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(54) HEATING CHAMBER WITH A HYBRID HEATING SYSTEM

(57) The subject of the present invention is a heating chamber with a hybrid heating system, in particular for automatic food preparation and processing systems. The heating system is a combination of different heat exchange methods, wherein the basic source of heating is microwave radiation assisted by infrared radiation. The walls (4) of the heating chamber (3) are connected to each other by a finger joint (6, 7) through suitably shaped protrusions (6) and slots (7) located essentially along edges of the joined walls (4), wherein the protrusion bottom (6) comprises, along the transverse edges, recesses (8) for close adherence of the joined elements.

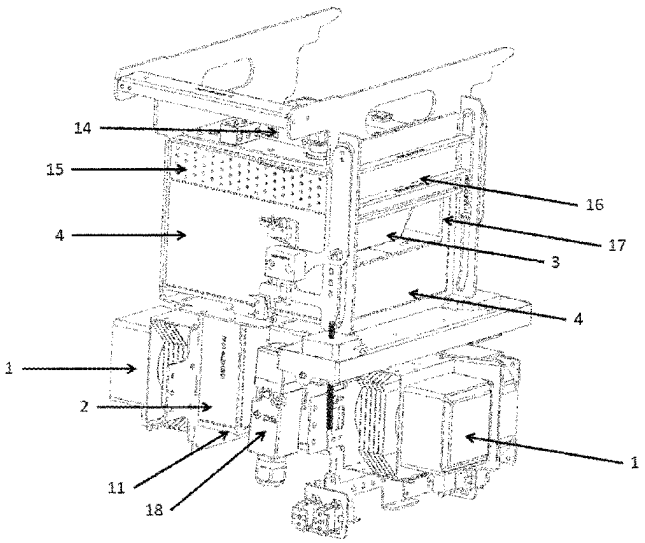

Fig. 1

EP 3 509 400 A1

Description

Technical Field

[0001] The invention relates to a heating chamber with a hybrid heating system, in particular for automatic food preparation and processing systems. The heating system is a combination of different heat exchange methods, wherein the basic source of heating is microwave radiation assisted by infrared radiation.

Background Art

[0002] A US patent application US4803324 discloses a microwave food oven assisted by a far-infrared radiator to provide uniform food heating in a relatively short time. The infrared radiator made of a ferrite heating plate coated with a ceramic layer absorbs microwave radiation and far infrared. The radiators can be shaped to suit the needs of focusing the heat beam on the heated product. The walls of the heating chamber enable the reflection of microwaves so that they can hit the heated portion after reflection. The heating chamber comprises also some elements that make it a more complex system, and therefore more susceptible to defects or damage. In the heating chamber, the meal is placed on a turntable, which is a conventional solution known from microwave ovens. Similarly, in a known solution, the heat radiator may be raised or lowered relative to the meal portion, which is to affect the heating time. Also the proposed variant of convection heating using heaters and a fan is an element whose effectiveness has certain limitations. An additional disadvantage is the possibility of damage to the system as a result of high operational load.

[0003] Another US document US4592485 discloses an apparatus dispensing cold and hot meals. The heating chamber is a classical microwave oven with a movable, segmented bottom, which at the same time is a border with the storage chamber and a tool that loads further meal portions served from below. The storage part, which is kept at low temperatures to facilitate the storage of products, is insulated from the heating chamber by an additional shielding layer, preventing the microwave radiation from penetrating the storage part. The interior of the heating chamber is coated with an absorptive layer to protect the magnetron against the return of the beam, but also limits the possibility of faster food heating and therefore lengthens the waiting time for meal preparation.

[0004] A German document DE3815466 discloses a meal vending machine comprising the preheating function and storage at a higher temperature in readiness for dispensing. The problem of quick meal dispensing was not solved by increasing the heating efficiency, but by adding the option of pre-ordering a meal, which then after heating is stored in a warm storage, where it maintains the temperature and thus allows for dispensing of a large number of portions in a short time. As a result, such solutions will work only in places where users have the option of such meal ordering (enterprises operating in shifts with specified breaks). Certain novelty is provided by the possibility of dividing the system into separate machines - cold storage, heating part, warm system and the possibility of replacing whole components, it raises, however, the price of the entire system and complicates the construction by requiring that the components are properly set and connected.

