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

(72) Inventors:
• **The inventor has agreed to waive his entitlement to designation.**

(54) **Microwave cooking appliance and method of operating it**

(57) A microwave cooking appliance, includes:
an interior chamber, including a cooking space (2) for accommodating foodstuffs to be-cooked;
an apparatus (20,21) for providing microwaves of at least one wavelength λ to the interior chamber; and
at least one plate-like member (4,22,23) having at least one surface reflective to microwaves and facing an opposite surface reflective to microwaves in the interior

chamber.

The plate-like member (4,22,23) is movable such as to vary a distance to the opposite surface whilst the microwaves are provided to the interior chamber. At least one of the plate-like members (4,22,23) is movable such as to allow a change in distance to the opposite surface by an amount of the order of at least a quarter wavelength λ .

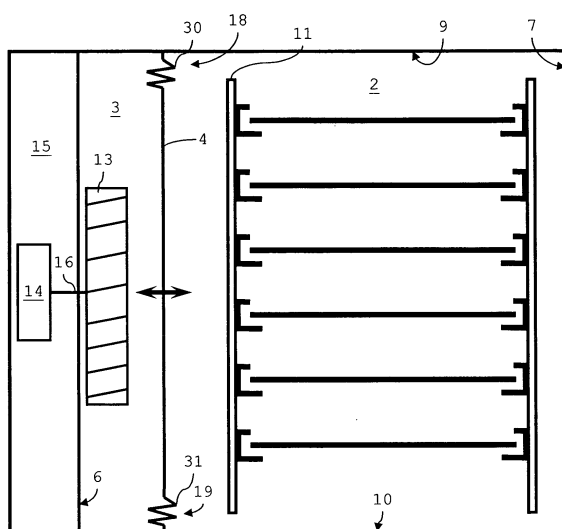


Fig. 3

Description

[0001] The invention relates to a microwave cooking appliance, including:

an interior chamber, including a cooking space for accommodating foodstuffs to be cooked;
an apparatus for providing microwaves of at least one wavelength λ to the interior chamber; and
at least one plate-like member having at least one surface reflective to microwaves and facing an opposite surface reflective to microwaves in the interior chamber,

wherein the plate-like member is movable such as to vary a distance to the opposite surface whilst the microwaves are provided to the interior chamber.

[0002] The invention also relates to a method of operating a microwave cooking appliance, in particular a microwave cooking appliance according to any one of the preceding claims, the cooking appliance including:

an interior chamber, including a cooking space for accommodating foodstuffs to be cooked;
an apparatus for providing microwaves of at least one wavelength λ to the interior chamber; and
at least one plate-like member having at least one surface reflective to microwaves and facing an opposite surface reflective to microwaves in the interior chamber,

wherein the plate-like member is allowed to move such as to vary a distance to the opposite surface whilst the microwaves are provided to the interior chamber.

[0003] An example of such an appliance and method is known. GB 1 105 021 B discloses a heating apparatus or oven construction including an electrically conducting oven liner or member having a polished inner surface defining a resonant cavity. The cavity contains conventional electric heating elements as well as a pedestal or tuning assembly for tuning the cavity and a coupling assembly for coupling radio frequency energy to the cavity from a fixed frequency oscillator. The pedestal is adjustable in height. The adjustable tuning assembly and coupling assembly return the resonant cavity to the frequency of the oscillator to ensure a maximum transfer of energy from the oscillator to the food. This does not ensure the absence of hot and cold spots. To accomplish this, the height of the cavity is made less than one wavelength of the frequency supplied by the oscillator to avoid standing waves and the problems introduced thereby. In an embodiment, the settings of the tuning assembly and the coupling assembly are continuously varies relative to each other. Because the continuous oscillation of the tuning assembly and the coupling assembly occur in quasi random relation to each other, the settings of these two assemblies will soon approach the relationship necessary to tune the resonant oven cavity to the oscillator. At

this time, the tuning assembly and coupling assembly are arrested in the proper positions relative to each other in which the resonant cavity is tuned to the oscillator.

[0004] A problem of the known appliance is that it is too small to be suitable for use in large kitchens. The provision of a stack of resonant cavities would require duplication of the coupling assemblies and tuning assemblies.

[0005] It is an object of the invention to provide a microwave cooking appliance and method of the types mentioned above in the opening paragraphs that are able to provide even heating in large cooking spaces.

