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(54) **CULTIVATION METHOD OF AGRICULTURAL PRODUCTS**

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(57) **ABSTRACT**

The present invention discloses a method for growing agricultural products in closed environments, particularly for vertical farms, comprising the steps of: arranging the agricultural products on a plurality of trays (**100**); arranging the plurality of trays (**100**) in a plurality of air conditioned grow rooms (**314***a*, **314***b*, **314***c*, **314***d*) inside a closed environment (**401**), each room (**314***a*, **314***b*, **314***c*, **314***d*) having artificial lighting and optimised climatic conditions for a determined type of agricultural products or for a specific growth phase of the agricultural products; moving the trays (**100**) from a first grow room (**314***a*, **314***b*, **314***c*, **314***d*) to a second grow room (**314***a*, **314***b*, **314***c*, **314***d*), each grow room (**314***a*, **314***b*, **314***c*, **314***d*) having artificial lighting parameters and differentiated climate control based on a certain growth phase of the agricultural products moved. The invention also discloses a system for implementing the described method.

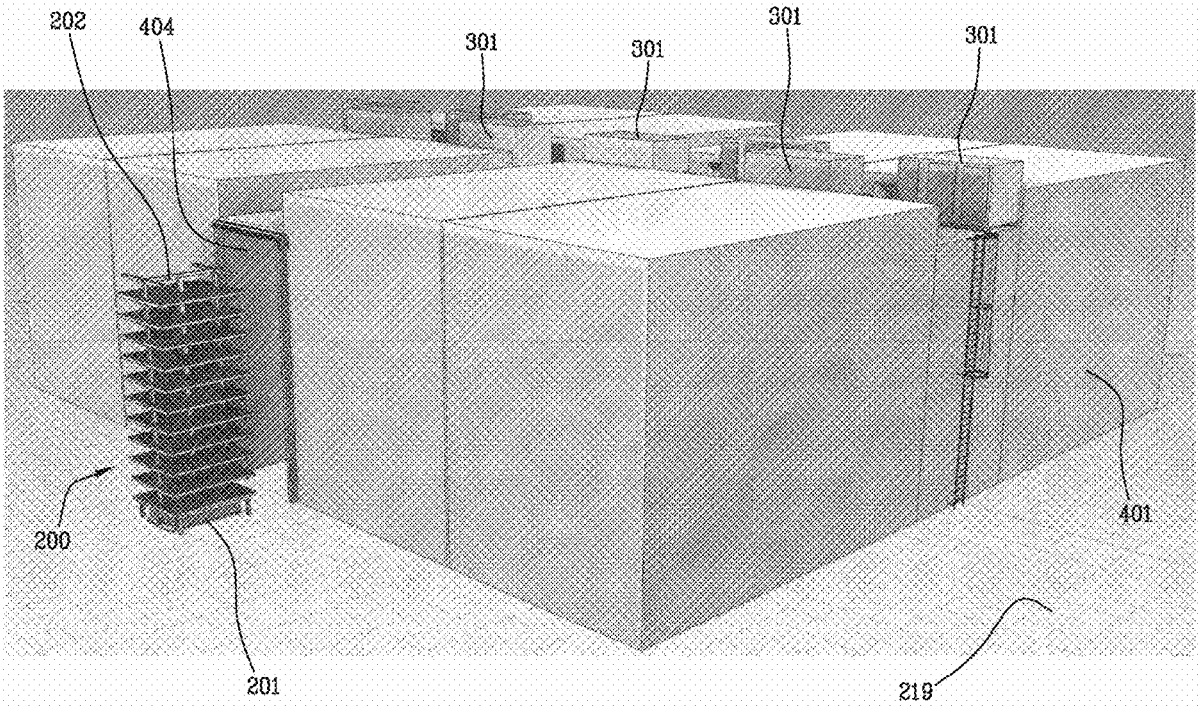

Fig.1

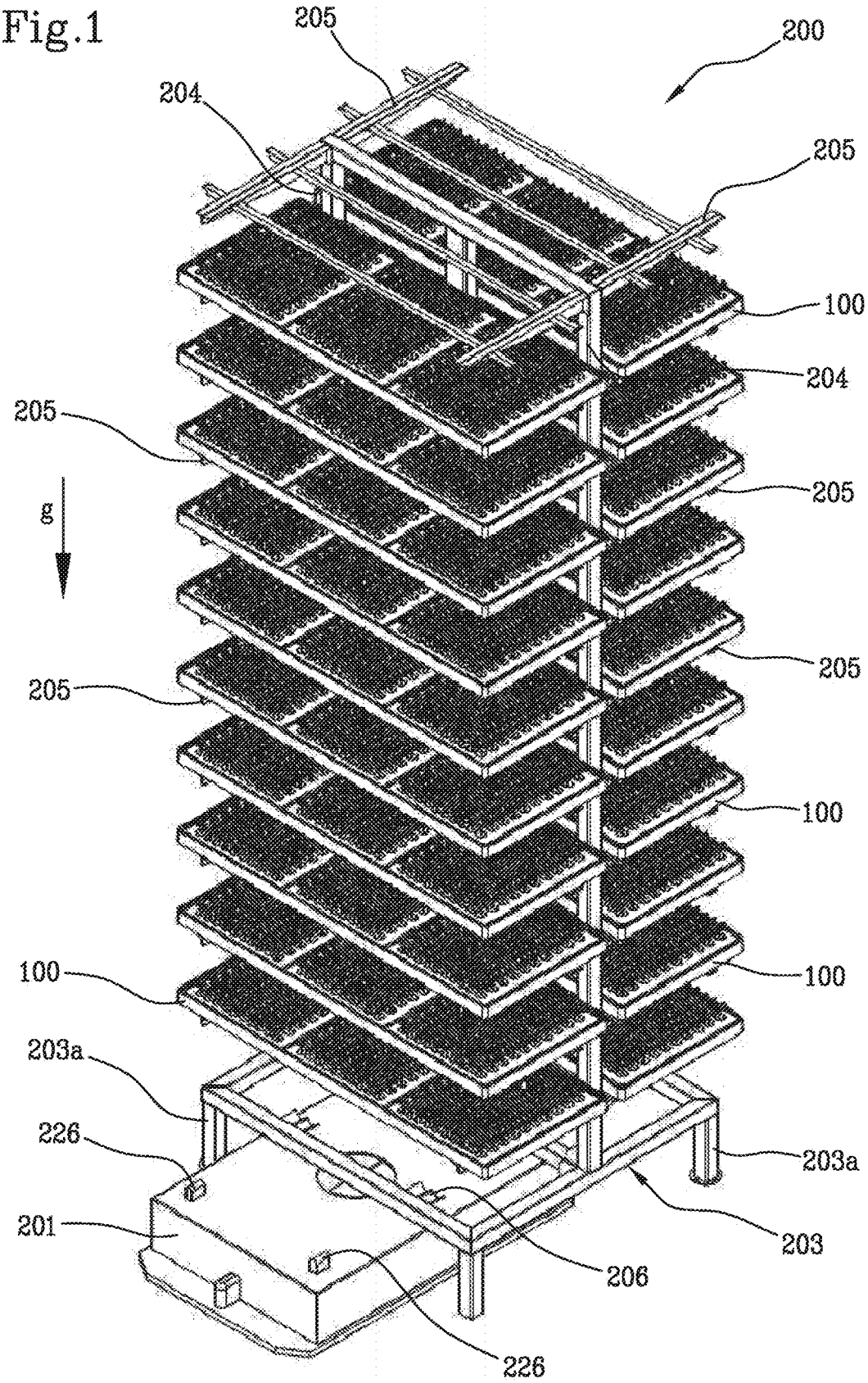
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Fig.2

