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(54) Microwave oven and method to control automatically the heating and/or cooking of food in said microwave oven

(57) The microwave oven comprises a magnetron for heating and/or cooking the food; a chamber (4) which allows arranging the food to be heated and/or cooked therein in a fixed manner and which has means (5) for distributing the electromagnetic waves therein; at least two thermal energy sensors (2a and 2b) arranged at different distances and with different angles from the food for detecting the temperature of said food; a control unit for managing the values acquired by said at least two thermal energy sensors (2a and 2b) and regulating the microwave oven operation when heating or cooking the food, wherein said magnetron is controlled by means of a control algorithm based on readings taken of said thermal energy sensors (2a and 2b).

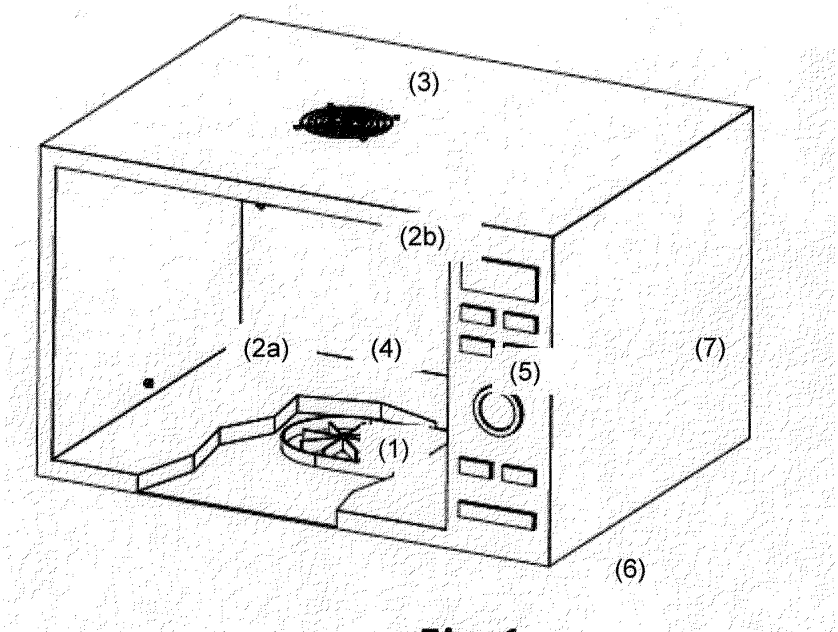

Fig. 1

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Description

Field of the Art

[0001] The present invention generally relates to a microwave oven and to a method in which the temperature of a food to be heated and/or cooked is monitored and controlled, and more particularly, in a first aspect, it relates to a microwave oven which allows automatically setting the time in which a magnetron of the microwave oven is injecting electromagnetic power until reaching a desired food temperature, as a result of a precise measurement of the food temperature depending on readings taken by different temperature sensors strategically arranged in the heating and/or cooking cavity of the microwave oven.

[0002] In a second aspect, the invention relates to a method implemented for automatically setting said operation time until the food reaches a specific temperature based on the food temperature measurements of said temperature sensors, enabling a simplified operation of the microwave oven in several specific operating modes, particularly: for heating to a specific temperature, for keeping food at a given temperature for a specific time period, for cooking at a low or medium temperature, for boiling for a predetermined time, etc., and also a simpler handling thereof by the user.

Background of the Invention

[0003] An automatic control for cooking in a microwave oven based on detecting the humidity in the cooking cavity of the oven is known from documents US 5445009, US 68759369, or EP 0697802. Said documents describe various methods, all of them intended for reducing or eliminating the effect of noise generated by the electromagnetic emission from the microwave oven itself in order to prevent distortions in the humidity readings taken by means of humidity sensors.

[0004] On the other hand, like the present invention, US 5693247 discloses a microwave oven including a precise mechanism for cooking a food based on detecting the temperature of the food arranged on a rotary support and which temperature is monitored by means of at least two temperature sensors separated a different distance in relation to the area that will be occupied by the food. However, in the microwave oven proposed in US 5693247, the temperature detection is performed by compensating the distance existing between the food and said sensors by means of using the answer of a second degree equation.