[0006] This object is achieved by the microwave cooking appliance according to the invention, which is **characterised in that** at least one of the plate-like members is movable such as to allow a change in distance to the opposite surface by an amount of the order of at least a quarter wavelength λ .

[0007] In an embodiment, at least one of the plate-like members substantially delimits the cooking space to one side thereof.

[0008] In a variant of this embodiment, the interior chamber has a floor, the at least one plate-like members delimiting the cooking space only to a respective side thereof that is generally transverse to the floor.

[0009] At least one plate-like member may substantially partition the interior chamber into the cooking space and at least one further space, in particular a further space accommodating a fan wheel.

[0010] In a variant of this embodiment, the plate-like member substantially partitioning the interior chamber is suspended, in particular from one or more surfaces defining the interior chamber, by at least one device including a resilient element.

[0011] Furthermore, this embodiment of the microwave cooking appliance may further include a control apparatus for varying a pressure difference between the further space and the cooking space so as to reposition the plate-like member substantially partitioning the interior chamber.

[0012] Also, the plate-like member substantially partitioning the interior chamber may be arranged to leave free an opening at at least one edge between the plate-like member and a surface defining the interior chamber.

[0013] The microwave cooking appliance may also include an apparatus for causing continual reciprocating movement of the plate-like member whilst the microwaves are provided to the interior chamber, in particular at a frequency in a range of 5-50 min⁻¹.

[0014] According to another aspect, the method of operating a microwave cooking appliance according to the invention is **characterised in that** an electromagnetic field distribution having minima and maxima is established in at least the cooking space and in that locations of the minima and maxima are changed by the movement of the at least one plate-like member.

[0015] The invention is based on the surprising insight that, because at least one of the plate-like members is

movable such as to allow a change in the distance to the opposite surface by an amount of the order of at least a quarter wavelength λ , it is possible for the positions of maxima and minima of a standing wave field distribution established in the interior chamber including the cooking space to be substantially interchanged. As a result, the cooking space can be large enough to form a resonant cavity without adverse consequences for the energy distribution in the cooking space. Because the distance between opposite reflective surfaces is allowed to vary whilst the microwaves are provided to the interior chamber, the surfaces that would otherwise cause standing wave patterns are moved.

[0016] Where at least one of the plate-like members substantially delimits the cooking space to one side thereof, the cooking space is not obstructed by the plate-like member or members. Moreover, the homogeneity of the energy distribution is improved across substantially the entire cooking space. The distance between reflecting surfaces on either side of the cooking space is varied at substantially all levels.

[0017] If the interior chamber has a floor and the at least one plate-like members delimits the cooking space only to a respective side thereof that is generally transverse to the floor, then the ceiling and floor do not comprise or support plate-like members. This embodiment is structurally easier to achieve, because the floor already supports the foodstuffs, or at least accessories for carrying the foodstuffs, and may additionally comprise components of an arrangement for draining the cooking space of moisture, e.g. cleaning liquids. The ceiling area can similarly comprise devices, e.g. a device for showering cleaning liquid into the cooking space, when empty, or a device for spraying aromas or other substances onto the foodstuffs in the cooking space. Moreover, it is generally desirable to keep the overall height of the cooking appliance low without decreasing the interior height of the cooking space, for which purpose one may wish to avoid horizontal plate-like members, at least in the cooking space.

[0018] If the at least one plate-like member substantially partitions the interior chamber into the cooking space and at least one further space, in particular a further space accommodating a fan wheel, then an additional plate-like member need not be provided. A partitioning member of this type is common in microwave cooking appliances with means for circulating the cooking atmosphere. This embodiment also makes more efficient use of available space, because the plate-like member must generally be additional to the walls defining the interior chamber. Those walls must be arranged to prevent microwave leakage. They cannot easily comprise the plate-like member for that reason.

[0019] If the plate-like member substantially partitioning the interior chamber is carried by, in particular suspended from, one or more surfaces defining the interior chamber, by at least one device including a resilient element, then at least some of the movement of the plate-

like member can be brought about without energising an actuator. Suspending the plate-like member by means of resilient elements obviates the need for bearings, making the construction cheaper. In particular if the appliance further includes a control apparatus for varying a pressure difference between the further space and the cooking space so as to reposition the plate-like member substantially partitioning the interior chamber, no separate actuators need be provided to move the plate-like member. Reciprocating movement can be brought about by increasing and decreasing the pressure difference between the further space and the cooking space against the force exerted by the resilient elements on the plate-like member.