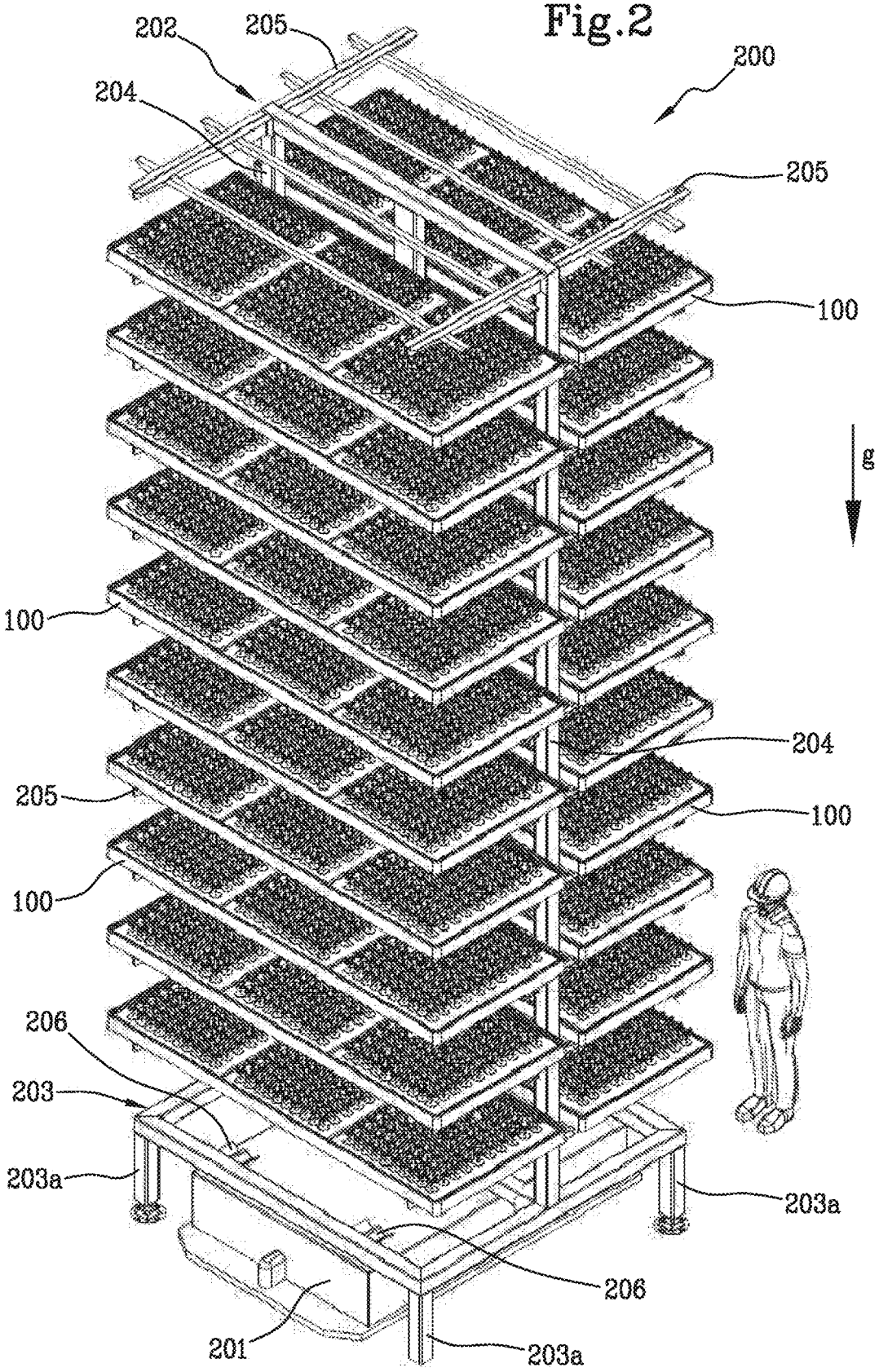
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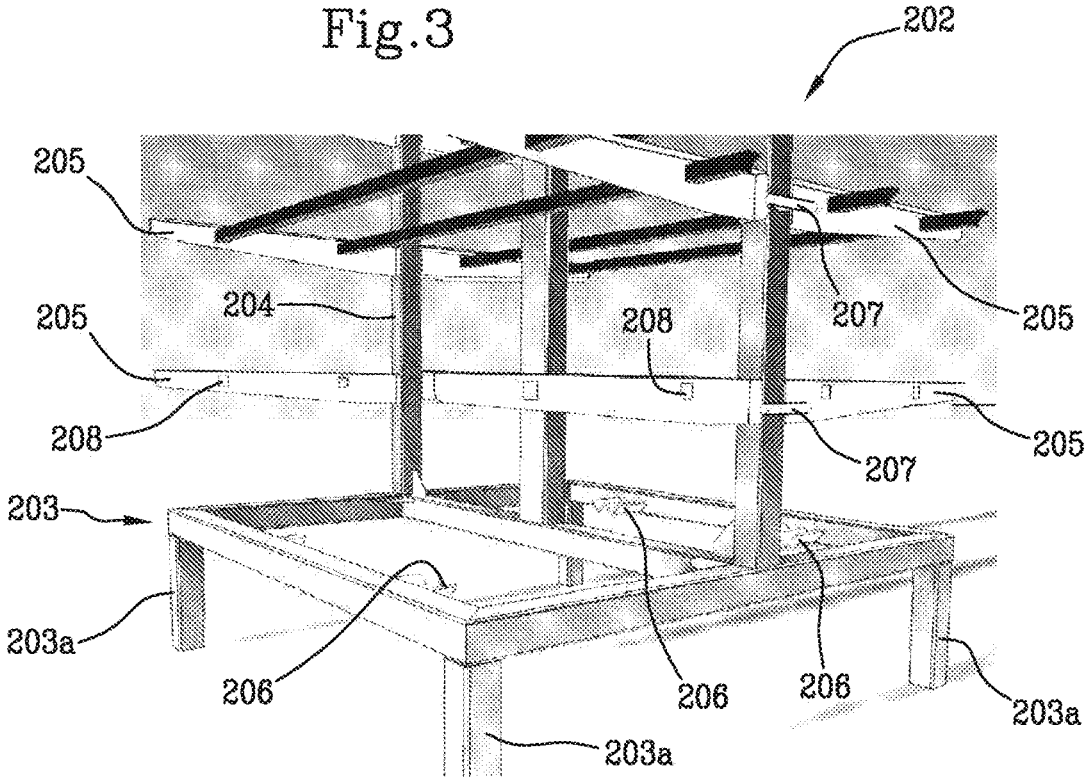
Fig.3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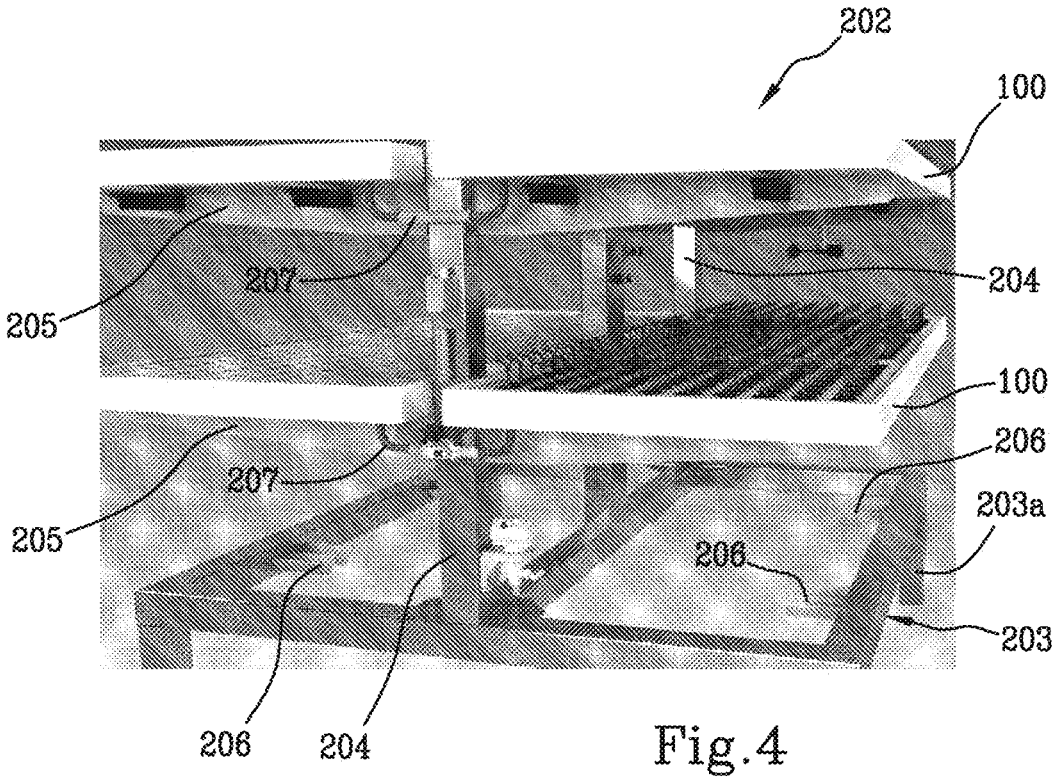
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Fig.4

