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(54) Automated cooking appliance and a method of automated control of the cooking process

(57) An automated cooking appliance comprises at least one sensor (1) of mechanical or acoustic vibrations, which is a 3D accelerometer (1A), operating in three dimensions and converting them into electric signals. The cooking appliance can comprise a cooking plate (2) and/or an oven (4). At least one heating device (3) is mounted beneath the cooking plate and/or in the oven. One or more vibration sensors (1, 1A) are mounted on the corners of the bottom side of the cooking plate, in physical contact with the plate. Two sensors (1, 1A) are mounted diagonally on two opposite corners, while three or four sensors (1, 1A) are mounted on three or four corners of the cooking plate, respectively. Preferably all sensors (1) are the 3D accelerometers (1A). Optionally at least one sensor (1) is a microphone (1M), capable to detect audible sounds and/or ultrasounds and to convert them into electric signals. This microphone (1M) can be placed on the side wall, ceiling, bottom or door of the oven, or under the plate. It can be connected acoustically with the interior of the oven by an acoustic channel (5). All vibration/acoustic sensors (1, 1A, 1M) are connected through the analogue or digital filter (6) to the processing unit (7) provided with the memory (8). The output of the processing unit is connected to the control unit (9) controlling the cooking appliance. The filtered signals are compared with the waveforms stored in the memory (8). A method of automated control of the cooking process is proposed, where the identification of the controlled heater mounted beneath the cooking plate when more than one heating device is switched-on is based on selective switching-off and switching-on of the heating devices for short periods of time that do not disturb the food processing, with simultaneous analysis of registered vibration/acoustic signals. The phase of the cooking process is determined from temporal evolution of the 3D vector of vibration/acoustic signal and/or from the temporal evolution of the waveforms extracted from the 3D vector analysed in the time domain.

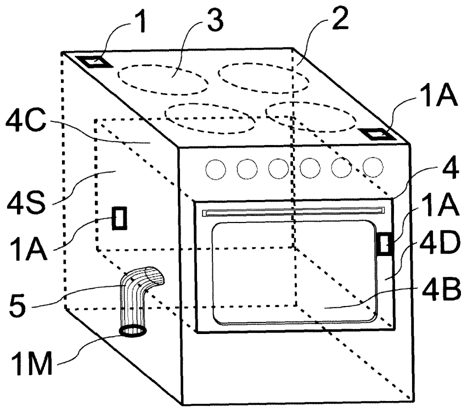

Fig. 2

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Description

[0001] The subject of the invention is an automated cooking appliance and a method of automated control of the cooking process. In particular the invention refers to a cooking plate (gas, electric, halogen, ceramic, or induction plate), optionally combined with an oven, either separate or integral with the cooking plate in common housing.

[0002] Many attempts have been undertaken to develop various means of control of the cooking process. Of particular interest are those that make use of vibrations and sounds generated during heating of cooking vessels like pots, kettles and pans. Known solutions related to the proposed invention can be roughly assigned to one of three groups: identification of the vessel physical position on the cooking plate, identification of boiling inside the cooking vessel, and use of microphones to register the sounds accompanying the cooking appliance usage.

[0003] In the first group, European patent applications EP2600690 A2 and EP2600691 A2 (Franco G.C. et al., ES / BSH BOSCH SIEMENS HAUSGERAETE, DE 05.06.2013) disclose a cooking hob. The device has a cooking plate provided with a free installation position for heating a pot. Position of a movable heating unit is adjusted to random position of the pot on the plate. A control unit receives a signal from an installation measurement unit to initiate determination of the installation position. The measurement unit comprises installation sensors, i.e. vibration sensors or accelerometers, placed under the hob and communicating with the plate. The control unit roughly determines the installation position based on spacing parameters i.e. signal propagation times. These signals propagate from the pot to one, two or three vibrations sensors. In the embodiments with one or two sensors, these are mounted, respectively, at one corner or two adjacent corners of the plate. In the third embodiment the additional third sensor is mounted in the middle of the opposite side of the plate. The heating unit is integrally formed with a position measurement unit.

[0004] Japanese patent document JP2012084531 A (MITSUBISHI ELECTRIC CORP., MITSUBISHI ELECTRIC HOME APPL., JP, 08.12.2011) discloses an induction heating cooker that includes a plurality of heating coils which are substantially uniformly distributed below a top plate. When one or more heated objects are mounted on the top plate, their positions are mapped relative to the coils with use of a web of sensors mounted beneath the plate. An output of at least one heating coil that is not fully covered by heated object is terminated or reduced when induction heating is performed.

[0005] Another Japanese patent document JP2011171207 A (Fujinami T., Sadahira T., JP / PANASONIC CORP., 08.12.2011) describes a heating cooker that comprises a top plate, a plurality of heating units, a heating controller for controlling heating power of the heating unit, a plurality of vibration detectors for detecting vibration of the top plate, and a device controller, which is connected to the heating controller and the vibration detectors, and controls the entire device. When the vibration detector detects vibrations of the top plate, the device controller determines which of the heating units generates vibrations from a phase difference of plurality of vibration waveforms detected by the vibration detector. Heating power of the heating unit is changed by the heating controller accordingly.