[0020] A recirculation of the atmosphere in the cooking space is brought about using a plate-like member substantially partitioning the interior chamber that is arranged to leave free an opening at at least one edge between the plate-like member and a surface defining the interior chamber. One or more openings in the plane of the plate-like member are provided for drawing the atmosphere from the cooking space into the further space.

[0021] An apparatus for causing continual reciprocating movement of the plate-like member whilst the microwaves are provided to the cooking chamber, in particular at a frequency in a range of 5-50 min⁻¹, ensures that no portion of the foodstuffs in the cooking space is left at a minimum in the field distribution for a prolonged fraction of the typical duration of a microwaving cooking operation.

[0022] With the method of operating the microwave cooking appliance an electromagnetic field distribution having minima and maxima can be established in at least the cooking space, but locations of the minima and maxima are continually changed by the movement of the at least one plate-like member during the microwave cooking process.

[0023] The invention will be explained in further detail with reference to the accompanying drawings, in which like parts are referred to by the same reference numerals, and in which:

Fig. 1 is a schematic cross-sectional top view a cooking appliance with movable metal plates;

Fig. 2 is a schematic cross-sectional view from the front of a first variant of the cooking appliance with a movable partition; and

Fig. 3 is a schematic cross-sectional view from the front of a second variant of the cooking appliance with a movable partition suspended by means of resilient elements.

[0024] Fig. 1 shows a cooking appliance 1 comprising an interior chamber substantially partitioned into a cooking space 2 and a pressure space 3 by means of a fluid

guide member 4. The interior chamber is defined by a back wall 5, left and right side walls 6,7 and a door 8, as well as by a ceiling 9 and floor 10 (Figs. 2 and 3). The walls 5,6,7, ceiling 9, floor 10 and door 8 are reflective to microwaves, being either made of metal or provided with a metal coating. In the case of the door 8, a metal mesh (not shown) can be provided on the inside of an otherwise transparent window, for example.

[0025] Foodstuffs to be heated are accommodated in the cooking space 2, which, in the illustrated embodiment, comprises a rack 11 for supporting trays 12 or other carriers for foodstuffs at various levels in the cooking space 2. The rack 11 is just an example of an accessory for supporting foodstuff carriers. In other embodiments, plate racks or the like can be provided, or the cooking space can be arranged to accommodate a trolley or a rotisserie assembly, for example.

[0026] The cooking appliance 1 illustrated in the drawings comprises a fan wheel 13 driven by a motor 14. The motor 14 is located in an electrical equipment chamber 15 and connected to the fan wheel 13 by means of an axle 16 extending through the side wall 6 in such a manner as substantially to prevent microwave leakage. The fan wheel 13 is part of a centrifugal fan, sucking in the cooking space atmosphere through a central opening 17 in the plane of the fluid guide member 4 and expelling it radially. The gases, fumes and vapour return to the cooking space by way of slits 18,19 left free at edges of the fluid guide member 4, by virtue of the fact that the centrifugal fan establishes a pressure difference between the pressure space 3 and the cooking space 2.

[0027] Although not shown, conventional electrical resistance heater elements can be placed in the flow generated by the central fan to provide electrical heating of the cooking space 2.

[0028] Additionally, injectors of vapour, aromas and the like can be present in the cooking appliance 1.

[0029] In the illustrated embodiments, the cooking appliance 1 further includes a microwave generator 20, e.g. a magnetron, and a waveguide 21 for providing microwaves generated by the microwave generator to the interior chamber. The microwave generator 20 generates electromagnetic waves with a frequency of about 2.45 GHz, which translates to a wavelength λ of about 12 cm. In other embodiments, other frequencies are used. In the illustrated embodiment, the waveguide 21 is provided with an aperture or antenna (not shown) for emitting microwave radiation into the pressure space 3 adjacent the cooking space. Both the pressure space 3 and cooking space 2 are dimensioned such that they can form resonant cavities, being typically several wavelengths deep and high and, in the case of the cooking space, wide.