[0005] Another example of an automatic meal vending machine with the meal heating option is disclosed in a Chinese document CN105118156A. The heating chamber is made by using a classic oven or by microwave radiation. It is thus the simplest solution with efficiency below expectations.

[0006] A French invention description FR2836267A1 describes a solution wherein the heating is provided by the use of microwave radiation assisted by a convection system. The efficiency of this type of solution is not high and will contribute to a long waiting for a meal. The efficiency of the machine was increased by multiplication of magnetrons, such solution, however, increases the price of the machine and requires better shielding in order to protect the food storage and the users.

[0007] A Polish patent PL221008B1 discloses a chamber with hybrid heating system, wherein a magnetron generating the microwaves and an emitter of infrared radiation are used as the energy sources, wherein it is preferable to use as the emitter of infrared radiation, in particular, a quartz bulb or an electric heater transferring the energy of thermal oscillations of matter. In addition, the chamber is equipped with an UV radiation emitter, in particular a quartz bulb used for sterilisation of the heated product and for interoperation sterilisation of the chamber. The walls of the chamber are made of a material absorbing and reflecting electromagnetic radiation from UV and microwave frequency ranges, but being, at least in part, transparent for visible light.

Summary of invention

[0008] The objective of the present invention is to provide an improved heating chamber that at least in part will eliminate the disadvantages of the prior art solutions.

[0009] This objective was achieved by providing a heating chamber with a hybrid heating system with a specially designed system for connecting the chamber walls.

[0010] According to the invention, a heating chamber with a hybrid heating system, in particular for automated food preparation and processing systems, comprises:

- a body consisting of walls that form a closed space for a heated product, wherein at least one of the walls is movable or has an opening for placing the product inside and pulling it out;
- a source of microwave radiation generating microwaves propagating inside the heating chamber, preferably a microwave emitter in the form of at least one magnetron;

a source of infrared radiation, preferably at least one infrared radiator in the form of a quartz bulb or an electric heater,
wherein the walls of the heating chamber are connected to each other by a finger joint through suitably shaped protrusions and slots located essentially along edges of the joined walls, wherein the protrusion bottom comprises, along the transverse edges, recesses for close adherence of the joined elements. To ensure electromagnetic tightness, the longest linear dimension of a leak is important - unlike in the case of hydraulic or pneumatic tightness, where the sum of the leakage area counts. The solution consisting in breaking the straight sections of connecting edges and at the same time making use of the elements breaking the straightness of the edges as elements positioning and joining the walls due to their shape, minimizes the number of joining operations, significantly simplifies the construction and assembly, as well as virtually guarantees that the walls of the chamber are tightly connected.

[0011] The recess is semicircular in shape with a radius ranging from 0.1 mm to 0.7 mm, preferably 0.2 mm.

[0012] Preferably, the magnetron is connected to a waveguide that is attached to the wall of the heating chamber in order to deliver microwave radiation to the heating chamber. At the input of the waveguide into the heating chamber, a microwave diffuser is placed for multidirectional and even distribution of microwaves inside the heating chamber. The microwave diffuser is in the form of a six-arm mechanical mixer.

[0013] Preferably, an infrared radiator is placed inside the heating chamber, and is separated from the part of the heating chamber, in which microwaves are propagated, by means of a perforated baffle that creates the space for propagation of infrared radiation, wherein the perforated baffle stops microwave radiation and allows for effective penetration of infrared radiation into the microwave propagation space.

[0014] The perforation of the baffle has a honeycomb structure with a largest mesh size from 2 mm to 5 mm, and preferably of 3.5 mm.

Advantageous effect of invention

[0015] The use of the finger joint to connect the walls eliminates the risk of microwave leakage through joint gaps, and thus prevents damage to the control systems, increases heating efficiency of the system and protects the user against adverse effects of radiation.

[0016] Due to the use of the microwave mixer the meal in the heating chamber is heated by a uniformly distributed field, which excludes the need for additional measures affecting the heating, such as rotating trays or more complex systems for displacing the heated meal.

Brief description of drawings

[0017] In the following, the invention will be illustrated in a preferred embodiment, with reference to the accompanying drawings, wherein:

Fig. 1 - shows the heating chamber in a perspective view.
Fig. 2 - shows the heating chamber in cross section.
Fig. 3 - shows the view of the interior of the chamber from a different perspective.
Fig. 4 - shows the method of joining the chamber elements by means of slots and protrusions.
Fig. 5 - shows the structure of the perforated baffle.
Fig. 6 - shows the structure and characteristic dimensions of the construction of slots and protrusions connecting the elements of the heating chamber.