[0006] Different approach to positioning of a cooking vessel on the hob is described in Japanese patent document JP2011124116 A (Yamada S. et al., JP / PANASONIC CORP., 23.06.2011) which discloses the electromagnetic cooker that includes a position determining means that compare a placement position and heating position of the cooking vessel. A position sensor detects the placing position so that heating can be performed most efficiently. A notification control means notify that the cooking vessel can be placed at a position where heating can be most efficient, by making a top plate vibrate, so that the positional relation of the cooking vessel and the heating device is determined.

[0007] An induction heating cooker which detects existence of a heated object and a shape (outline) of its bottom is disclosed in Japanese patent document JP2010080187 A (Imai S. et al., JP / PANASONIC CORP., 08.04.2010). The induction heating cooker includes a heating coil for performing induction heating, a heating control means controlling supply of high frequency current to the heating coil, a plate arranged on the heating coil, the heated object subjected to induction-heating by mounting on the plate, and a vibration sensor at a lower part of the plate. The existence and shape of the heated object can be determined on the basis of the information transmitted from the vibration sensor, however the procedure is not disclosed in this document.

[0008] In the second group of inventions, i.e. those disclosing the attempts to control the cooking process, an international patent application WO2014001097 A1 (Bauer H.J. et al., DE / BSH BOSCH SIEMENS HAUSGERAETE, ROBERT BOSCH GMBH, 03.01.2014) discloses the cooking device equipped with a cooking chamber and at least one sensor for detecting at least one property of the cooking chamber. At least one sensor is a lambda sensor, which can protrude into the cooking chamber. In this case determination of the state inside the cooking chamber is based on chemical properties of gases.

[0009] Control of the cooking state inside an electromagnetic oven boiler is proposed in Chinese patent document CN102692040 A (Xiaohui L., CN / ZHEJIANG UNIV. TECHNOLOGY, 26.09.2012). A micro acceleration transducer chip detects a vibration signal transmitted by a boiler body to a ceramic glass plate. The electromagnetic oven monitors the vibration of the ceramic glass plate through the micro acceleration transducer in real time. In case the current vibration acceleration exceeds a preset threshold value, the judgment of boiling state can be made. Otherwise, the judgment of non-boiling state is selected. In the first case a first time meter is started to record the heating time, and when the heating time reaches a preset heating time value, the main power source is switched off, the electromagnetic oven stops heating temporarily, and a second time meter is started to record the heating suspension time. When the heating suspension time achieves a preset suspension time value, the main power source of the electromagnetic oven is restarted to heat the boiler body.

[0010] Japanese patent document JP2011247526 A (PANASONIC CORP., 08.12.2011) describes the cooker including: a top plate forming the outer shell, a heater for heating a cooking container, a heating controller for controlling the heating power of the heater, a temperature detector for detecting temperatures of the cooking container, a vibration sensor for detecting vibrations of the top plate, and a cooking container identifier for identifying vibration characteristics of the cooking container based on the detected values by the temperature detector and the vibration sensor. The cooker is configured so that the control contents of the heating controller vary according to the detected results by the cooking container identifier, which allows ways to detect boiling to switch according to the characteristics of the cooking container.

[0011] Vibrations accompanying boiling of water are explored in Chinese utility model application CN201507964 U (Zhiyong W., CN, 16.06.2010). An induction cooker comprises an upper cover, a panel and a circuit control board, wherein the panel is arranged on the upper surface of the upper cover. The upper cover is also provided with a water vibrating sensor which comprises a shell, an inner cover, a piezoelectric ceramic piece and a conductive column. The piezoelectric ceramic piece is provided with an electric connecting wire which is communicated with the circuit control board. By detection of vibrations dry burning and damage of the cookware can be avoided.

[0012] More advanced approach is proposed in Japanese patent document JP2009079891 A (Fukuda M. et al., JP / MITSUBISHI ELECTRIC CORP., MITSUBISHI ELECTRIC HOME APPL., 16.04.2009). A heating cooker has a top plate for placing the pan with prepared food, a heating means for heating the pan through the top plate, a vibration sensor detecting the pan vibrations, connected to a smoothing circuit, and a processor determining whether the output of the vibration sensor is related to disturbance other than vibration of the pan caused by heating when the output value of the vibration sensor exceeds the preset threshold, and determines the boiling of the food by comparing the output value of the vibration sensor with preset values.

[0013] Even more sophisticated approach is proposed in international patent application WO2007132674 A1 (Nagamitsu S., Noda M., JP / MATSUSHITA ELECTRIC IND CO LTD, NAGAMITSU SACHIO, NODA MAKIKO, 22.11.2007), where conditions of an object to be heated in a cooking container is accurately detected to more effectively prevent a cooking failure. An induction heating section heats the cooking container by induction heating. A vibration detection section detects vibration of the cooking container through a top plate. A vibration waveform extraction section extracts the vibration waveform of a frequency component corresponding to a frequency predetermined times higher than an induction heating frequency. A determination section determines conditions of the object to be heated based on the vibration waveform extracted by the vibration waveform extraction section.