[0030] Normally, an electromagnetic field distribution would form in an oven cavity of the dimensions indicated above, the field distribution having fixed minima and maxima. This could lead to an uneven cooking result. The position of the minima and maxima depends on several factors, including the resonant frequency, the dimen-

sions and geometry of the oven cavity, the dimensions and configuration of antennas or waveguide apertures for feeding the microwaves into the oven cavity, the presence and configuration of foodstuffs and accessories in the oven cavity, etc.

[0031] The illustrated cooking appliance 1 is provided with first and second plate-like members 22,23 that are movable so as to vary the distance between them and opposite reflective surfaces delimiting the cooking space 2, in this case, the inside surface of the door 8 and the fluid guide member 4, respectively. In addition, the fluid guide member 4 is movable in a direction transverse to its plane, just like the first and second plate-like members 22,23.

[0032] The first and second plate-like members 22,23 and the fluid guide member 4 are movable whilst microwave energy is being fed into the interior chamber. Because they delimit the cooking space 2 to the rear and to the sides, the dimensions of the resonant cavity comprising the cooking space 2 change, in use, and thus also the positions of the minima and maxima of the electromagnetic field distribution. Over a period typical for most cooking operations (several minutes), the positions may be changed from five to fifty times, for example, so that the average energy distribution over the cooking period is relatively homogeneous.

[0033] In the illustrated embodiment, the plate-like members 22,23 extend in height over the major part of the height of the cooking space 2 (distance between floor 10 and ceiling 9), e.g. more than 80 % or even 90 %, so that a relatively large degree of homogeneity of the microwave energy distribution at substantially all levels can be achieved. This is an effect that would be hard to achieve with only one or a few mode stirrers that are conventionally used to achieve a more homogeneous energy distribution. It also allows one to provide only one waveguide 21 or antenna, or at least a limited number thereof. Similarly, the first plate-like member 22 substantially delimits the cooking space 2 in the sense that it extends over the major part of the width thereof (distance between fluid guide member 4 and opposite side wall 7), e.g. more than 80 or 90 % of the width. In an alternative embodiment (not shown), the first plate-like member 22 substantially covers the entire rear wall 5 of the interior chamber.

[0034] In the illustrated embodiment, actuators 24,25,26,27 are provided for moving the first and second plate-like members 22,23. Any suitable type of actuator can be used, including mechanical or electromagnetic actuators, for example. The amplitude of movement of the first and second plate-like members 22,23 is at least of the order of a quarter of the wavelength of the microwaves, i.e. at least 1 cm, but generally about 3 cm or more. This ensures substantial displacement of the maxima and minima of the electromagnetic field distribution. Movement may be continuous, e.g. sinusoidal, or the position of the plate-like members 22,23 can be changed at intervals in a step-like manner.

[0035] The characteristics of the movement of the plate-like members 22,23 correspond to those for the fluid guide member 4. However, the actuator mechanisms can differ, two alternatives being illustrated in Figs. 2 and 3 respectively.

[0036] In the first alternative (Fig. 2), the fluid guide member 4 is suspended between the ceiling 9 and floor 10 of the interior chamber by means of pins 28,29 that travel in apertures (not shown in detail) in the ceiling 9 and floor 10. Actuators (not shown) provided outside the interior chamber move the pins 28,29 such that the fluid guide member 4 reciprocates in a directions generally transverse to its plane. The actuators can include an electrical motor or an electromagnetic actuator, for example.

[0037] In the embodiment of Fig. 3, the fluid guide member 4 is suspended from the floor 10 and ceiling 9 of the interior chamber by means of resilient elements 30,31 in the form of coil springs. Other types of element may be used. The resilient elements 30,31 can be made of plastics or spring steel, for example. They are sufficiently flexible to allow the fluid guide member 4 to move over a distance in the order of several centimetres towards and away from the upright side wall 6 of the interior chamber. They provide a restoring force tending in the same direction. This force counters the force due to the pressure difference between the pressure space 3 and the cooking space 2 (i.e. the pressure difference between the two sides of the fluid guide member 4). In use, the position of the fluid guide member 4 is changed periodically by adjusting the pressure difference between the pressure space 3 and the cooking space 2. To this end, an appropriate control device adjusts the settings of the centrifugal fan.

[0038] The embodiment of Fig. 3 thus requires no additional actuators. Moreover, the suspension arrangement does not extend through either the ceiling 9 or the floor 10 of the interior chamber. This makes it easier to seal off the interior chamber to prevent microwaves and/or fumes escaping.