[0005] One drawback of the mentioned document is that due to the placement of the sensors in the upper portion of the cooking chamber and to the arrangement of the rotary tray, the temperature sensors are not always focused on one and the same point so the readings obtained for the temperature of the foods will need more complex and less precise calculations. Furthermore, the arrangement of sensors proposed by US 5693247 is severely affected by the emission of vapors and gases derived from the food, particularly its water content.

Description of the Invention

[0006] Therefore, there is a general interest in the field of microwave ovens to enable automatically controlling oven operation for a desired cooking and/or heating of different classes of foods (various foods and/or drinks) in said microwave oven, monitoring and controlling the temperature of the foods in a very efficient manner while they are being cooked and/or heated inside said microwave oven.

[0007] To that end according to a first aspect, the invention provides a microwave oven with an automatic control for controlling the temperature of a food to be heated and/or cooked, which conventionally comprises: a magnetron or electromagnetic energy generator for heating and/or cooking the food; a chamber for receiving the food to be heated and/or cooked therein; at least two thermal energy sensors arranged at different distances from the food in said chamber for measuring the temperature of said food; and a control unit for managing the values acquired by said at least two thermal energy sensors and regulating the microwave oven operation when heating or cooking the food.

[0008] In a characteristic manner, and unlike the solutions previously known in the state of the art, in the proposed microwave oven, said at least two thermal energy sensors are arranged oriented with different angles for detecting the temperature of the lower and upper portions of the food; the food is arranged on a fixed supporting surface; the chamber of the oven has means for distributing the electromagnetic waves generated by said magnetron, and said magnetron is controlled by means of a control algorithm housed in said control unit which operates by taking a plurality of readings of said thermal energy sensors, measuring temperature values of the food in the two lower and upper portions a plurality of times, simultaneously with a predetermined electromagnetic energy supply state, said algorithm automatically regulating the electromagnetic energy supply depending on said temperature values measured by said at least two thermal energy sensors, the temperature and energy supply measurement ranges being variable during the time of heating and/or cooking the food in the microwave oven and depend on an objective temperature at which said food is to be heated and/or cooked.

[0009] In a characteristic manner, said predetermined energy supply state is zero or a value below a prefixed threshold suitable for preventing possible interferences which may be produced due to the electromagnetic waves or microwaves generated in said chamber with said thermal energy sensors.

[0010] According to one embodiment, the time variable electromagnetic energy supply can be carried out by means of generating micro-outages in said supplied electromagnetic energy, either at regular or non-regular intervals, the readings of the sensors being taken during said micro-outages, or alternatively, by means of an Inverter® power control system, which will allow reducing the supplied electromagnetic energy level below the prefixed threshold in one or several moments of cooking and/or heating, and in general varying the energy capacity supplied.

[0011] According to another embodiment, the thermal energy sensors are thermopile infrared sensors arranged such that they allow taking reliable and constant readings of the temperature of the food inside the microwave oven, and can thus interact with the magnetron power. In a preferred embodiment, these sensors are arranged in a side wall, positioned slightly above the food supporting plane, and in an upper wall of the chamber, inside or outside the chamber, and oriented such that they are pointing towards a central point of the supporting surface; readings of the most significant points of the food are thus allowed.

[0012] If said sensors are arranged outside the chamber, they will be accessed through one or more holes which will communicate the inside and the outside of the chamber. Said one or more holes will preferably have an opening such that interferences of said electromagnetic waves from said microwave oven with the sensor are prevented.

[0013] The proposed microwave oven further includes an extractor provided for extracting from the chamber water vapor or other possible gases which can be produced when cooking and/or heating said food. According to a preferred embodiment, said extractor will be provided with an extraction mouth spaced away from said at least two thermal energy sensors. On the other hand, the means used for distributing the electromagnetic waves also include a rotary reflector positioned below said food supporting plane.

[0014] According to an alternative embodiment, the microwave oven can also include a home automation module which allows monitoring and/or controlling the objective temperature from a user mobile computing device, for example, with a smartphone, a PDA, a tablet or a computer, etc., and it can further include a safety timer module to prevent overcooking and/or overheating said food.

[0015] In yet another alternative embodiment, the microwave oven can include one or several dedicated push buttons for accessing specific cooking and/or heating programs with electromagnetic energy supply control for at least the following processes: heating up to a prefixed temperature; keeping the temperature for cooking and/or heating the food at a prefixed temperature; cooking at a temperature kept below a prefixed threshold; or boiling a food for a prefixed time.