[0014] Within the third group of inventions with a microphone applied, most of the solutions involve remote voice control of cooking appliances. These are not related to the proposed invention. In much smaller number of solutions a microphone is used as a sensor of acoustic noise. Again, most of these inventions are focused on reducing noise generated during cooking, in particular on the induction cooker, therefore they are not closely related to the proposed invention. The example is Japanese patent document JP2011175887 A (Takemura S., Niyama K., JP / PANASONIC CORP., 08.09.2011) where generation of noise with reverse phase, i.e. opposite to the phase of the noise detected with the microphone, is proposed.

[0015] German patent application DE10058671 A1 (Dorwarth R., DE / EGO ELEKTRO GERAETEBAU GMBH, 29.05.2002) discloses a cooking vessel on a ceramic plate over a heating element which has a restricted outlet for the steam having a supersonic whistle sensed by a microphone connected to the receiving unit whose output is fed to a control unit controlling the heating element.

[0016] In Japanese patent document JP20092250444 A (Niwa T., JP / PANASONIC CORP., 29.10.2009) the sound generated by a spark in a microwave oven is detected by a microphone mounted on the wall of the cooking chamber. Signal processing is performed while switching filters by a signal processing means having a group of filters of various characteristics. Determination of the spark and the control of the motion of a magnetron are performed by a microcomputer as a spark determining means.

[0017] According to the solution proposed in another invention of the same inventor JP2009127923 A (Niwa T., JP / PANASONIC CORP., 11.06.2009) the sound generated accompanied by the spark is guided to a microphone disposed on a place of a good temperature condition, i.e. separated from the cooking chamber, by a sound guide path.

[0018] Extended analysis of sounds registered by a microphone is proposed in German patent application DE102007058936 A1 (Erdmann K., DE / BSH BOSCH SIEMENS HAUSGERAETE, 10.06.2009). The sensor device has a connection alternative for an acoustic sensor which is a microphone to detect noise of a household appliance. An evaluation unit is provided, which is arranged in such a manner that the noise is recognized and produces an output signal that is dependent on the noise for a household appliance.

[0019] None of the above described inventions solves satisfactorily the problem of automated control of the cooking appliance. This technical problem is of great importance, in particular for elderly or disabled people, but also in relation to small children which are much more than adults exposed to dangerous events in the kitchen. Automation of the food processing at home increases safety in the kitchen and accounts for greater comfort of life, especially for physically impaired people. But also for relatively young and healthy population the advantages of saving time and energy are of high concern.

[0020] Proposed invention is a step forward in automated control of the cooking process and it offers the technical means for detection, extraction and evaluation of information that is contained in mechanical and/or acoustical noise generated during the cooking process. This invention enables to make use of both quasi-random noise accompanying cooking as well as vibration effects that occur during placing or removing the pot from the cooking plate. The vibrations and noise can be treated as deterministic or indeterministic signals, therefore various analytical approaches can be applied.

[0021] In the proposed invention an automated cooking appliance comprises at least one heating device, e.g. a gas, electric, ceramic, halogen or induction heater, and at least one sensor of mechanical or acoustic vibrations. The core of the invention is in that this at least one sensor of mechanical or acoustic vibrations is a 3D accelerometer, capable to detect vibrations in three dimensions and to convert them into the electric signals, either analogue or digital.

[0022] Although in many of known solutions application of an accelerometer was proposed, this invention is a significant breakthrough against the commonly accepted solutions. The reason is in that the state of the art teaches about the use of the accelerometers which are the detectors working in only one dimension. However, vibrations of the cooking plate are very complex physical 3D phenomena. Spatial (3D) distribution of the vibration modes carries much more information than even simple multiplication of the number of 1D modes by 3, i.e. by the number of dimensions. In some cases the modes of vibrations transverse to the cooking plate are predominant. The example is placing of a pot or falling of a drop of water on the plate. In other cases longitudinal modes, i.e. vibrations in a plane of the cooking plate (i.e. in directions parallel to the cooking plate) are stronger. The example is interaction of the bottom of the cooking vessel with the cooking plate when the temperature increases and the materials expand, or opposite, when the temperature decreases and the materials shrink. Such interactions depend strongly on the kind of the cooking appliance. For example expansion of the vessel bottom follows that of the glass in ceramic plates with electric heaters, while in induction heaters this is expansion of the glass that follows that of the vessel bottom.

[0023] General approach is to calculate the coordinates of a 4D vector (i.e. 3D+T: its value and direction in 3D space in given moment of time T). A series of 4D vectors comprises all vibration/acoustic modes. This 4D vector can be projected on selected directions, not necessarily vertical or horizontal, and time-dependent waveforms characteristic for these directions can be calculated. The waveforms assigned to the same process (e.g. boiling of water) but realised on different heaters can be similar provided they are calculated from the 4D vector projected on different directions.

[0024] The above analysis shows the power of control of the cooking process, provided that at least one 3D accelerometer is applied in the cooking appliance.

[0025] Directional analysis of spatial noises and vibrations of the cooking plate enables to define position of the noise source and characterize the phases of the cooking process. The 3D waveforms characteristic for given kind of the cooking appliance can be extracted and stored in the cooking appliance memory. A library of such waveforms makes possible to control the cooking process much more precisely than when the state-of-the-art 1D accelerometers are used.

[0026] Another essential feature of the invention is in that the 3D accelerometer can be mounted under the hob as in the examples presented above, or on the side wall, ceiling, bottom, or the door of an oven, the microwave oven included.