[0039] The continual adjustment of the electromagnetic field distribution in the interior chamber, in particular in the cooking space 2 ensures that the foodstuffs at the different levels and at different positions on the trays 12 are heated at approximately the same rate.

[0040] The invention is not limited to the embodiments described above, which may be varied within the scope of the accompanying claims. The elements of the invention can be essential to the invention both individually and in any combination.

[0041] Embodiments in which only the fluid guide member 4 is movable, and in which the other plate-like members 22,23 are absent, also provide the effects set out above, and are easy to build, as well as being easy to clean, in use.

LIST OF REFERENCE NUMERALS

[0042]

1	Cooking appliance
2	Cooking space
3	Pressure space
4	Fluid guide member
5	5
5	Back wall
6	Left side wall
7	Right side wall
8	Door
9	Ceiling
10	10
10	Floor
11	Rack
12	Tray
13	Fan wheel
14	Motor
15	15
15	Equipment chamber
16	Axle
17	Opening
18	Slit
19	Slit
20	20
20	Microwave generator
21	Waveguide
22	First plate-like member
23	Second plate-like member
24	Actuator
25	25
25	Actuator
26	Actuator
27	Actuator
28	Pin
29	Pin
30	30
30	Resilient element
31	Resilient element

Claims

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1. Microwave cooking appliance, including:

an interior chamber, including a cooking space (2) for accommodating foodstuffs to be cooked; an apparatus (20,21) for providing microwaves of at least one wavelength to the interior chamber; and

at least one plate-like member (4,22,23) having at least one surface reflective to microwaves and facing an opposite surface reflective to microwaves in the interior chamber, wherein the plate-like member (4,22,23) is movable such as to vary a distance to the opposite surface whilst the microwaves are provided to the interior chamber,

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characterised in that

at least one of the plate-like members (4,22,23) is movable such as to allow a change in distance to the opposite surface by an amount of the order of at least a quarter wavelength λ .

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2. Microwave cooking appliance according to claim 1,

wherein
at least one of the plate-like members (4,22,23) substantially delimits the cooking space (2) to one side thereof.

3. Microwave cooking appliance according to claim 2, wherein
the interior chamber has a floor (10), the at least one plate-like members (4,22,23) delimiting the cooking space (2) only to a respective side thereof that is generally transverse to the floor (10). 5 10
4. Microwave cooking appliance according to any one of the preceding claims, wherein
at least one plate-like member (4) substantially partitions the interior chamber into the cooking space (2) and at least one further space (3), in particular a further space (3) accommodating a fan wheel (13). 15
5. Microwave cooking appliance according to claim 4, wherein
the plate-like member (34) substantially partitioning the interior chamber is suspended, in particular from one or more surfaces (10,9) defining the interior chamber, by at least one device including a resilient element (30,31). 20 25
6. Microwave cooking appliance according to claims 4 and 5, further including
a control apparatus for varying a pressure difference between the further space (3) and the cooking space (2) so as to reposition the plate-like member (4) substantially partitioning the interior chamber. 30
7. Microwave cooking appliance according to any one of claims 4-6, wherein
the plate-like member (4) substantially partitioning the interior chamber is arranged to leave free an opening (18,19) at at least one edge between the plate-like member (4) and a surface (10,9) defining the interior chamber. 35 40
8. Microwave cooking appliance according to any one of the preceding claims, including
an apparatus (24,25,26,27,28,29) for causing continual reciprocating movement of the plate-like member (4,22,23) whilst the microwaves are provided to the interior chamber, in particular at a frequency in a range of 5-50 min⁻¹. 45 50
9. Method of operating a microwave cooking appliance (1), in particular a microwave cooking appliance according to any one of the preceding claims, the cooking appliance including: 55

an interior chamber, including a cooking space (2) for accommodating foodstuffs to be cooked;
an apparatus (20,21) for providing microwaves

of at least one wavelength λ to the interior chamber; and

at least one plate-like member (4,22,23) having at least one surface reflective to microwaves and facing an opposite surface reflective to microwaves in the interior chamber,

wherein the plate-like member (4,22,23) is allowed to move such as to vary a distance to the opposite surface whilst the microwaves are provided to the interior chamber, **characterised in that**

an electromagnetic field distribution having minima and maxima is established in at least the cooking space (2) and **in that** locations of the minima and maxima are changed by the movement of the at least one plate-like member (4,22,23).