[0016] According to a second aspect, the invention provides a method for automatically controlling the temperature of a food to be cooked and/or heated in a microwave oven, which conventionally generates electromagnetic energy by means of a magnetron for heating and/or cooking a food placed inside a chamber within a microwave oven, wherein the electromagnetic waves generated by said magnetron are distributed, and wherein at least two thermal energy sensors are arranged in two different areas in said chamber for measuring the temperature of said food.

[0017] In a characteristic manner, the proposed method comprises arranging the food on a fixed supporting surface inside said chamber and orienting said at least two thermal energy sensors for detecting the temperature of the lower and upper portions of the food which, as has been indicated above, is fixed. Furthermore, the provided method controls the electromagnetic energy supply by controlling said magnetron by means of an algorithm which operates by taking a plurality of readings of said thermal energy sensors, measuring temperature values of the food in said two lower and upper portions a plurality of times, simultaneously with a predetermined electromagnetic energy supply state preventing interferences with said thermal energy sensors, said algorithm automatically regulating the electromagnetic energy supply depending on said temperature values measured by said at least two thermal energy sensors in relation to an objective temperature of said cooking and/or heating and, the temperature and energy supply measurement time intervals being the same or variable during the time of heating and/or cooking the food in the microwave oven depending on said objective temperature at which said food is to be heated and/or cooked, such that amounts of electromagnetic energy adapted to the energy necessary for achieving said objective temperature are supplied in the same or different batches.

[0018] Finally and according to one embodiment, the time variable electromagnetic energy supply can be carried out either by means of generating micro-outages determining there between said batches of energy supply or in contrast, by means of an Inverter® power control system determining a reduction in the supplied electromagnetic energy below a prefixed level, said batches of energy supply being defined between two consecutive, reduced energy levels.

[0019] If said supply is generated by micro-outages, the operating cycles of the magnetron transformer are performed at a very high frequency to optimize cooking the foods in a uniform manner. These micro-outages will preferably be closer to one another in time the closer the food gets to the objective temperature to be achieved.

[0020] In addition to compensating for the temperature difference between the food to be heated and/or cooked (content) and the vessel (container) as a result of the continuous temperature detection by the two thermal energy sensors, the present invention will allow, due to the implementation of the mentioned control algorithm, providing a significant overall temperature value of the food which can then be shown to the user, for example, by means of a display.

Brief Description of the Drawings

[0021] The foregoing and other features and advantages will be better understood from the following detailed description of several embodiments in reference to the attached drawings in which:

Figure 1 is an illustration of the microwave oven proposed according to the first aspect of the invention.
Figures 2A, 2B and 2C are the illustrations of the evolution undergone by the electromagnetic energy generated by the magnetron controlled according to the method of this invention depending on the micro-outages or on the Inverter® power according to several embodiments.

Detailed Description of an Embodiment

[0022] In reference to Figure 1, said figure shows a microwave oven which comprises a food supporting surface formed, as is already known in the field, by a ceramic plate 1 which is porous to electromagnetic radiations or microwaves, a centrally arranged electromagnetic wave distribution system 5 (in the illustrated example, the system is made up of a rotor or turbine) to which the electromagnetic waves are driven by a waveguide guiding the waves generated by the magnetron (not illustrated, however, the magnetron is of a conventional type, i.e., an electromagnetic wave or microwave generator common in this field of the art and has a power suitable for the required performance) said rotor or turbine being located below the food, distributing the waves homogenously throughout the cavity 4 without the need of using the rotary plate, successfully distributing the generated electromagnetic waves or microwaves uniformly throughout the cavity 4 of the microwave oven and all through the food, temperature sensors 2a and 2b and a vapor extractor 3.

[0023] According to the first aspect of the invention, the supporting surface of the food is formed by the actual porous ceramic plate 1, i.e., the food remains fixed during cooking and/or heating.