[0027] In preferred embodiment the cooking appliance comprises a cooking plate, and at least one heating device mounted beneath the cooking plate. At least one sensor of mechanical or acoustic vibrations is mounted on the corner of the bottom side of the cooking plate, in physical contact with the cooking plate.

[0028] In more complex embodiment the cooking appliance contains two sensors of mechanical or acoustic vibrations mounted diagonally on two opposite corners of the cooking plate. Accuracy of calculations can be increased with data harvested from two instead of one sensors. Diagonal placing of the sensors minimizes the measuring errors. Besides, in most common cooking plates with four heaters, diagonal positioning of the sensors divides the plate on two symmetric zones, therefore accuracy of control of the cooking process can be the same for each heater.

[0029] In even more advanced embodiment the cooking appliance contains three or four sensors of mechanical or acoustic vibrations mounted on three or four corners of the cooking plate, respectively.

[0030] In mostly recommended embodiment all sensors of mechanical or acoustic vibrations in the cooking appliance are the 3D accelerometers. However, combination of only one 3D accelerometer with 1D accelerometers can be a cheaper but still reasonably accurate solution in some applications.

[0031] In a very practical application of the invented cooking appliance it comprises an oven with side walls, ceiling wall, bottom wall and door, wherein the oven is provided with at least one heating device.

[0032] A method of automated control of the cooking process is proposed, where the identification of the controlled heater mounted beneath the cooking plate in a case when more than one heating device is switched-on is based on selective switching-off of the heating devices for a short period of time that is not disturbing the food processing, with simultaneous analysis of the signals registered by the sensors of mechanical or acoustic vibrations. Usually the heaters are automatically switched on and off in regular intervals, according to the power pre-set manually, to control the temperature inside the cooking vessel. What is proposed in this invention is to introduce fully controllable switching-on/off routines combined with simultaneous analysis of vibration/acoustic signals to fully control a number of parallel (i.e. simultaneous) cooking processes.

[0033] For example when a hob with four cooking areas is fully used, all four different processes, like boiling, frying, roasting and heating, can be controlled even with the only one 3D accelerometer used. The heaters can be selectively switched-off by the controller for about 0.1-1 s. A "heating gap" as short as 0.5 s is usually long enough to detect a change of the 3D vector. For more precise characterisation of particular cooking processes longer breaks in heating are required, lasting about 1-3 seconds. Overall process of cooking effectively remains undisturbed, because after the heating gap the controller increases or maximizes power supplied to the heater for about 1-4 seconds and then returns to the power selected either manually by the user or automatically by the controller. Selective switching-off can be applied to various numbers of heaters at given moment of time. For example if cooking process on given heater is analyzed, all other heaters can be switched-off simultaneously for a moment. According to another solution, the heaters are switched-off in a sequence.

[0034] The cooking process is quasi-deterministic, so its phase in given moment of time can be determined from temporal evolution of the 3D vector of the vibration/acoustic signal and/or from the temporal evolution of the waveforms extracted from the 3D vector analysed in time domain. Duration of samples determining instantaneous 3D vectors depends on particular routine and may vary from about 1 ms to 100 ms (about 10 Hz to 1 kHz sampling frequency).

[0035] In another series of embodiments of the proposed cooking appliance with at last one 3D accelerometer, at least one sensor of mechanical or acoustic vibrations is a microphone, capable to detect audible sounds and/or ultrasounds, and to convert them into the electric signals, either analogue or digital.

[0036] At least one microphone can be placed on the side wall, or ceiling wall, or bottom wall of the oven. This simple solution can be applied to the cooking appliances where the temperature of the oven casing is moderate, e.g. in microwave ovens.

[0037] An oven where much heat is produced, e.g. for baking in a temperature close to 200°C, require a modified approach. According to the other solution direct exposure of the sensor to the heat from the oven is avoided, because the at least one microphone is connected acoustically with the interior of the oven by an acoustic channel, and separated from the oven casing. This acoustic channel is leading to the side wall, or ceiling wall, or bottom wall of the oven. Geometry of the channel is adjusted to acoustic characteristics of particular oven. The channel or a part of it can be a solid or can be filled with a thermal insulator that is neutral to the sounds, e.g. soft mineral wool or aerogel.

[0038] The 3D accelerometer can be used to analyse vibrations and noises related to the oven door. During operation of the oven, the door can be slightly or fully opened, closed or touched, e.g. by a child. Any of such events produces characteristic vibrations. The door with multiple (two, three or even more) glass panels is ventilated which generates noises specific to the conditions inside the oven. Therefore it is recommended to mount the 3D accelerometer in a vicinity of the oven door or directly on the door of the cooking appliance, to detect vibrations and transform them into usable signals.

[0039] In all above described solutions of the cooking appliance all sensors of mechanical or acoustic vibrations, i.e. the accelerometers and/or the microphones, are connected through the analogue or digital filters to the processing unit provided with the memory. The output of the processing unit is connected to the control unit that controls the cooking appliance.

[0040] Digital filtering of the 3D signals (i.e. of the 4D vectors) transmitted by the sensors is realised by the processing unit and the filtered signals are compared with the waveforms stored in the memory. Digital filtering can include projecting the 4D vector on selected spatial directions, as was described above. Other procedures like transformation from time to frequency domain by e.g. the Fourier transform are optionally included in digital filtering as well.