Description of embodiments

[0018] In one preferred embodiment of the invention, the heating chamber 3 is in the form of a cuboidal body consisting of walls 4 connected to each other. One of the walls 4, conventionally referred to as the front one, is equipped with a door 16 that allows for placing the food product for heating inside the heating chamber 3 through the opening 17 in the wall 4.

[0019] The door 16 and the opening 17 in the wall 4, through which the heated product moves towards the recipient, are designed in such a way as to prevent the radiation from leaking out of the heating chamber 3. The door leaf 16, vertically movable on rolls 18, in the last phase of the automatically controlled movement is further tightened to the edge of the opening 17 in such a way that the opening is covered with a safety margin of 1 mm to 10 mm, preferably between 2-5 mm. Such a connection provides additionally thermal tightness in the heating chamber 3, and automatic control does not allow magnetrons 1 to be activated when the door 16 is open.

[0020] Due to the nature of radiation, even the smallest leak can lead to radiation leakage, thus exposing the user or other elements of the system to damage. For this reason, the elements of the heating chamber, i.e. the walls forming the body of the heating chamber 3, are connected using finger joint, which eliminates the risk of microwave leakage through joint gaps, thus preventing damage to the control systems and increasing the heating efficiency of the system. The walls 4 forming the heating chamber 3 have a thickness of more than 0.2 mm and less than 10 mm, preferably in the range of 1-2 mm for practical reasons. The walls 4 are connected to each other by protrusions 6 and slots 7 (or fingers) that are located along the edges of the walls 4. The width of the slot 20 or finger 7 and the spacing 19 between them is 3 mm. The protrusion bottom 6 comprises semicircular recesses 8 in the material with a small radius 21 (ranging from 0.1 to 0.7 mm, preferably 0.2). The recesses 8 are made along the transverse edge that connects the side of the

protrusion 6 with the bottom. The role of the recess 8 is to ensure that the joined elements closely adhere to each other.

[0021] The heating chamber is equipped with a hybrid heating system which is implemented in at least two ways, wherein the main heating source is microwave radiation. In the presented example, two magnetrons 1 placed below the heating chamber 3 are used, which magnetrons are connected to the waveguides 2 placed in the openings in the lower wall 4 of the heating chamber 3. The dimensions of both the chamber and the entire system to which it belongs take into account the dimensions of the wave emitted from the magnetron 1, which is the source of microwave radiation, and the waveguide 2, by means of which the microwave radiation is delivered to the heating chamber 3. Due to the possibility of magnetron damage 1 and the possibility of user burns, insulation is used to prevent the return of microwave radiation to the magnetron 1 and the radiation leakage outside the heating chamber 3. Due to the fact that the radiation propagating in the chamber 3 can lead to eddy currents in the housing elements, it is necessary to properly feed the microwave radiation into the heating chamber 3, so that it does not cause excessive heating of the chamber walls 4 and the waveguide 2 due to the abovementioned eddy currents.

[0022] The operation frequency of the magnetrons 1 used (using a commercially available LG 2M246 model as an example) is in the range 0.9 GHz - 5.9 GHz, preferably 2450-2470 MHz, which results in a wavelength from the interval 121.45 mm - 122.44 mm (and for 0.9 GHz 33.33 mm, and for 5.9 GHz 50.85 mm). After emission from the two magnetrons 1 attached to the waveguides 2 going out of the chamber, the microwaves propagate along the waveguides to the heating chamber 3, where, right at the entry 5 of the waveguide 2 into the heating chamber 3, they are multi-directionally scattered by a six-arm mechanical microwave mixer 10, to finally reach the top of the heating chamber 3, where the product is heated. The introduction of the microwave diffuser 10 eliminates the need to use a turntable under the heated product, which greatly simplifies the construction of the chamber, reduces its geometrical dimensions, and thus reduces the manufacturing costs. The waveguides 2 with standard sizes according to the WR340 / WG9A / R26 standard (EIA Standard / RSCS Standard / IEC Standard) have transverse dimensions of 3.4 "(86.36 mm) x 1.7" (43.18 mm). The placement of the magnetron 1 in the waveguide 2 is characterized in that its antenna is offset by ¼ wavelength relative to the waveguide bottom 11, with the total length of the waveguide 2 equal to one wavelength of the microwave radiation used.