[0024] The temperature sensors 2a and 2b provided are preferably thermopile type infrared sensors. These electronic devices convert thermal energy into electric energy by means of small thermocouples connected in series, being able to take readings of the surface temperature of the food to be heated and/or cooked without needing to be in contact. These sensors generate an output voltage of between 0 and 5V, and allow taking readings of between -20ºC and 120ºC. According to the proposal of this invention, said thermal energy sensors are always pointing strategically towards the same point of an area provided for locating the food or vessel, so one 2a will preferably be arranged in one of the side walls of the chamber 4 of the microwave oven, such that it is capable of measuring the temperature of the food in the lower plane slightly above the supporting area 1, and another sensor 2b will be arranged in one of the upper walls of the same chamber 4 for measuring the temperature in the upper plane of the food. Alternatively said sensors 2a and 2b could be centrally located in one and the same side wall at different heights, their different angular orientation and their positioning towards the area intended for receiving the food which, as has been indicated, is fixed, during the cooking and/or heating operation being important, thereby assuring uniformity when taking temperatures.

[0025] On the other hand, the vapor extractor 3 is arranged at a distance from the sensors 2a and 2b such that when the food is being heated, the possible water vapors or other gases that may be generated are quickly extracted from the chamber 4 of the oven such that they do not influence the measurement detected by the sensors 2a and 2b. In a preferred embodiment, this vapor extractor 3 has an extraction mouth situated in the upper portion of the microwave oven, as can be observed in Figure 1. Nevertheless, in an alternative embodiment, the mentioned extractor could also be located in the opposite wall of the chamber 4 where the sensors 2a and 2b are arranged to assure an immediate separation of the vapor or moisture generated in relation to the area occupied by the sensors 2a and 2b, which sensors can thus take a "clean" reading of the surface temperature of the food on which these sensors are focused.

[0026] The control of the thermal energy sensors 2a and 2b and of the power supply of the magnetron will be performed by means of a microcontroller or a microprocessor. Particularly, a Microchip® PIC such as Microchip® PIC24FJ64GA006 could be used. This microcontroller will have the desired time and temperature as inputs, in addition to door open sensors/detectors and the mentioned thermopile sensors 2a and 2b. As outputs, it will have the control for lighting the chamber of the oven, the rotor or turbine 5 of the microwave oven and a transformer powering the magnetron. With the internal menu of the PIC, the invention allows determining the type of heating to be performed: quick, slow, progressive, increasing exponentially, decreasing exponentially, etc. The behavior of the magnetron once reaching desired food temperature can also be determined. This control will be performed with a configurable PID.

[0027] In a preferred embodiment, the control algorithm has been designed for gradually performing, for example, micro-outages in the electromagnetic energy generated by the magnetron depending on the actual temperature of the food at the time of taking the measurement and the objective temperature. As mentioned above, these micro-outages will generally be of a shorter duration closer to one another in time as the temperature of the food measured by means of the two thermal energy sensors 2a and 2b becomes closer to the objective temperature and will generally comprise, in a first sequence, outages of a very different duration.

[0028] In one embodiment, Figure 2A, the electromagnetic energy supply is controlled by means of generating micro-outages separating fragments of common maximum electromagnetic power (sectors of the same height) and the thermopile sensors 2a and 2b take the different temperature readings when the magnetron is not emitting electromagnetic power. In this particular case, depending on the reading of the temperature of the food (which, in a preferred example, is the mean of the two temperatures, a lower and a higher temperature, measured by the thermopiles 2a and 2b), electromagnetic waves will be injected at maximum power for a specific time (the invention proposes up to three possible different time durations), the closer the read temperature is to the objective temperature or *temp_set,* the shorter these time periods will be.

[0029] In another embodiment, Figure 2B, the technology used for controlling the electromagnetic energy supply is an Inverter® technology but micro-outages are also performed to enable taking the reading of the thermopiles 2A and 2B and the duration of the micro-outages and the time which the magnetron is emitting electromagnetic power are fixed. In this particular case, the electromagnetic energy supplied to the food varies depending on the power level provided by the Inverter® technology, such that the closer the read temperature is to the objective temperature, the lower the power emitted by the magnetron is. In the drawing, a section in which energy is not injected until the detected temperature drops has been included in the area close to the objective temperature which has been surpassed and the energy supply to said objective temperature is thus completed.

[0030] In yet another embodiment, Figure 2C, the technology used for controlling the electromagnetic energy supply is Inverter® technology without the need of performing micro-outages to take the reading of the thermopiles 2A and 2B. In this particular case, when the electromagnetic power supplied to the food is less than the reading frequency, it is possible to take a series of readings continuously with the subsequent regulation of the supplied electromagnetic power using the same strategy proposed by the method of the invention.