[0041] The cooking appliance is very often a set of the cooking plate and the oven which are adjusted to building-up in a dedicated kitchen furniture.

[0042] In a free-standing variant of the cooking appliance the cooking plate and the oven are build in a common housing.

[0043] The natural environment of proposed cooking appliance is a kitchen in an apartment or in a house, however industrial use of the invention in a food factory, a restaurant or the like is strongly recommended. The cooking appliance can be automatically or manually controlled, depending on preset programme (routine) executed by the controller.

[0044] Selected features of the invention are illustrated on the drawings, where:

- Fig. 1 shows schematically two examples of the cooking appliance with the 3D accelerometer: a cooking plate and an oven;
- Fig. 2 illustrates schematically a cooking appliance

comprising a cooking plate and an oven in a free-standing housing; the hob is provided with two sensors mounted diagonally in opposite corners of the plate, while the hob has a 3D sensor on the door and back wall, and a microphone communicating with the oven through a sound guiding channel;

- Fig. 3 shows the 4D (or: 3D+T) vector of vibrations V(x,y,z,t) in horizontal/vertical coordinates {x,y,z} and its projections V(x',y',z',t) in a specific set of spatial coordinates {x',y',z'}, with extracted temporal waveforms $V_{x'}$(t), Vy,(t), $V_{z'}$,(t);

- Fig. 4 illustrates schematically detection and analysis of the vibration/acoustic signal; in illustrated example the filter converts three temporal waveforms into three functions of frequency with use of the Fourier transform.

[0045] The preferred embodiments of the system according to the invention are described hereinafter.

[0046] The automated cooking appliance comprises at least one heating device and at least one sensor of mechanical or acoustic vibrations. This sensor (1) of mechanical or acoustic vibrations is a 3D accelerometer (1A), capable to detect vibrations in three dimensions and to convert them into the electric signals, either analogue or digital.

[0047] The cooking appliance comprises a cooking plate (2), and at least one heating device (3) is mounted beneath the cooking plate. Preferably four heaters are mounted beneath the cooking plate, but embodiments with two heaters or only one heater are equally interesting, especially in the induction stoves. The sensor (1, 1A) of mechanical or acoustic vibrations is mounted on the corner of the bottom side of the cooking plate, in physical contact with the cooking plate, about 3-4 cm from the edges of the plate.

[0048] In the embodiment containing two sensors (1, 1A) of mechanical or acoustic vibrations these are mounted diagonally on two opposite corners of the cooking plate. In the cooking appliances that contain three or four sensors (1, 1A) of mechanical or acoustic vibrations, these are mounted on three or four corners of the cooking plate, respectively.

[0049] Preferably all sensors (1) of mechanical or acoustic vibrations are the 3D accelerometers (1A).

[0050] In the cooking appliance according to the invention at least one sensor (1) of mechanical or acoustic vibrations is a microphone (1M), capable to detect audible sounds and/or ultrasounds and to convert them into the electric signals, either analogue or digital.

[0051] The cooking appliance comprises an oven (4) with the side walls (4S), ceiling wall (4C), bottom wall (4B) and the door (4D), wherein the oven is provided with at least one heating device. At least one microphone (1M) is placed on the side wall, or ceiling wall, or bottom wall of the oven. Alternatively, this microphone (1M) is connected acoustically with the interior of the oven by an acoustic channel (5), and separated from the oven walls. The acoustic channel is leading to the side wall, or ceiling wall, or bottom wall of the oven. This channel can be shaped from a peace of metal acting as a waveguide for acoustic waves.

[0052] In another embodiment the accelerometer (1A) is mounted in a vicinity of the oven door or directly on the door.

[0053] All sensors (1, 1A, 1M) of mechanical or acoustic vibrations are connected through the analogue or digital filters (6) to the processing unit (7) provided with the memory (8), and the output of the processing unit is connected to the control unit (9) of the cooking appliance.

[0054] Digital filtering is realised by the processing unit (7) and the filtered signals are compared with the waveforms stored in the memory (8).

[0055] Preferably the cooking plate (2) and the oven (4) are adjusted to building-up in a dedicated kitchen furniture. Alternatively, the cooking plate (2) and the oven (4) are build in a common free-standing housing.

Claims

1. An automated cooking appliance comprising at least one heating device and at least one sensor of mechanical or acoustic vibrations **characterised in that** at least one sensor (1) of mechanical or acoustic vibrations is a 3D accelerometer (1A), capable to detect vibrations in three dimensions and to convert them into the electric signals, either analogue or digital.

2. The cooking appliance according to claim 1 **characterised in that** it comprises a cooking plate (2), and at least one heating device (3) is mounted beneath the cooking plate, and at least one sensor (1, 1A) of mechanical or acoustic vibrations is mounted on the corner of the bottom side of the cooking plate, in physical contact with the cooking plate.

3. The cooking appliance according to claim 2 **characterised in that** it contains two sensors (1, 1A) of mechanical or acoustic vibrations mounted diagonally on two opposite corners of the cooking plate.

4. The cooking appliance according to claim 2 **characterised in that** it contains three or four sensors (1, 1A) of mechanical or acoustic vibrations mounted on three or four corners of the cooking plate, respectively.