[0023] The hybrid product heating system comprises also a second source of energy in the form of an infrared radiator 9 that emits infrared radiation, thus supporting the product heating process carried out using the main heating source from the magnetrons 1. Due to different powers in the series of manufactured infrared lamps 9, appropriate selection of their powers should be considered, so that the product heating time is compatible with the capabilities of the microwave emitter 1.

[0024] Above the heating chamber 3 there is an additional space 12 in the form of a chamber or compartment, containing two radiators 9 that emit infrared radiation with a power of not less than 30W and no more than 2kW, preferably 375W each, which, in order to protect them from microwave radiation, are separated from the heating chamber 3 by a perforated baffle 13. The perforated baffle is connected to the walls 4 of the heating chamber by means of the finger joint 6, 7 as described earlier. The baffle 13 has a honeycomb structure with openings 19 with the largest mesh size from 2 to 5 mm - preferably 3.5 mm. This size is so selected to prevent further propagation of microwave radiation, thus protecting the infrared radiators 9 and the users of the device, and on the other hand to allow the infrared radiation to be transmitted through the openings 19 towards the heated food product, and their shape maximizes the surface area the infrared radiation is transmitted through. Preferably the surface area of the perforation of baffle 13 comprising the openings 19 is selected in such a way that the infrared radiation is able to have an effect on the entire outer surface of the heated product. The dimensions of the heating chamber, which are in relation to the wavelength of the microwave radiation used, are 1.5 x 1.25 x 0.75 (length x width x height) of the wavelength emitted by the magnetron.

[0025] Above the propagation space 12 of the infrared radiators 9, there is an air movement stimulating device 14 that forces air to move towards the heating chamber 3. Its role is to guide water evaporating from the product back into the heating chamber 3, whereby the heated meal maintains an adequate moisture level, which has a positive effect on its organoleptic properties. In addition, in the infrared radiation propagation space 12, the walls 4 of the heating chamber 3 comprise venting holes 15, which are arranged laterally relative to the infrared radiators 9, support heat exchange with the environment and regulate the level or remove the excess of water vapour in the space 12 of the infrared radiators 9. The capacity of these elements as determined by the amount of pumped air should be in the range of 10-100 m^3/h, preferably 61.2 m^3/h.

Reference signs list

[0026]

1. Magnetron
2. Waveguide
3. Heating chamber
4. Walls of the heating chamber
5. Waveguide outputs to the heating chamber
6. Protrusions
7. Slots/lock fingers
8. Semicircular recesses

9. Infrared radiator
10. Microwave diffuser/mixer
11. Waveguide bottom
12. Infrared propagation space
13. Perforated partition separating the heating chamber from the infrared propagation space
14. Air movement stimulating device/fan
15. Venting holes
16. Heating chamber door
17. Opening for loading the meal to the heating chamber
18. Power cut-off from magnetrons
19. Spacing between protrusions
20. Slot width
21. Semicircular recess radius
22. Protrusion height - equal to the thickness of the sheets to which the element is joined

Claims

1. A heating chamber with a hybrid heating system, in particular for automated food preparation and processing systems, comprising:

a body consisting of walls (4) that form a closed space for a heated product,
wherein at least one of the walls (4) is movable or has an opening (17),
enabling in that way to place the product inside and to pull it out;
a source of microwave radiation generating microwaves propagating inside the heating chamber (3), preferably a microwave emitter in the form of at least one magnetron (1);
a source of infrared radiation, preferably at least one infrared radiator (9) in the form of a quartz bulb or an electric heater,

characterised in that
the walls (4) of the heating chamber (3) are connected to each other by a finger joint (6, 7) through suitably shaped protrusions (6) and slots (7) located essentially along edges of the joined walls (4), wherein the protrusion bottom (6) comprises, along the transverse edges, recesses (8) for close adherence of the joined elements.

2. The heating chamber according to claim 1, **characterised in that** the recess (8) is semicircular in shape with a radius ranging from 0.1 mm to 0.7 mm, preferably 0.2 mm.