[0031] On the other hand, the power emitted by the magnetron will be distributed in the on/off cycles. These cycles will be controlled by the PIC that will send the information corresponding to the high voltage transformer powering the magnetron.

[0032] In a possible embodiment, this proposed microwave oven has a capacity of 20 liters, a microwave power of 800W and a ceramic surface which is transparent to the electromagnetic waves emitted. It further generates maximum power pulses with a variable duration depending on the percentage of power which has been selected and which is to be applied to the food. In an alternative embodiment, it also has a new timer for controlling the cooking time and the objective temperature at which the food is to be cooked and/or heated.

[0033] Given that the method described based on the mentioned algorithm allows very precise cooking and/or heating, it has been provided in a preferred embodiment that the microwave oven has knobs or push buttons 7 located in the front panel 6 of the microwave oven allowing direct access to the intelligent cooking processes or programs. For example, directly heating the food at a prefixed temperature; keeping a food at a given temperature (input temperature or a desired preservation temperature); cooking at a low or medium temperature (e.g., cooking eggs or fish or in contrast, cooking a stew); boiling the food for a prefixed time (e.g., for infusions, pastas, etc.)

[0034] On the other hand, according to another alternative embodiment, the microwave oven can also have a home automation module to monitor and/or control the objective temperature from a user mobile computing device and/or also a safety timer module to prevent overcooking or overheating said food.

[0035] The scope of this invention is defined in the following set of claims.

Claims

1. A microwave oven for automatically controlling the heating and/or cooking of foods which comprises:

- a magnetron for heating and/or cooking the food;
- a chamber (4) for receiving the food to be heated and/or cooked therein;
- at least two thermal energy sensors (2a and 2b) arranged at different distances from the food in said chamber (4) for measuring the temperature of said food; and
- a control unit for managing the values acquired by said at least two thermal energy sensors (2a and 2b) and regulating the microwave oven operation when heating and/or cooking the food,

characterized in that

- said at least two thermal energy sensors (2a and 2b) are arranged oriented with different angles for detecting the temperature of lower and upper portions of the food;
- a supporting surface (1), fixed, holding the food;
- said chamber (4) of the microwave oven has means (5) for distributing the electromagnetic waves generated by said magnetron; and
- said magnetron is controlled by means of a control algorithm housed in said control unit, which operates by taking a plurality of readings of said thermal energy sensors (2a and 2b), measuring temperature values of the food in said two lower and upper portions, a plurality of times, simultaneously with a predetermined electromagnetic energy supply state, said algorithm automatically regulating the electromag-

netic energy supply depending on said temperature values measured by said at least two thermal energy sensors (2a and 2b), the temperature and energy supply measurement ranges being variable during the time of heating and/or cooking the food in the microwave oven and as a function of an objective temperature at which said food is to be heated and/or cooked.

2. The oven according to claim 1, **characterized in that** said predetermined energy supply state is zero or a value below a prefixed threshold suitable for preventing interferences of the electromagnetic waves generated in said chamber (4) with said thermal energy sensors (2a and 2b).

3. The microwave oven according to claim 1, **characterized in that** said time variable electromagnetic energy supply is carried out by means of generating micro-outages in said supplied electromagnetic energy at regular or non-regular intervals, readings of the thermal energy sensors (2a and 2b) being taken during said micro-outages.

4. The microwave oven according to claim 1, **characterized in that** said time variable electromagnetic energy supply is carried out by means of an Inverter® power control system, which allows varying the supplied electromagnetic energy level and reducing it below said prefixed threshold in one or several moments of heating and/or cooking.

5. The microwave oven according to claim 1, **characterized in that** said at least two thermal energy sensors (2a and 2b) are arranged in a side wall, positioned slightly above the food supporting plane, and in an upper wall of said chamber (4), inside thereof, and oriented pointing towards a central point of the supporting surface (1).

6. The microwave oven according to claim 1, **characterized in that** said at least two thermal energy sensors (2a and 2b) are arranged in a side wall, positioned slightly above the food supporting plane, and in an upper wall of said chamber (4), outside thereof, with an access through one or more holes, and oriented pointing towards a central point of the supporting surface (1).

7. The microwave oven according to claim 5 or 6, **characterized in that** it further comprises an extractor device (3) for extracting from the chamber (4) water vapor or gases which are produced when heating and/or cooking said food, at least one extraction mouth being arranged spaced away from said at least two thermal energy sensors (2a and 2b).