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

1. Microwave cooking appliance, including:

an interior chamber, including a cooking space (2) for accommodating foodstuffs to be cooked;
an apparatus (20,21) for providing microwaves of at least one wavelength λ to the interior chamber, and

at least one plate-like member (4,22,23) having at least one surface reflective to microwaves and facing an opposite surface reflective to microwaves in the interior chamber,

wherein the plate-like member (4,22,23) is movable such as to vary a distance to the opposite surface whilst the microwaves are provided to the interior chamber,

characterised in that

at least one of the plate-like members (4,22,23) is movable such as to allow a change in distance to the opposite surface by an amount equal to at least a quarter of the at least one wavelength λ .

2. Microwave cooking appliance according to claim 1, wherein

at least one of the plate-like members (4,22,23) substantially delimits the cooking space (2) to one side thereof.

3. Microwave cooking appliance according to claim 2, wherein the interior chamber has a floor (10), the at least one plate-like members (4,22,23) delimiting the cooking space (2) only to a respective side thereof that is generally transverse to the floor (10).

4. Microwave cooking appliance according to any one of the preceding claims,

wherein

at least one plate-like member (4) substantially partitions the interior chamber into the cooking space (2) and at least one further space (3), in particular a further space (3) accommodating a fan wheel (13). 5

5. Microwave cooking appliance according to claim 4, wherein

the plate-like member (34) substantially partitioning the interior chamber is suspended, in particular from one or more surfaces (10,9) defining the interior chamber, by at least one device including a resilient element (30,31). 10

6. Microwave cooking appliance according to claims 4 and 5, further including a control apparatus for varying a pressure difference between the further space (3) and the cooking space (2) so as to reposition the plate-like member (4) substantially partitioning the interior chamber. 15 20

7. Microwave cooking appliance according to any one of claims 4-6, wherein the plate-like member (4) substantially partitioning the interior chamber is arranged to leave free an opening (18,19) at at least one edge between the plate-like member (4) and a surface (10,9) defining the interior chamber. 25

8. Microwave cooking appliance according to any one of the preceding claims, including an apparatus (24,25,26,27,28,29) for causing continual reciprocating movement of the plate-like member (4,22,23) whilst the microwaves are provided to the interior chamber, in particular at a frequency in a range of 5-50 min⁻¹. 30 35

9. Method of operating a microwave cooking appliance (1) according to any one of the preceding claims, the cooking appliance including:

an interior chamber, including a cooking space (2) for accommodating foodstuffs to be cooked; an apparatus (20,21) for providing microwaves of at least one wavelength λ to the interior chamber; and 40 45

at least one plate-like member (4,22,23) having at least one surface reflective to microwaves and facing an opposite surface reflective to microwaves in the interior chamber, 50

wherein the plate-like member (4,22,23) is allowed to move such as to vary a distance to the opposite surface whilst the microwaves are provided to the interior chamber, wherein 55

an electromagnetic field distribution having minima and maxima is established in at least the cooking space (2), and locations of the minima and maxima are changed by the movement of the at least one plate-like member (4,22,23).