5. The cooking appliance according to claim 1 or 2 or 3 or 4 **characterised in that** all sensors (1) of mechanical or acoustic vibrations are the 3D accelerometers (1A).

6. The cooking appliance according to any of preceding claims **characterised in that** at least one sensor (1) of mechanical or acoustic vibrations is a microphone (1M), capable to detect audible sounds and/or ultrasounds and to convert them into the electric signals, either analogue or digital.

7. The cooking appliance according to any of preceding claims **characterised in that** it comprises an oven (4) with side walls (4S), ceiling wall (4C), bottom wall (4B) and door (4D), wherein the oven is provided with at least one heating device.

8. The cooking appliance according to claim 7 **characterised in that** at least one microphone (1M) is placed on the side wall, or ceiling wall, or bottom wall of the oven.

9. The cooking appliance according to claim **7 characterised in that** at least one microphone (1M) is connected acoustically with the interior of the oven by an acoustic channel (5), and separated from the oven walls, and where the acoustic channel is leading to the side wall, or ceiling wall, or bottom wall of the oven.

10. The cooking appliance according to claim 7, or 8, or 9 **characterised in that** the accelerometer (1A) is mounted in a vicinity of the oven door or directly on the door.

11. The cooking appliance according to any of preceding claims **characterised in that** all sensors (1, 1A, 1M) of mechanical or acoustic vibrations are connected through at least one analogue or digital filter (6) to the processing unit (7) provided with the memory (8), and wherein the output of the processing unit is connected to the control unit (9) controlling the cooking appliance.

12. The cooking appliance according to any of preceding claims **characterised in that** digital filtering is realised by the processing unit (7) and the filtered signals are compared with the waveforms stored in the memory (8).

13. The cooking appliance according to any of claims from 1 to 12 **characterised in that** the cooking plate (2) and the oven (4) are adjusted to building-up in a dedicated kitchen furniture, or the cooking plate (2) and the oven (4) are build in a common free-standing housing.

14. A method of automated control of the cooking process **characterised in that** the identification of the controlled heater mounted beneath the cooking plate when more than one heating device is switched-on is based on selective switching-off and switching-on of the heating devices for short periods of time that do not disturb the food processing, with simultaneous analysis of the signals registered by the sensors of mechanical and/or acoustic vibrations.

15. The method according to claim 14 **characterised in that** the phase of the cooking process is determined from temporal evolution of the 3D vector of vibration/acoustic signal and/or from the temporal evolution of the waveforms extracted from the 3D vector analysed in the time domain.

Amended claims in accordance with Rule 137(2) EPC.

1. An automated cooking appliance comprising at least one heating device and one or more sensors of mechanical or acoustic vibrations connected directly or indirectly to a control unit, **characterised in that** at least one sensor (1) of mechanical or acoustic vibrations is a 3-axis accelerometer (1A), capable to detect three spatial components (V_x, V_y, V_z) of vibration vector (V) in three independent directions (x, y, z) and to convert them into three independent electric signals ($V_x(t)$, $V_y(t)$, $V_z(t)$), either analogue or digital, and to feed these signals to the control unit (9) which has a means to determine a phase of the cooking process on a basis of temporal evolution of the 3-component vector ($V_{x'}$, $V_{y'}$, $V_{z'}$) of vibration/acoustic signal in transformed spatial coordinates (x', y', z'), and temporal evolution of the vibration/acoustic waveforms ($V_{x'}(t)$, $V_{y'}(t)$, $V_{z'}(t)$) extracted from the 3-component vector analysed in time (t) domain in transformed spatial coordinates (x', y', z').

2. The cooking appliance according to claim 1 **characterised in that** it comprises a cooking plate (2), and at least one heating device (3) is mounted beneath the cooking plate, and at least one sensor (1, 1A) of mechanical or acoustic vibrations is mounted on the corner of the bottom side of the cooking plate, in physical contact with the cooking plate.

3. The cooking appliance according to claim 2 **characterised in that it** contains two sensors (1, 1A) of mechanical or acoustic vibrations mounted diagonally on two opposite corners of the cooking plate.

4. The cooking appliance according to claim 2 **characterised in that** it contains three or four sensors (1, 1A) of mechanical or acoustic vibrations mounted on three or four corners of the cooking plate, respectively.

5. The cooking appliance according to claim 1 or 2 or 3 or 4 **characterised in that** all sensors (1) of mechanical or acoustic vibrations are the 3-axis accel-

erometers (1A).

6. The cooking appliance according to claim 1 or 2 or 3 or 4 **characterised in that** at least one sensor (1) of mechanical or acoustic vibrations is a microphone (1M), capable to detect audible sounds and/or ultrasounds and to convert them into electric signals, either analogue or digital.

7. The cooking appliance according to any of preceding claims **characterised in that** it comprises an oven (4) with the side walls (4S), ceiling wall (4C), bottom wall (4B) and door (4D), wherein the oven is provided with at least one heating device.

8. The cooking appliance according to claim 7 **characterised in that** at least one microphone (1 M) is placed on the side wall, or ceiling wall, or bottom wall of the oven.