8. The microwave oven according to claim 1, **characterized in that** said means (5) for distributing the electromagnetic waves comprise a rotary reflector positioned below said food supporting plane.

9. The microwave oven according to claim 1, **characterized in that** said thermal energy sensors (2a and 2b) are thermopile type infrared sensors.

10. The microwave oven according to claim 1, **characterized in that** it further comprises a home automation module which allows monitoring and/or controlling the objective temperature from a user mobile computing device.

11. The microwave oven according to claim 10, **characterized in that** it further comprises a safety timer module to prevent overcooking said food.

12. The microwave oven according to any one of the preceding claims, **characterized in that** it comprises one or several dedicated push buttons (7) for accessing specific cooking and/or heating programs with electromagnetic energy supply control for at least the following processes:

- heating up to a prefixed temperature;
- keeping the food for a prefixed time at a prefixed temperature;
- defrosting;
- cooking at a temperature kept below a prefixed threshold;
- boiling a food for a prefixed time.

13. A method for automatically controlling the heating and/or cooking of foods in a microwave oven, which comprises generating electromagnetic energy by means of a magnetron for heating and/or cooking a food placed inside a chamber within a microwave oven, wherein the electromagnetic waves generated by said magnetron are distributed and wherein at least two thermal energy sensors are arranged in two different areas in said chamber for measuring the temperature of said food, **characterized in that** it comprises

- arranging the food on a supporting surface, fixed, inside said chamber;
- orienting said at least two thermal energy sensors for detecting the temperature of a lower and upper portions of the food; and
- controlling the electromagnetic energy supply by means of controlling said magnetron by means of an algorithm which operates by taking a plurality of readings of said thermal energy sensors measuring temperature values of the food in said two lower and upper portions a plurality of times, simultaneously with a predetermined electromagnetic energy supply state pre-

venting interferences with said thermal energy sensors, said algorithm automatically regulating the electromagnetic energy supply depending on said temperature values measured by said at least two thermal energy sensors in relation to an objective temperature of said cooking and/or heating and, the temperature and energy supply measurement time intervals being the same or variable during the time of heating and/or cooking the food in the microwave oven and a function of said objective temperature at which said food is to be heated and/or cooked, such that amounts of electromagnetic energy adapted to the energy necessary for achieving said objective temperature are supplied in the same or different batches.

14. The method according to claim 13, **characterized in that** it comprises carrying out said time variable electromagnetic energy supply by means of generating micro-outages determining there between said batches of energy supply.

15. The method according to claim 13, **characterized in that** it comprises carrying out said electromagnetic energy supply by means of an Inverter® power control system determining a variable power and a reduction in the supplied electromagnetic energy below a prefixed level, said batches of energy supply being defined between two consecutive, reduced energy levels.