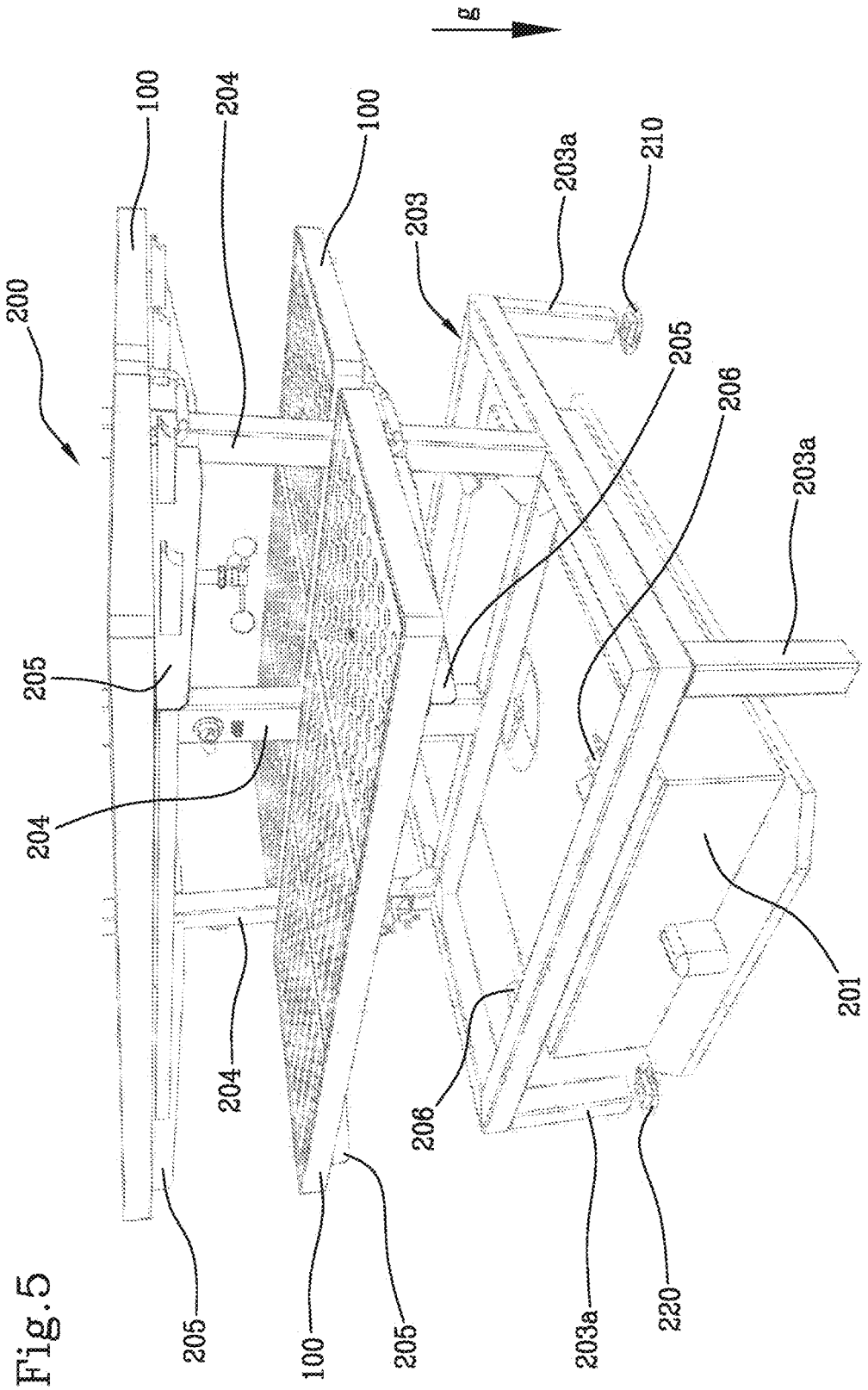
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Fig.5