3. The heating chamber according to claim 1, **characterised in that** the magnetron (1) is connected to a waveguide (2) that is attached to the wall (4) of the heating chamber (3) in order to deliver microwave radiation to the heating chamber (3).

4. The heating chamber according to claim 3, **characterised in that** at the input of the waveguide (2) into the heating chamber (3), a microwave diffuser (10) is situated for multidirectional and even distribution of microwaves inside the heating chamber (3).

5. The heating chamber according to claim 4, **characterised in that** the microwave diffuser (10) is in the form of a six-arm mechanical mixer.

6. The heating chamber according to claim 1, **characterised in that** an infrared radiator (9) is placed inside the heating chamber (3), and is separated from the part of the heating chamber (3), in which microwaves are propagated by means of a perforated baffle (13) that creates a space (12) for propagation of infrared radiation, wherein the perforated baffle (13) stops microwave radiation and allows for effective penetration of infrared radiation into the microwave propagation space.

7. The heating chamber according to claim 6, **characterised in that** the perforation of the baffle (13) has a honeycomb structure with a largest mesh size from 2 mm to 5 mm, and preferably of 3.5 mm.

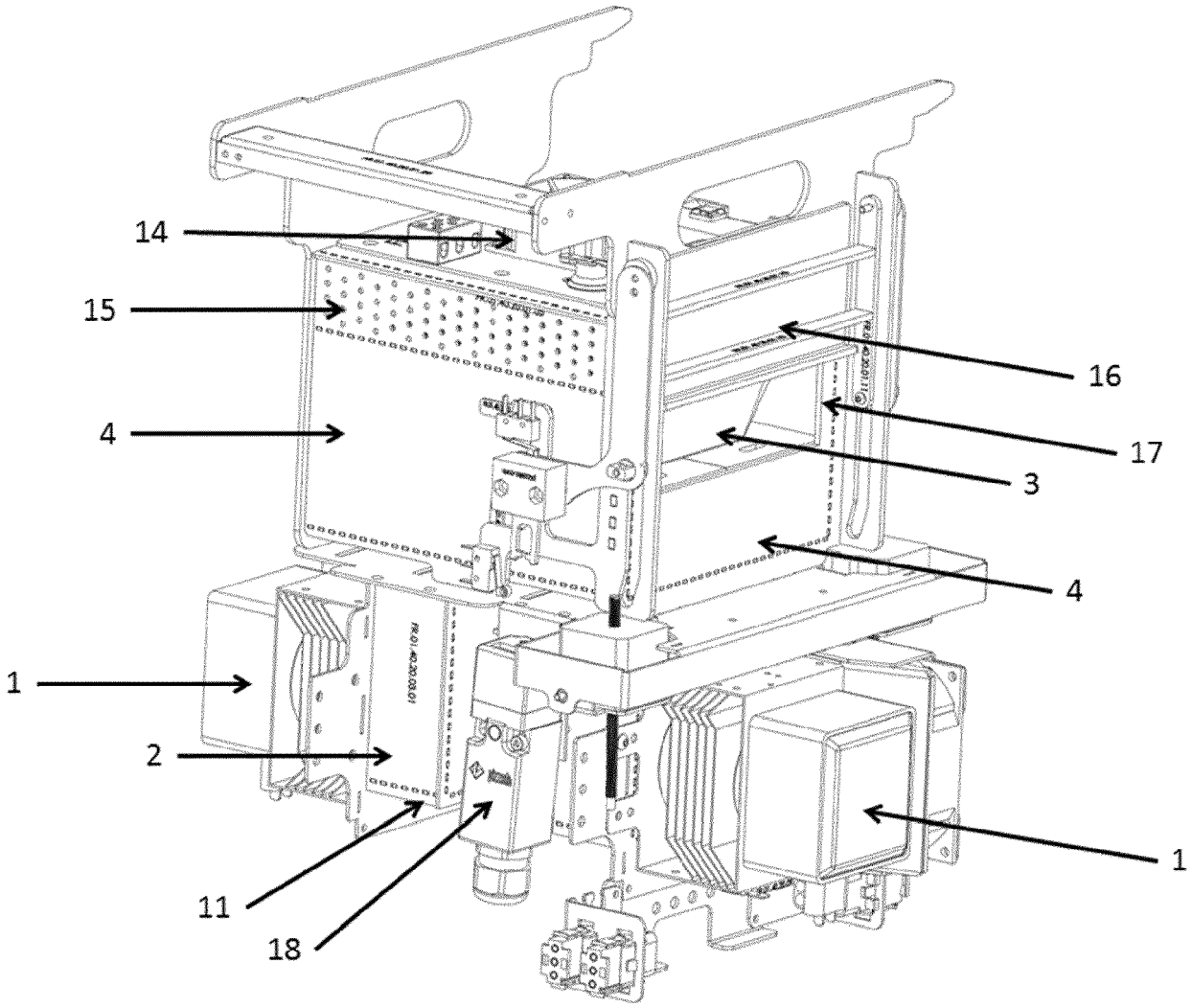