9. The cooking appliance according to claim 7 **characterised in that** at least one microphone (1 M) is connected acoustically with the interior of the oven by an acoustic channel (5), and separated from the oven walls, and where the acoustic channel is leading to the side wall, or ceiling wall, or bottom wall of the oven.

10. The cooking appliance according to claim 7, or 8, or 9 **characterised in that** the accelerometer (1A) is mounted in a vicinity of the oven door or directly on the door.

11. The cooking appliance according to any of claims from 1 to 10 **characterised in that** the cooking plate (2) and the oven (4) are adjusted to building-up in a dedicated kitchen furniture, or the cooking plate (2) and the oven (4) are build in a common freestanding housing.

12. The cooking appliance according to any of preceding claims **characterised in that** all
sensors (1, 1A, 1M) of mechanical or acoustic vibrations are connected through at least one analogue or digital filter (6) to the processing unit (7) provided with the memory (8), and wherein the output of the processing unit is connected to the control unit (9) controlling the cooking appliance.

13. The cooking appliance according to claim 12 **characterised in that** digital filtering is realised by the processing unit (7) and the filtered signals are compared with the vibration/acoustic waveforms stored in the memory (8).

14. The cooking appliance according to any of preceding claims **characterised in that** the vibration/acoustic waveforms are stored in the memory (8) either in time (t) domain ($V_{x'}$(t), $V_{y'}$(t), $V_{z'}$(t)) or in frequency (f) domain ($V_{x'}$(f), $V_{y'}$(D, $V_{z'}$(f)).

15. The cooking appliance according to claim 12 or 13 **characterised in that** the control unit (9) is equipped with the identification means for identification of the controlled heating device (3) mounted beneath the cooking plate (2), and when more than one heating device is switched-on the identification means identify the controlled heating device on a basis of selective switching-off and switching-on of the heating devices for short periods of time that do not disturb the food processing, with simultaneous analysis of the signals registered by the sensors (1, 1A) of mechanical and/or acoustic vibrations.