Fig.7

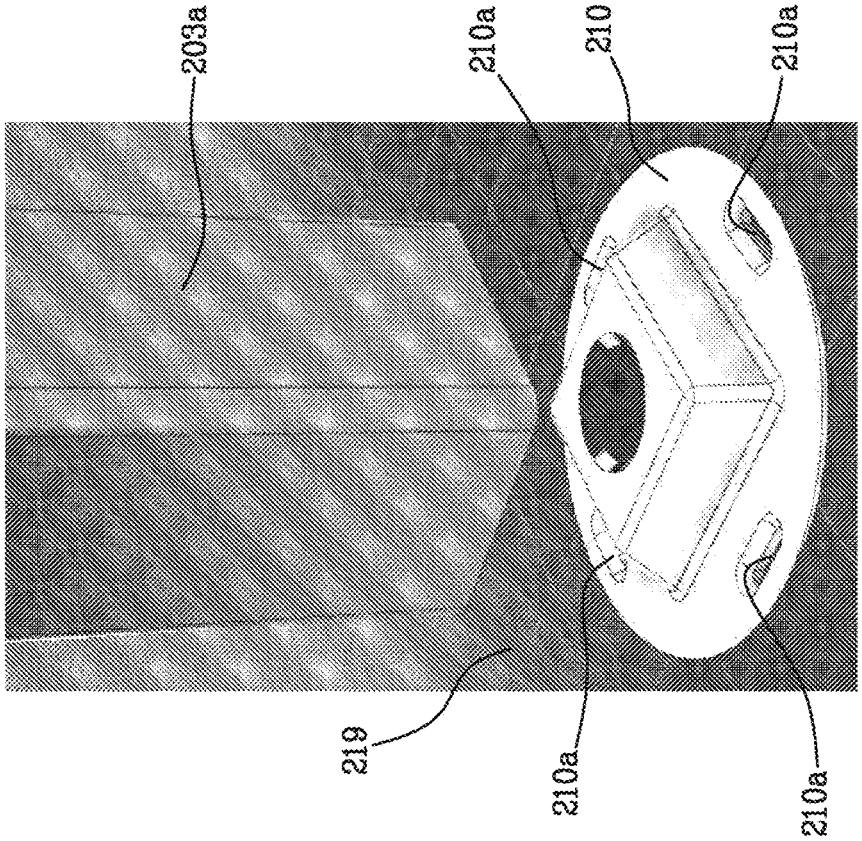
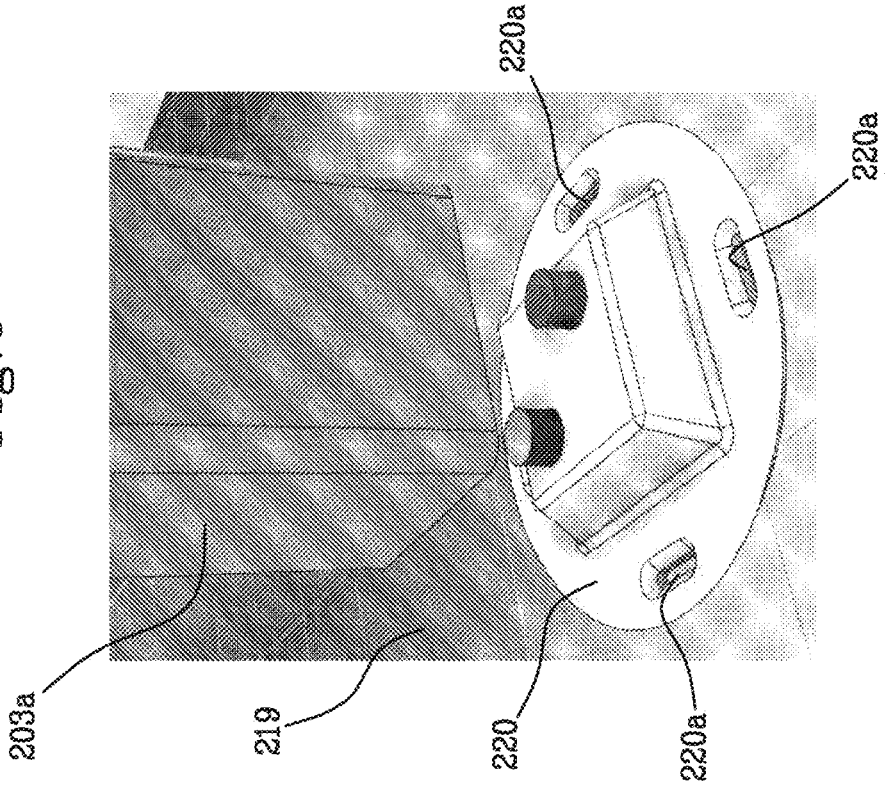