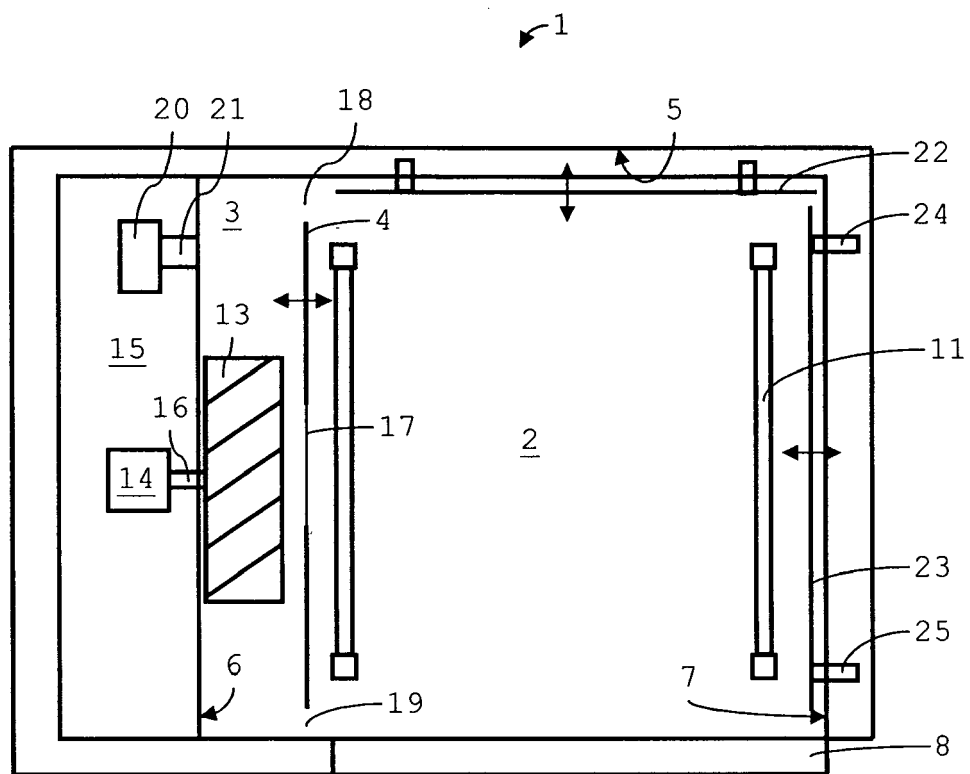


Fig. 1

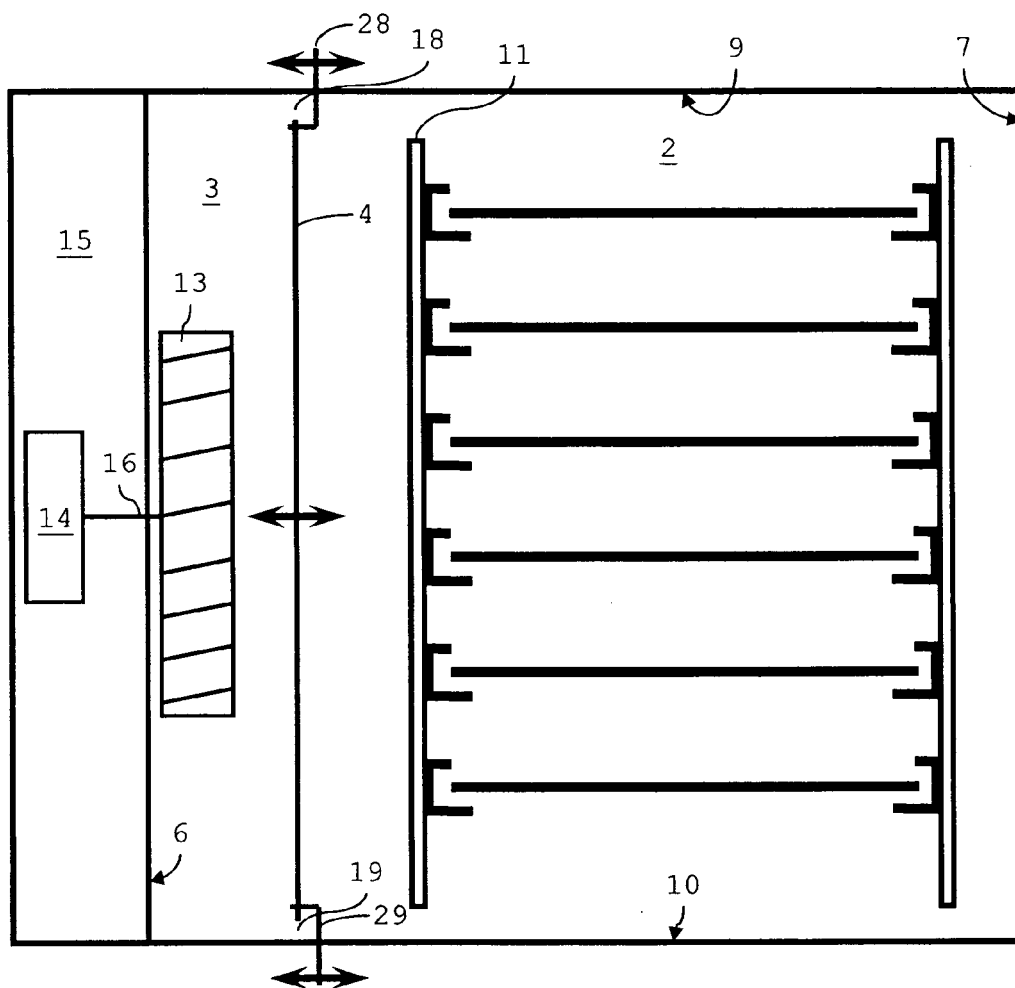


Fig. 2

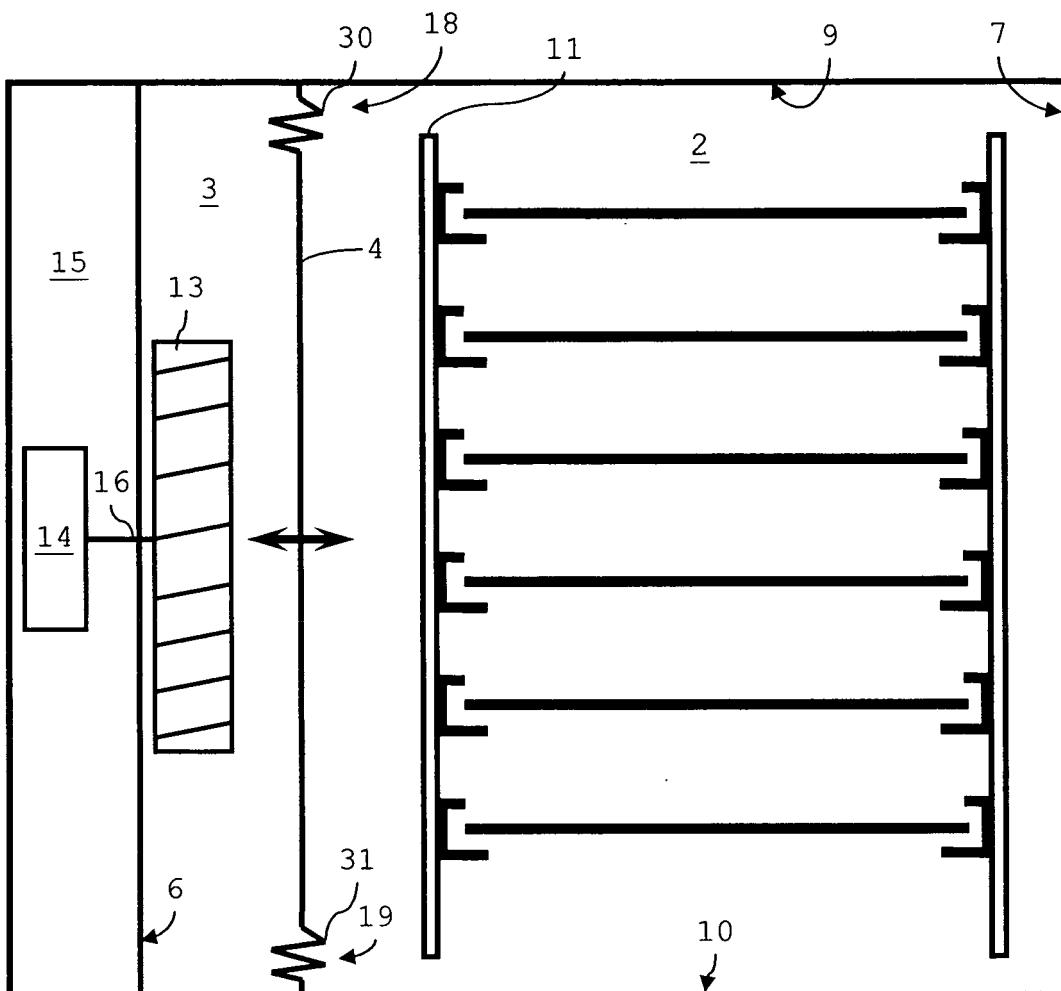


Fig. 3



EUROPEAN SEARCH REPORT

Application Number
EP 09 29 0205

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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			TECHNICAL FIELDS SEARCHED (IPC)
			H05B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 19 June 2009	Examiner Garcia, Jesus
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 T : theory or principle underlying the invention 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			

2

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 09 29 0205

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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19-06-2009

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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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