Fig. 1

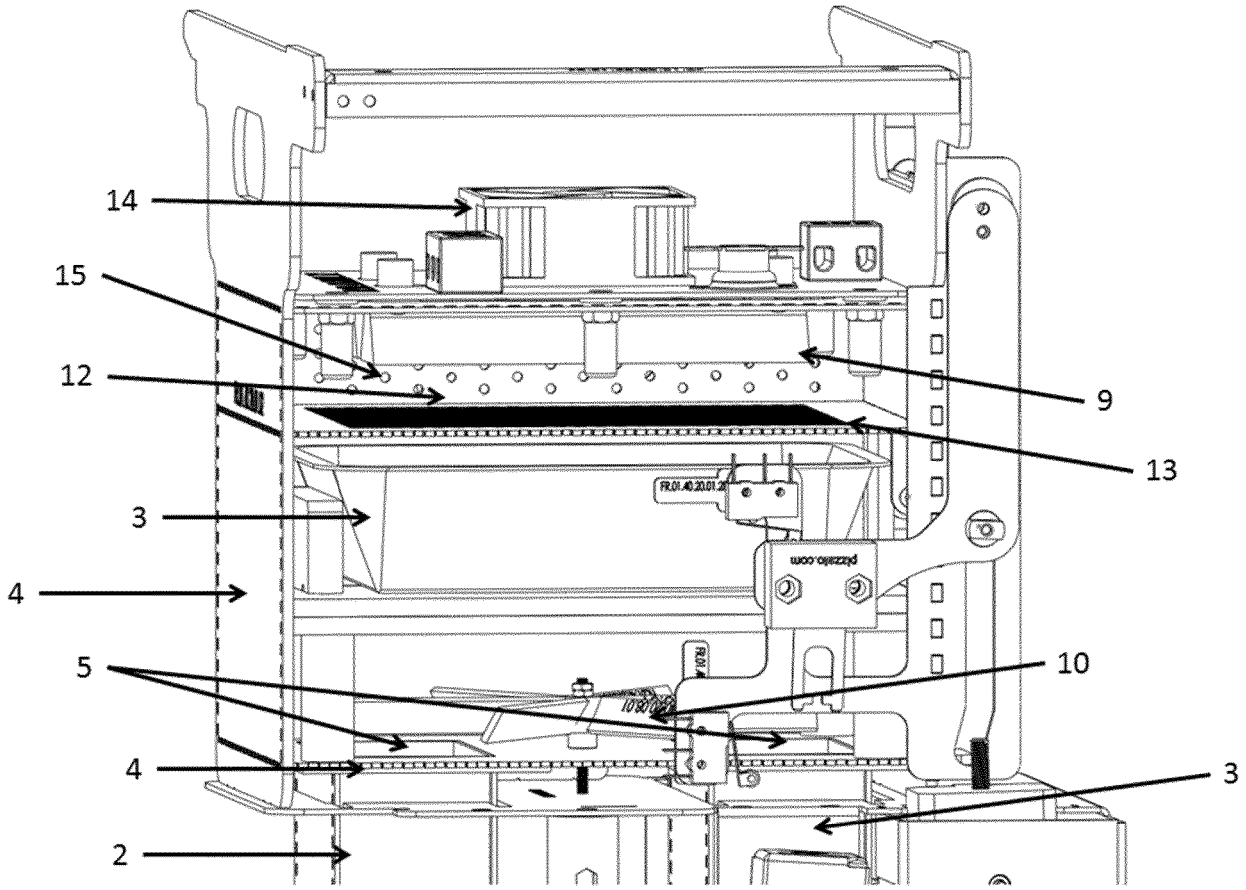

Fig. 2

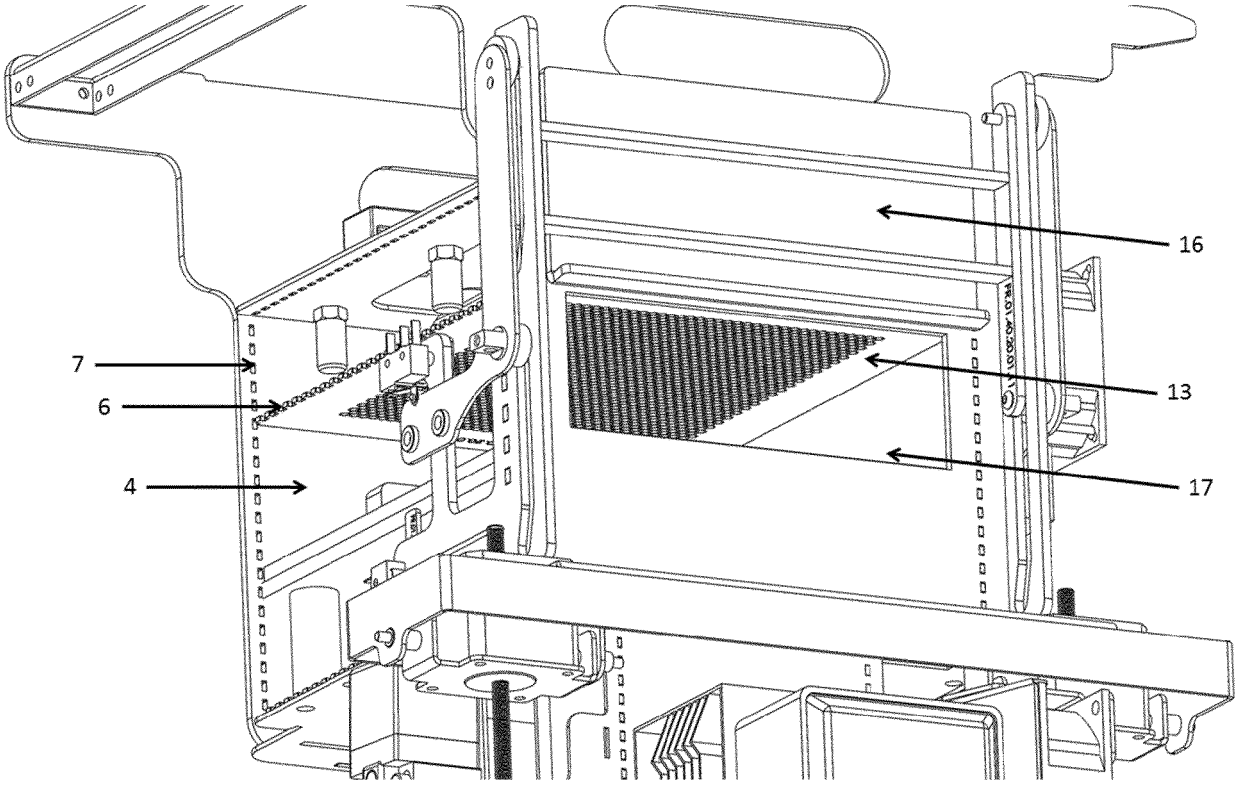

Fig. 3

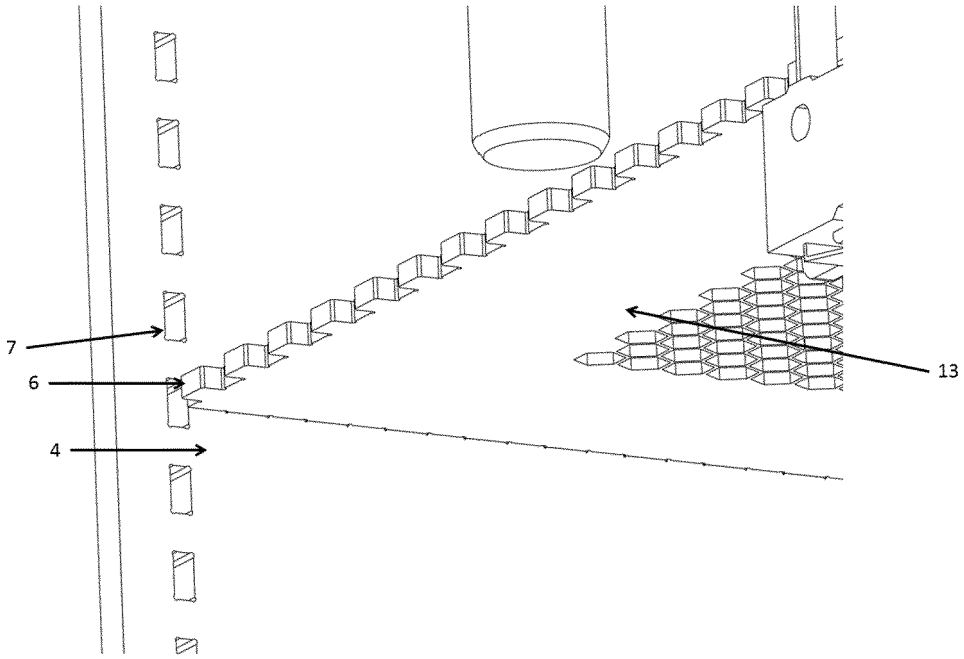

Fig. 4

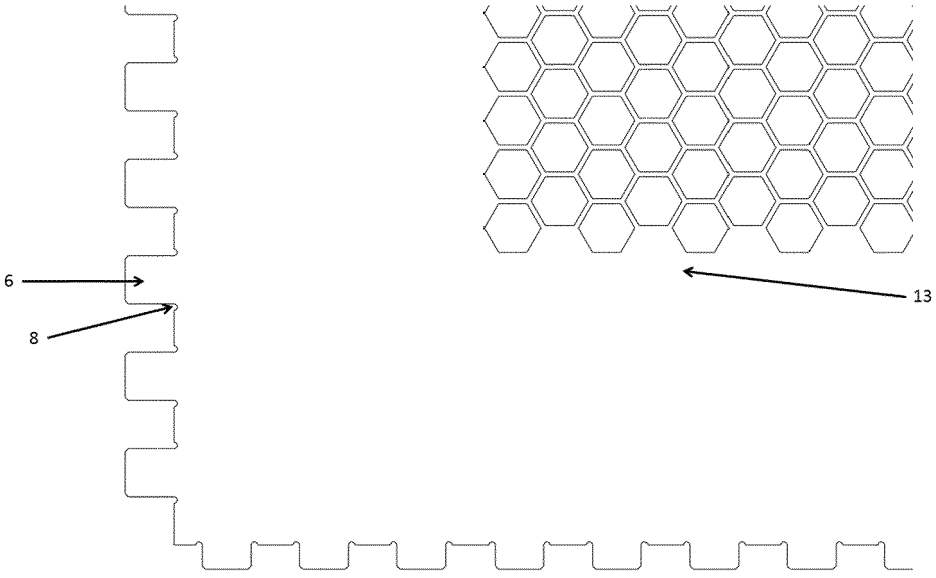

Fig. 5

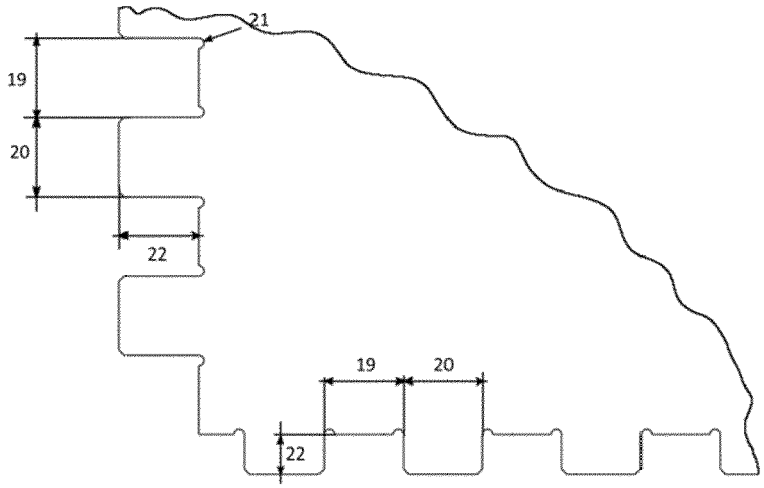

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 19 46 1501

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	14 May 2019	de la Tassa Laforgue

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