Fig.6



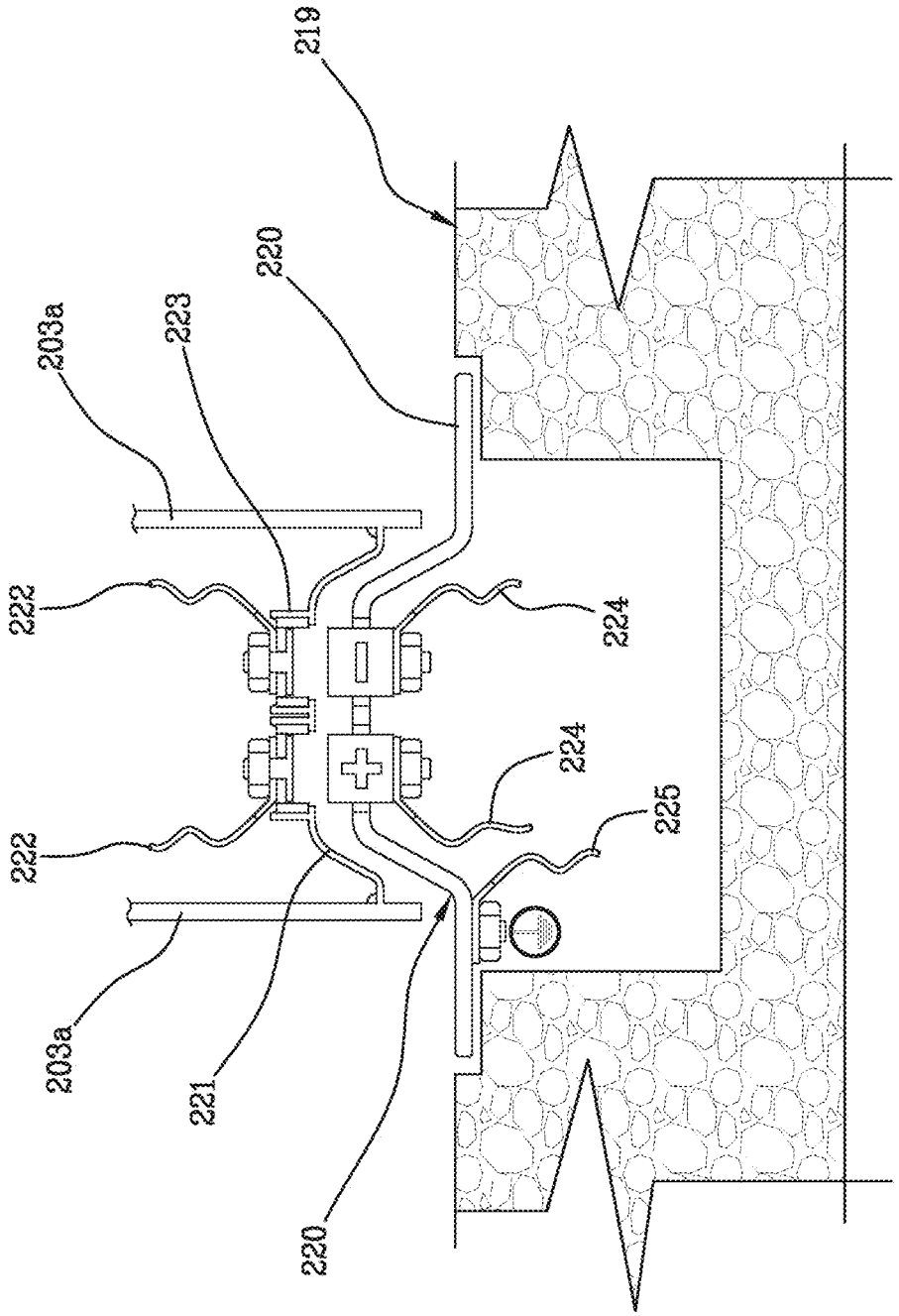


Fig.6a

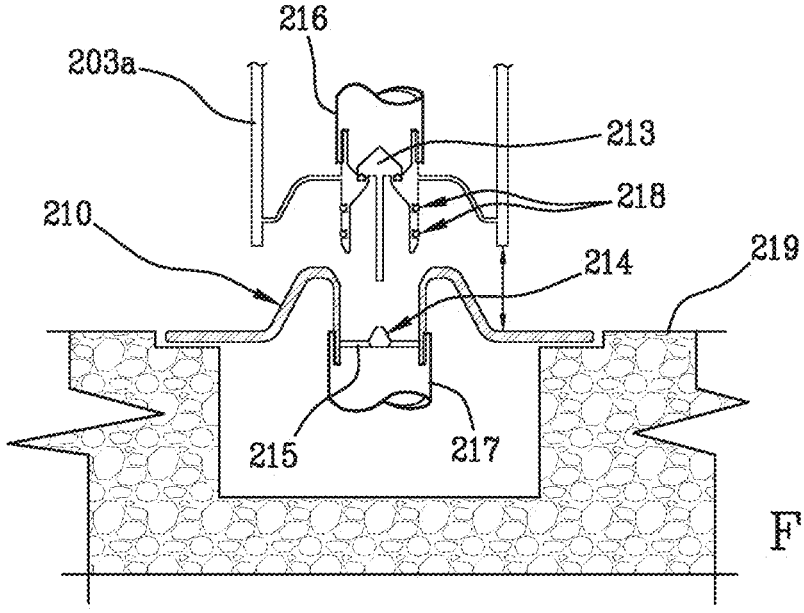


Fig.7a

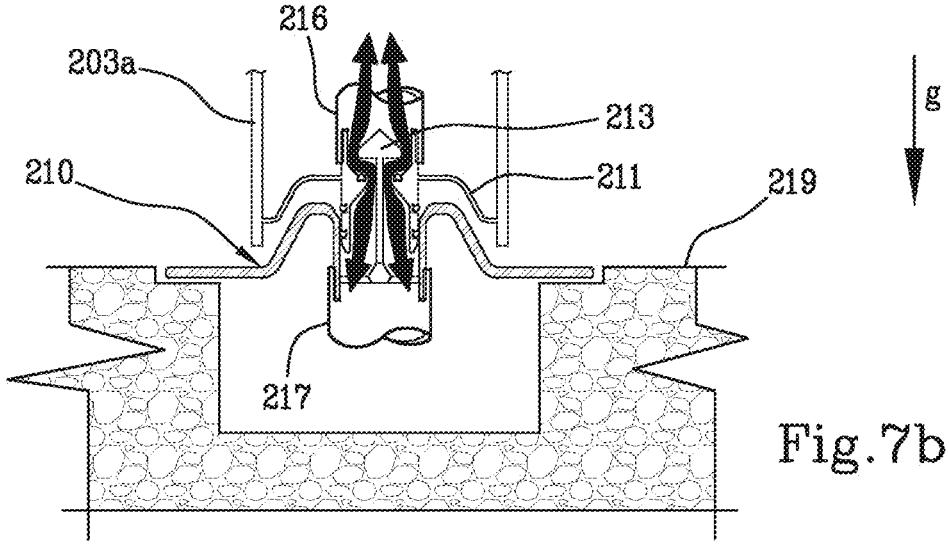


Fig.7b

