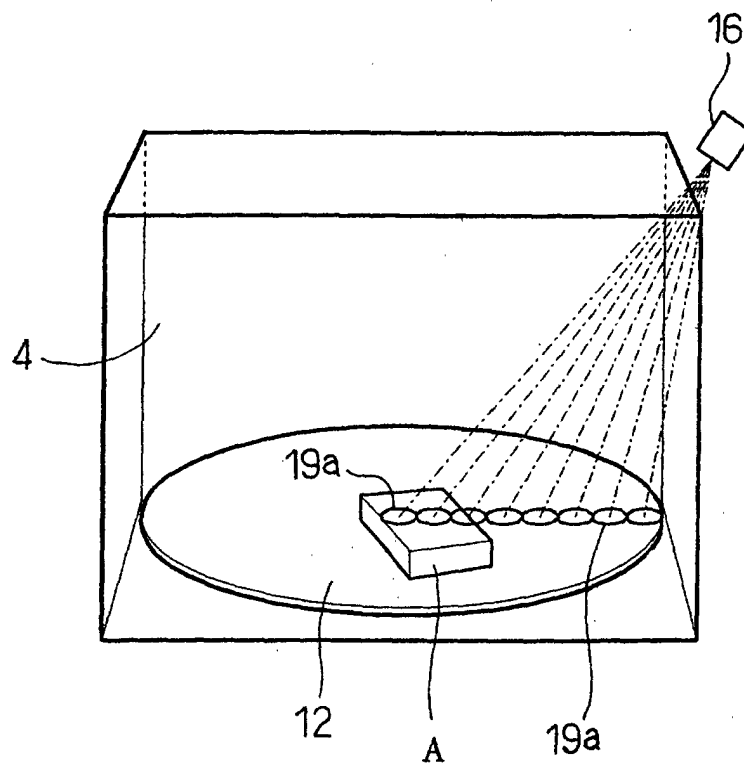


FIG. 5

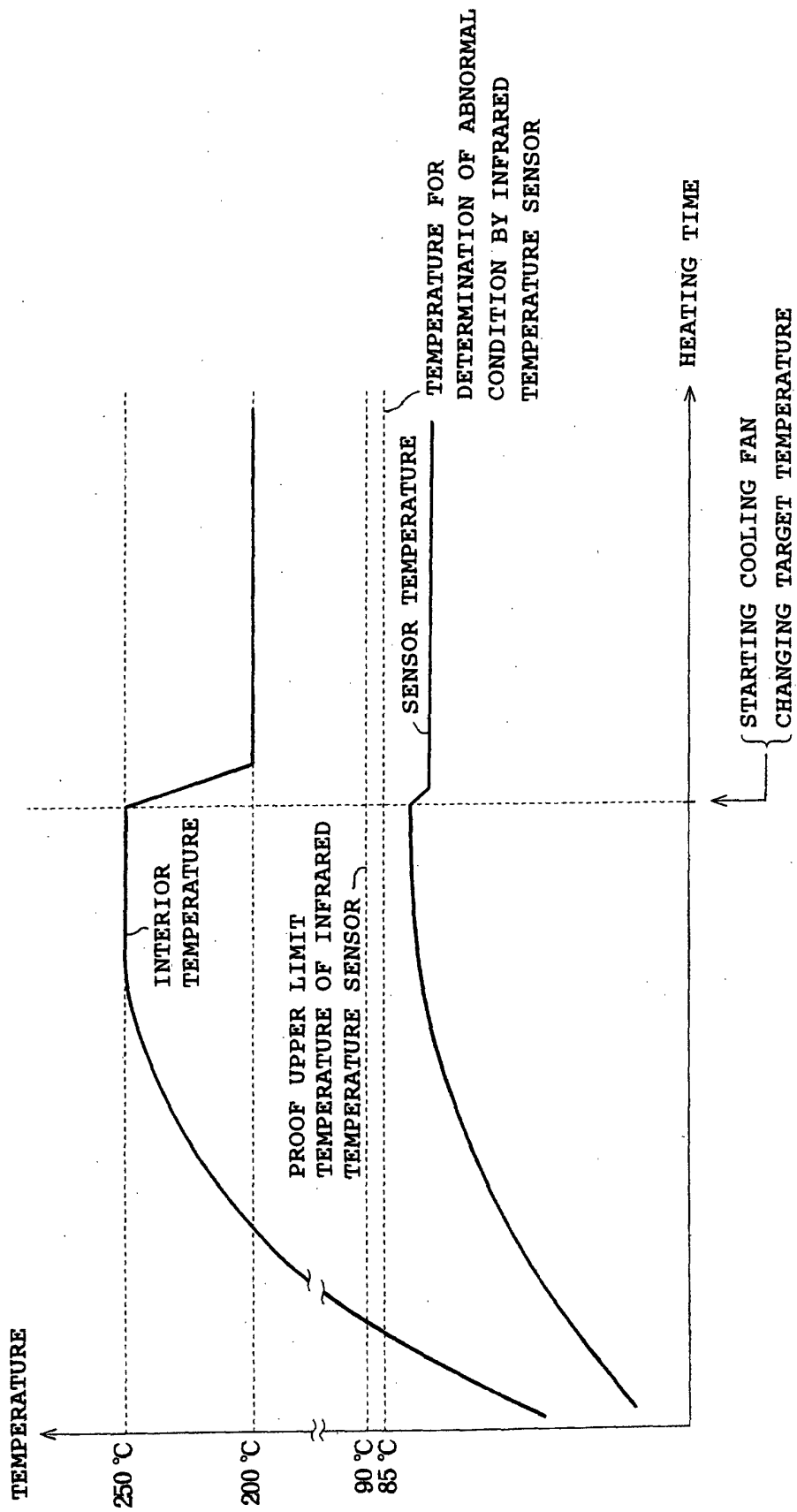