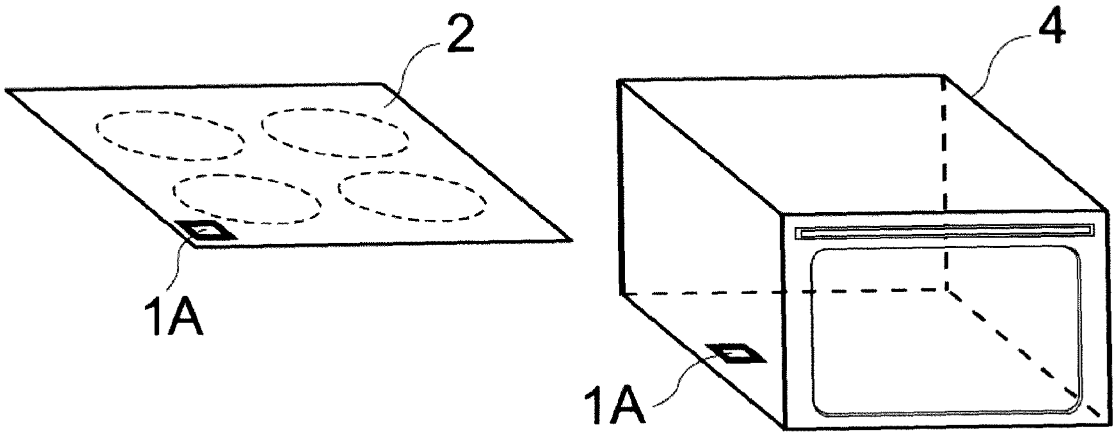

Fig. 1

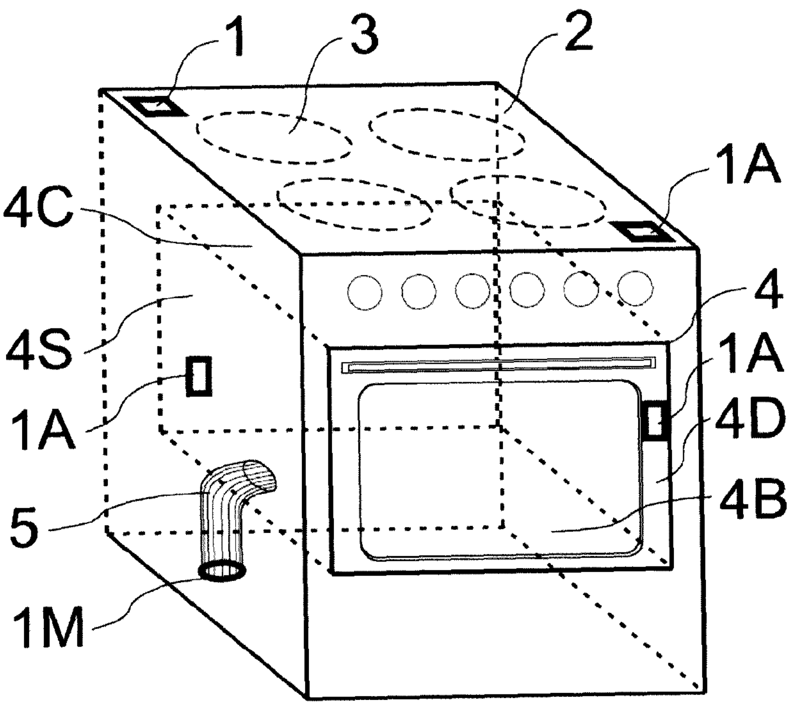

Fig. 2

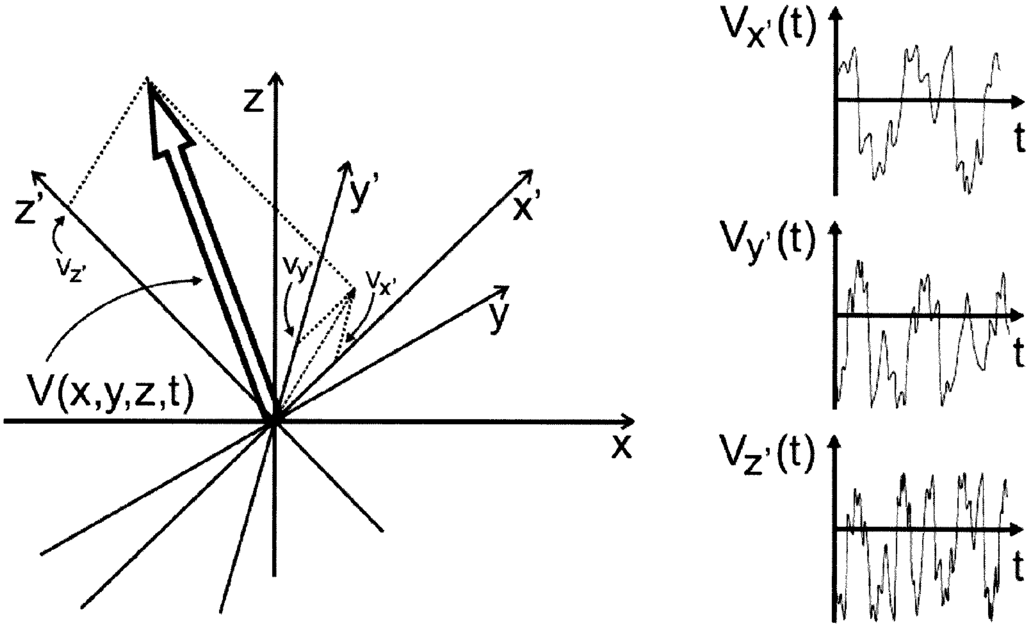
z
z'
y'
x'
y
x
$V_{z'}$
$V_{y'}$
$V_{x'}$
V(x,y,z,t)
$V_{x'}(t)$
$V_{y'}(t)$
$V_{z'}(t)$
t

Fig. 3

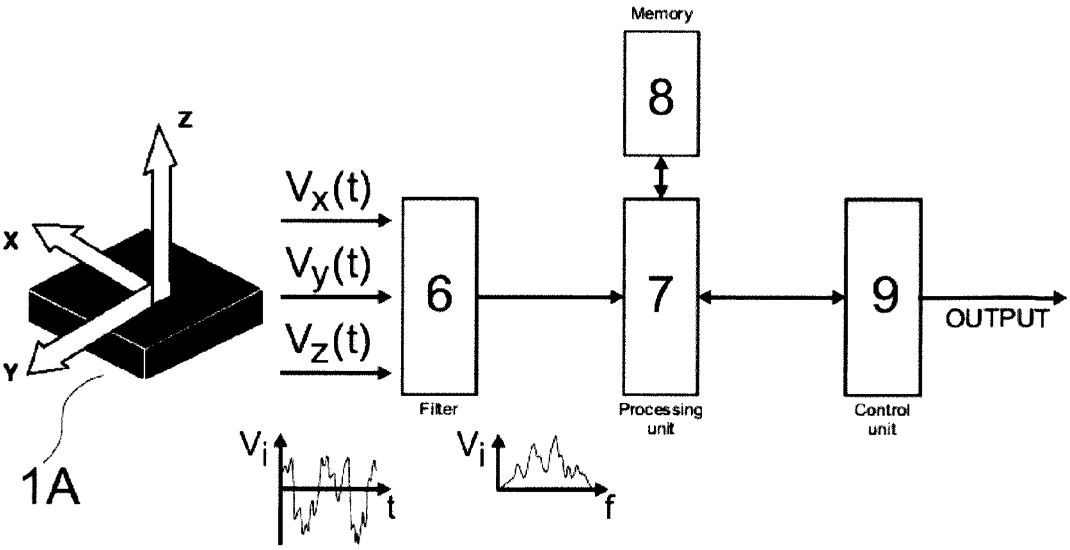
Memory
8
z
x
Y
1A
$V_x(t)$
$V_y(t)$
$V_z(t)$
6
7
9
OUTPUT
Filter
Processing unit
Control unit
V_i
t
f

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 14 46 0004

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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~~The present search report has been drawn up for all claims~~

2

Place of search	Date of completion of the search	Examiner
Munich	3 July 2014	Barzic, Florent

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

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Application Number

EP 14 46 0004

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1-13

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION SHEET B

Application Number
EP 14 46 0004

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-13

   Automated cooking appliance using electrical signals from 3D-accelerometer

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2. claims: 14, 15

   Method of automated control of cooking appliance for multiple heating devices

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 14 46 0004

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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03-07-2014

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EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

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