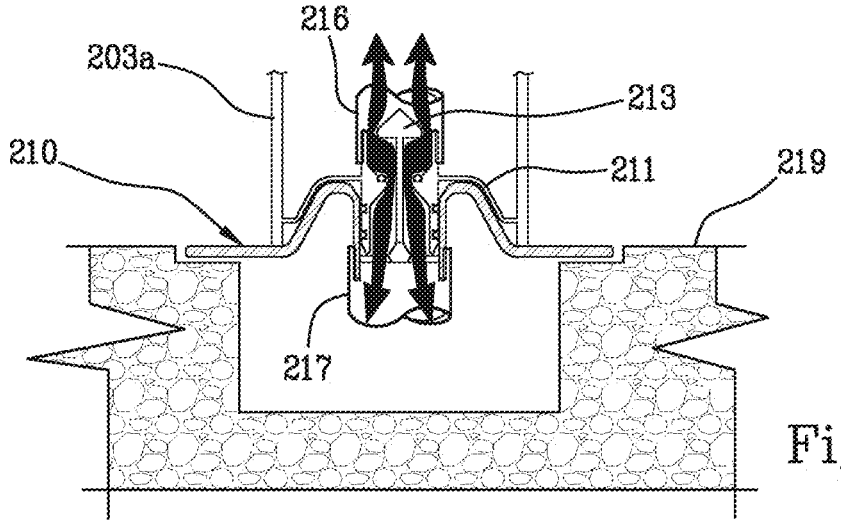


Fig.7c

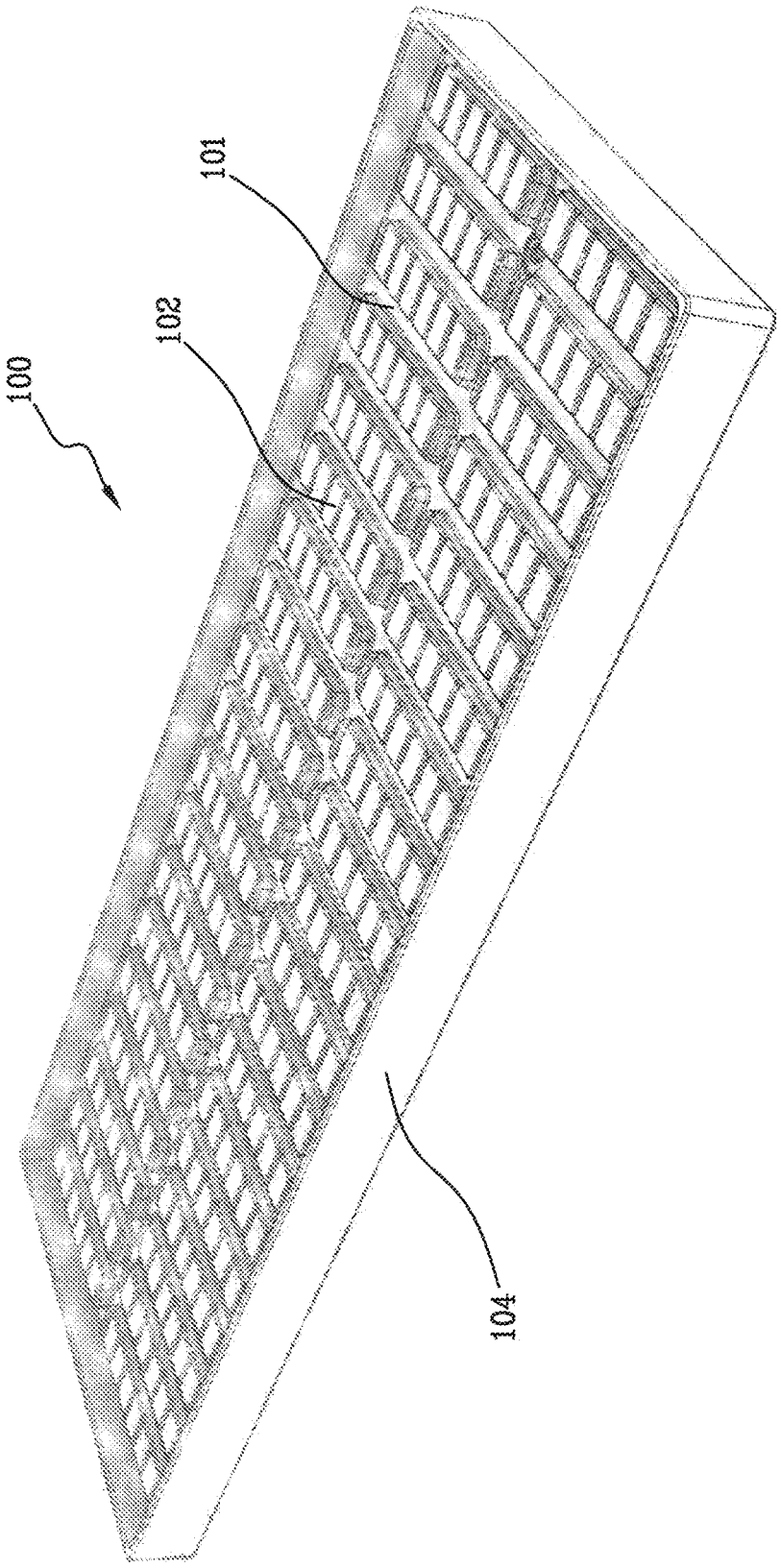


Fig.8a

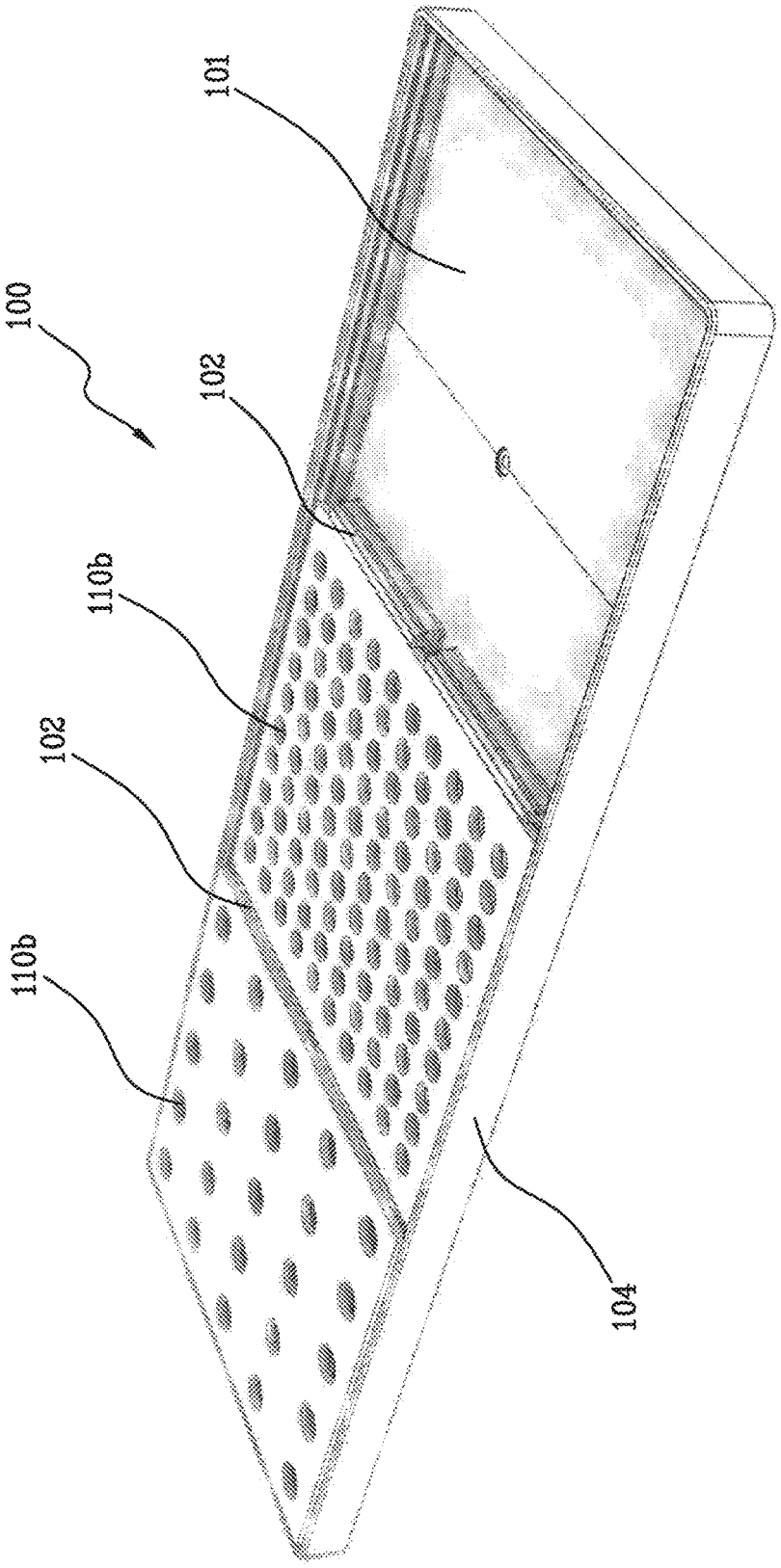
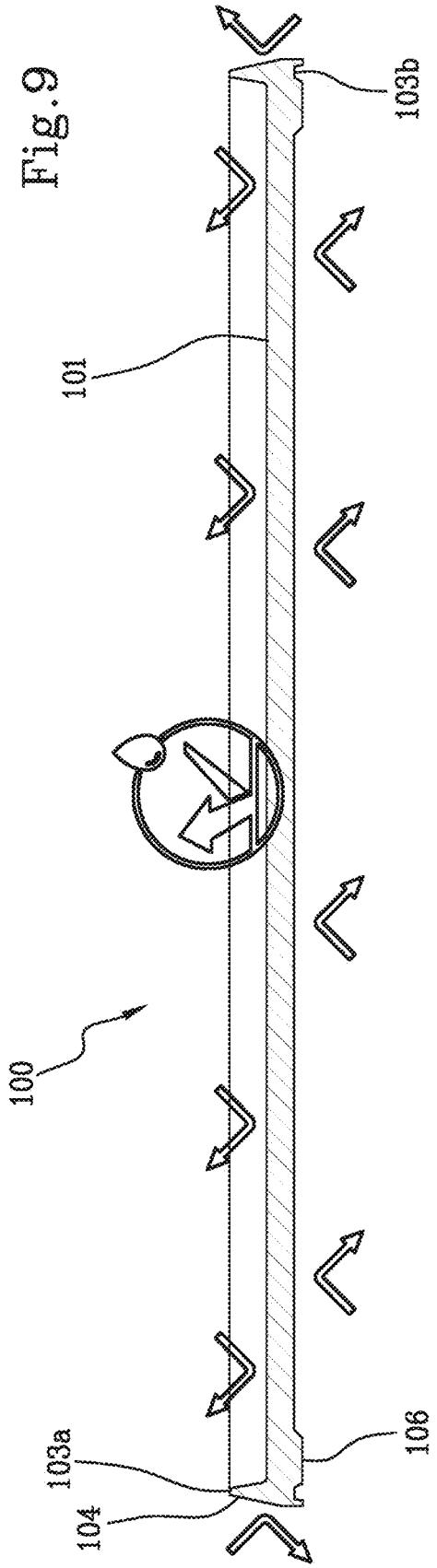