FIG. 6

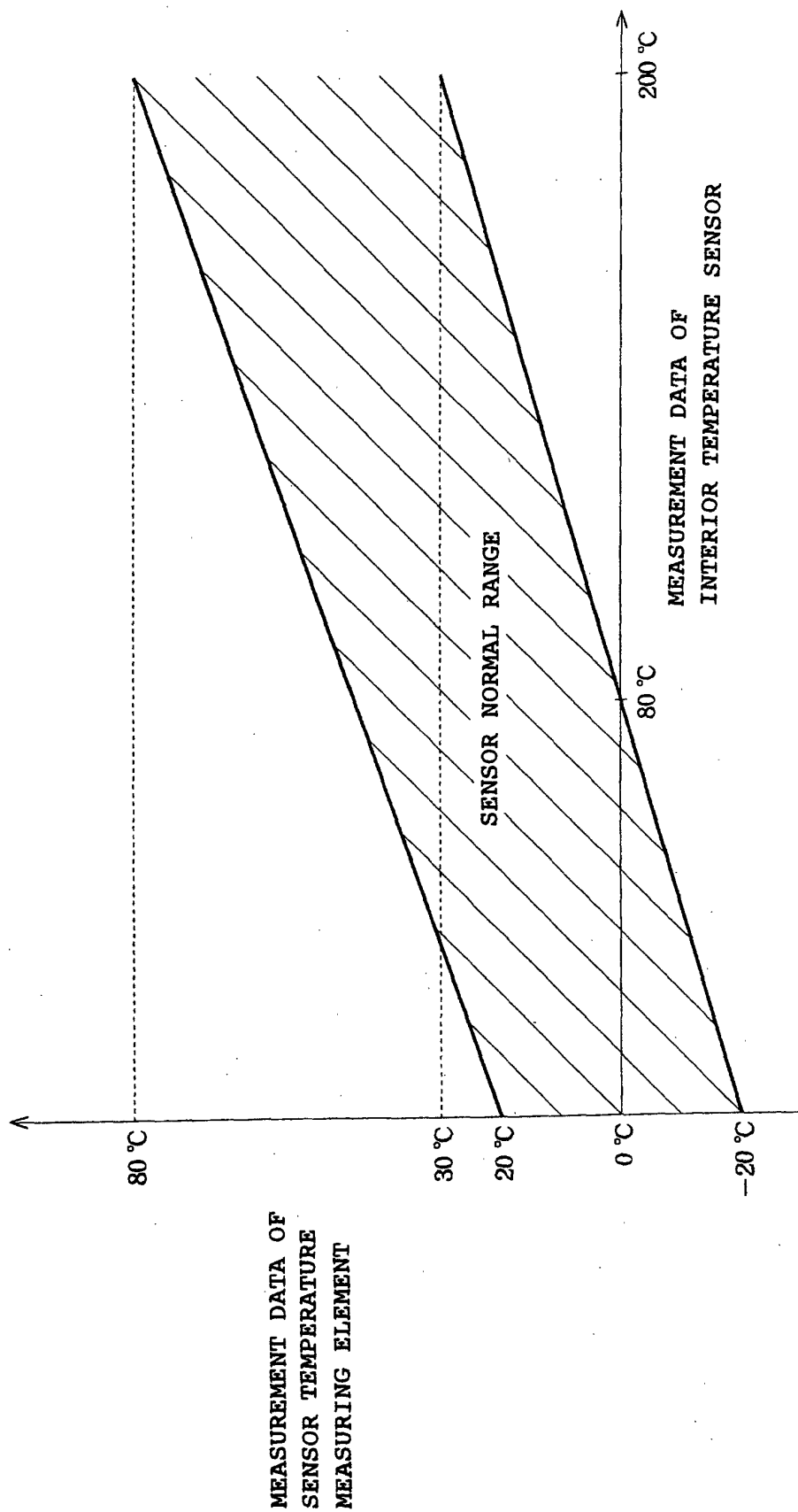


FIG. 7