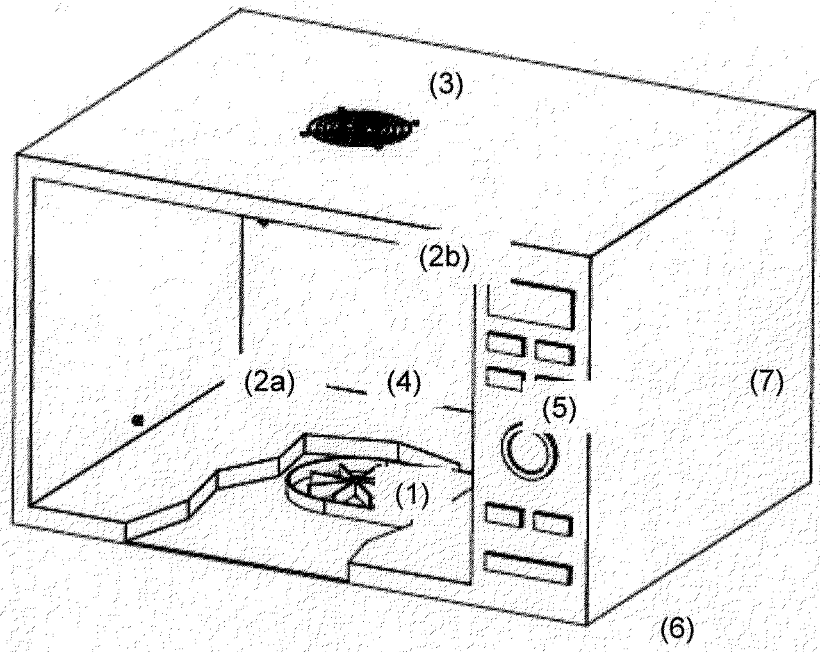

Fig. 1

Fig. 2A

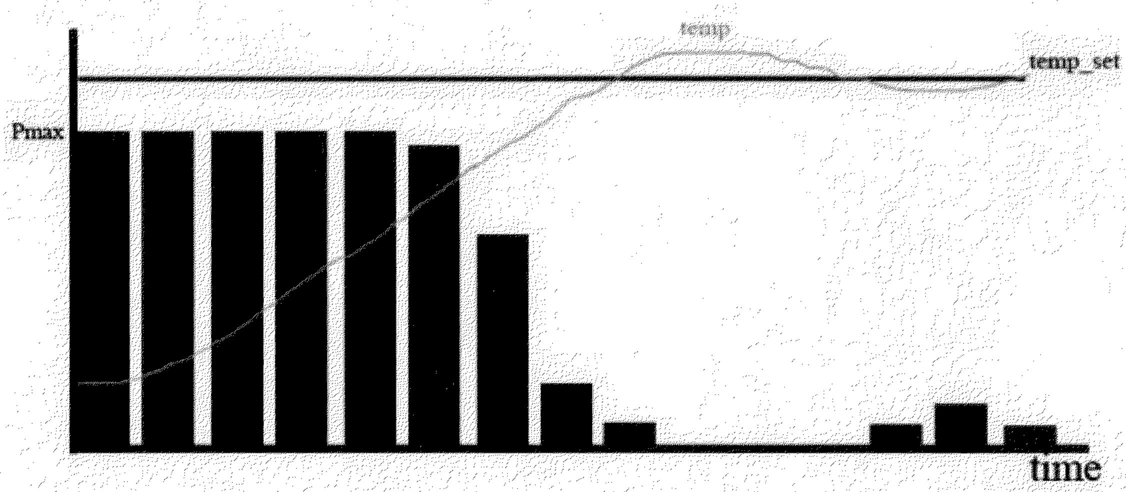

Fig. 2B

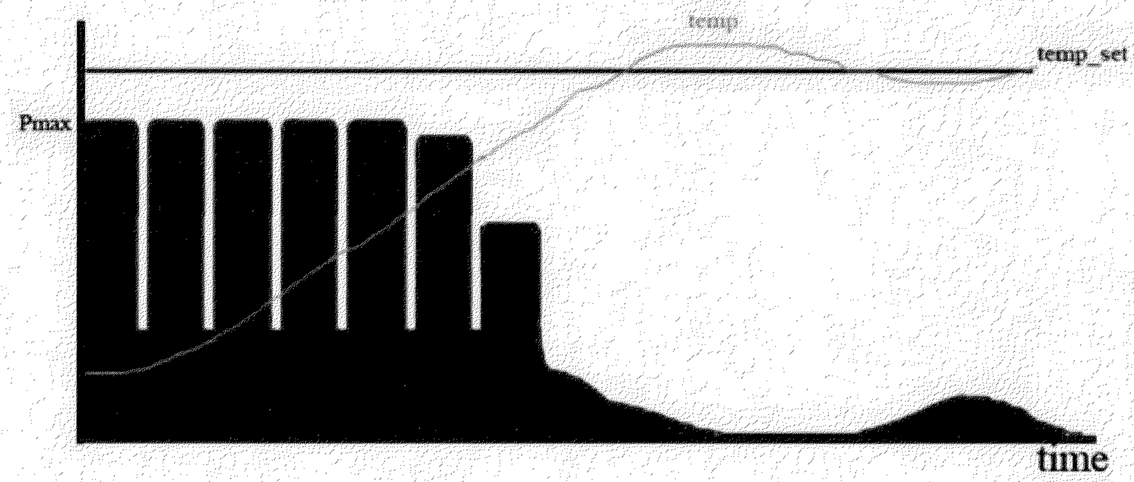

Fig. 2C

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EUROPEAN SEARCH REPORT

Application Number
EP 13 38 0005

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H05B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	12 July 2013	Gea Haupt, Martin

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 13 38 0005

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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