Fig.8b

Fig.9



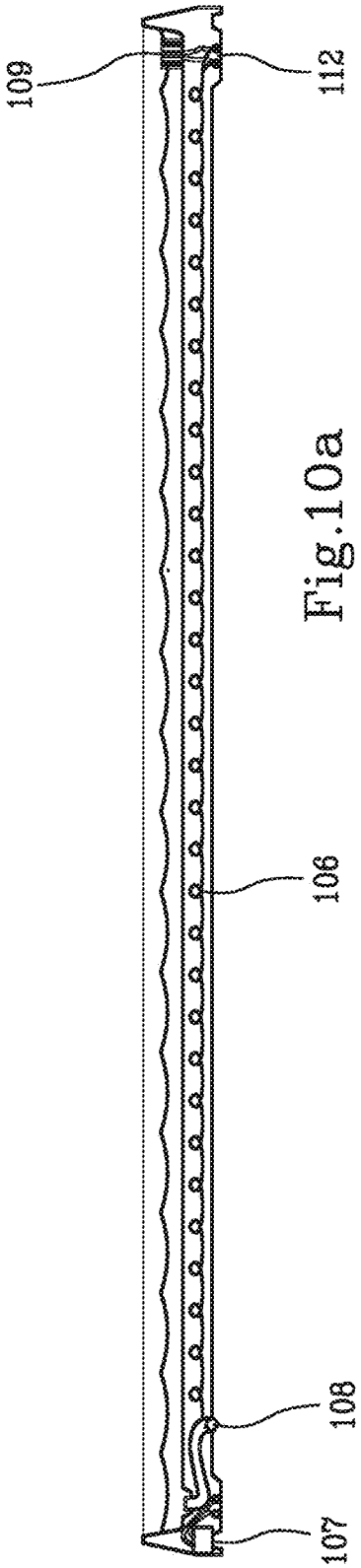


Fig.10a

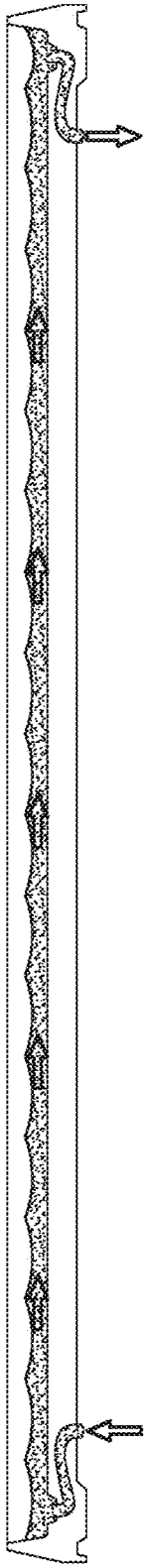


Fig.10b

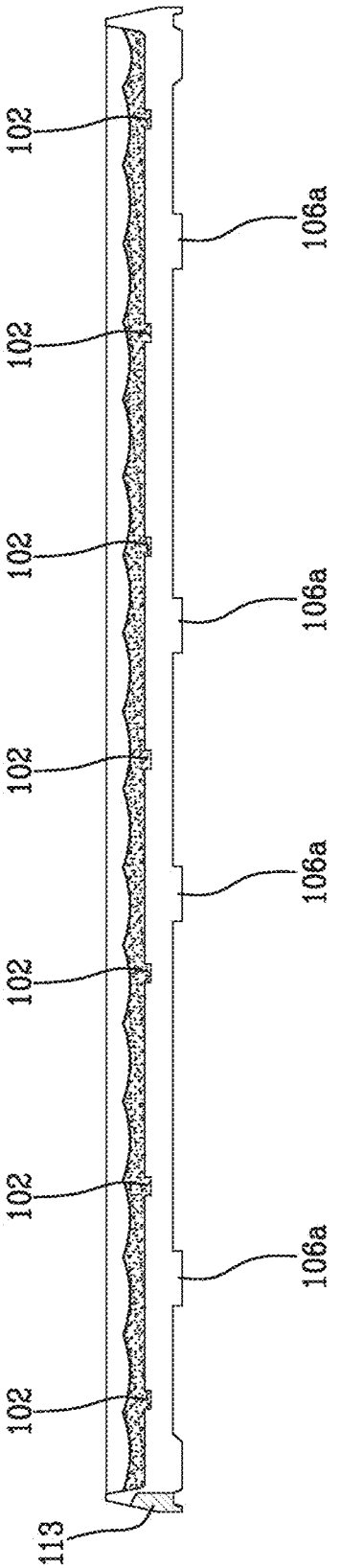


Fig.10c

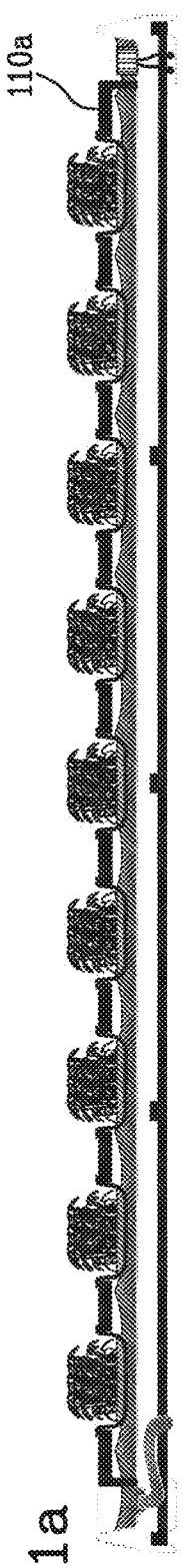


Fig.11a

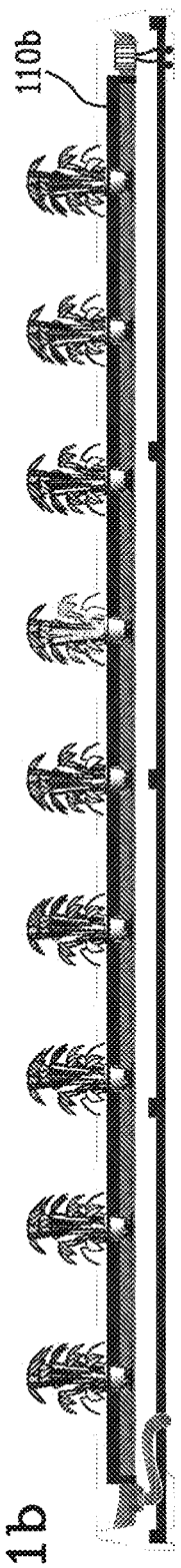


Fig.11b

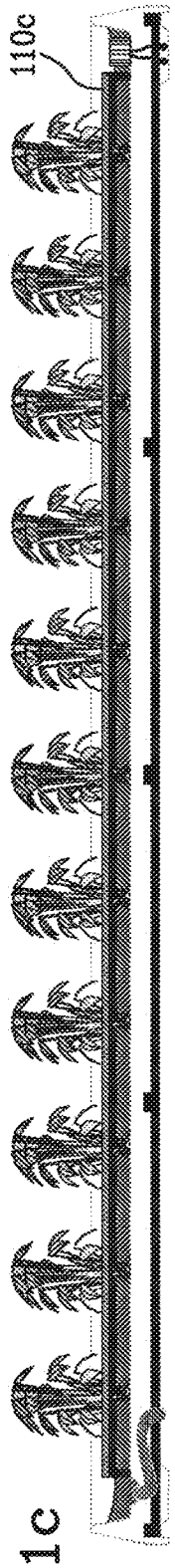


Fig.11c

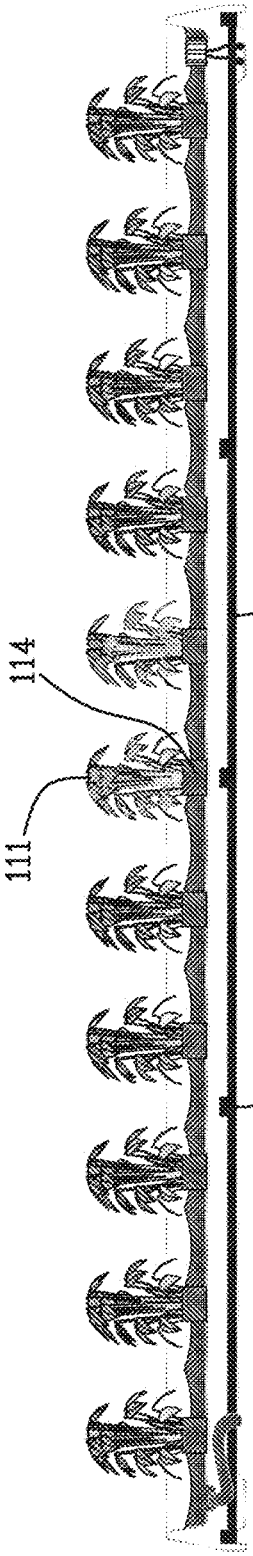
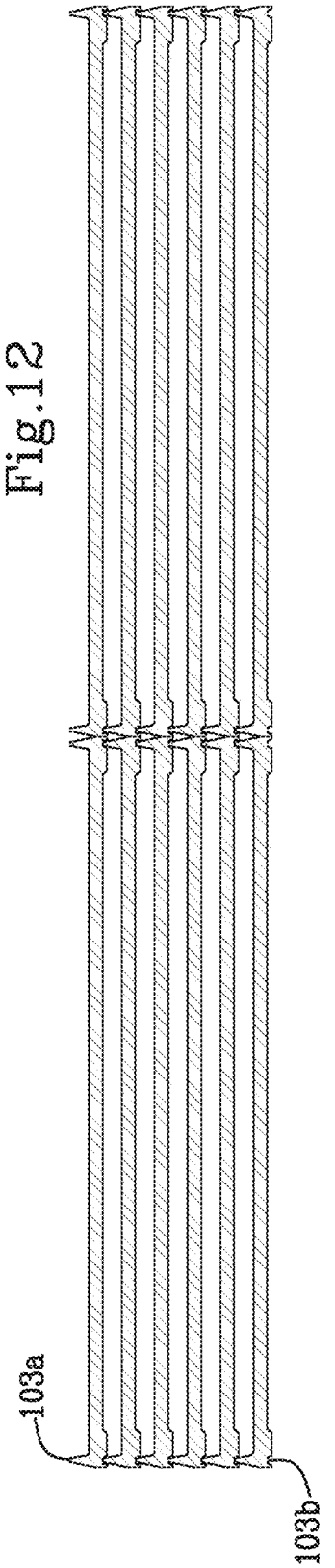


Fig.11d



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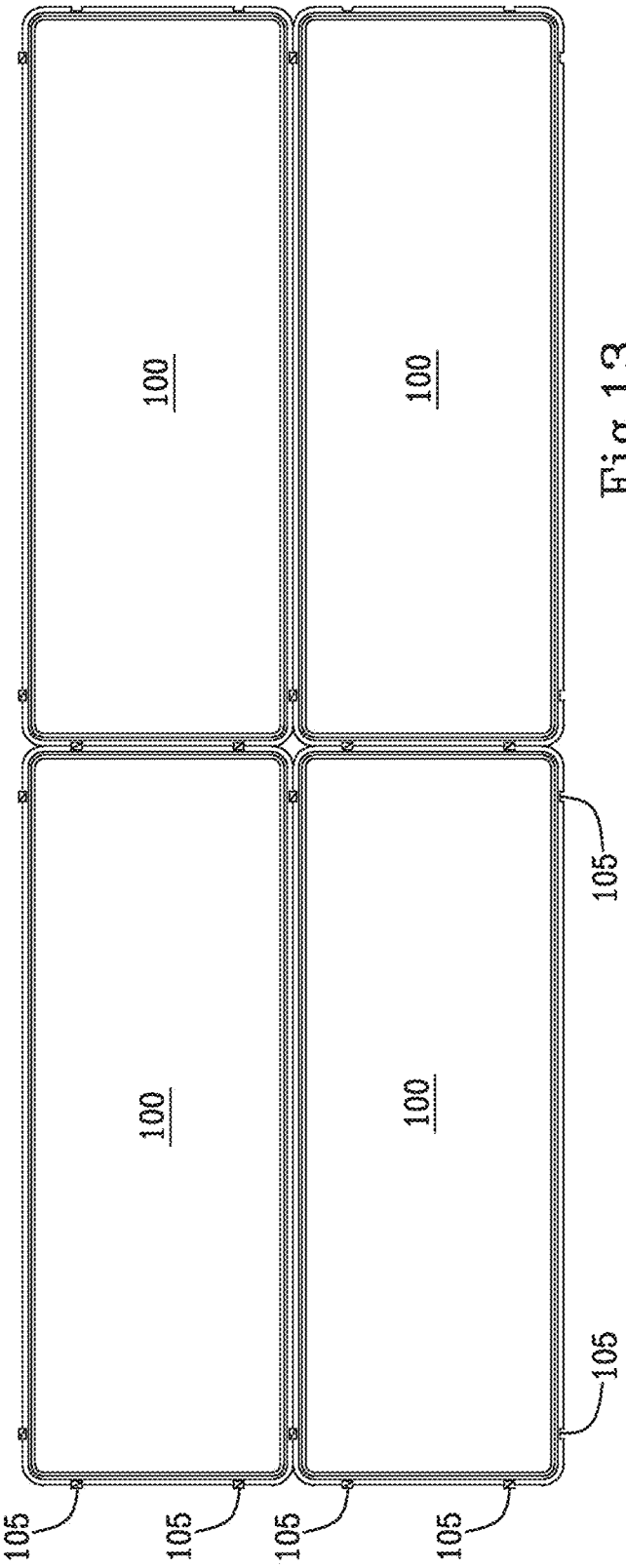

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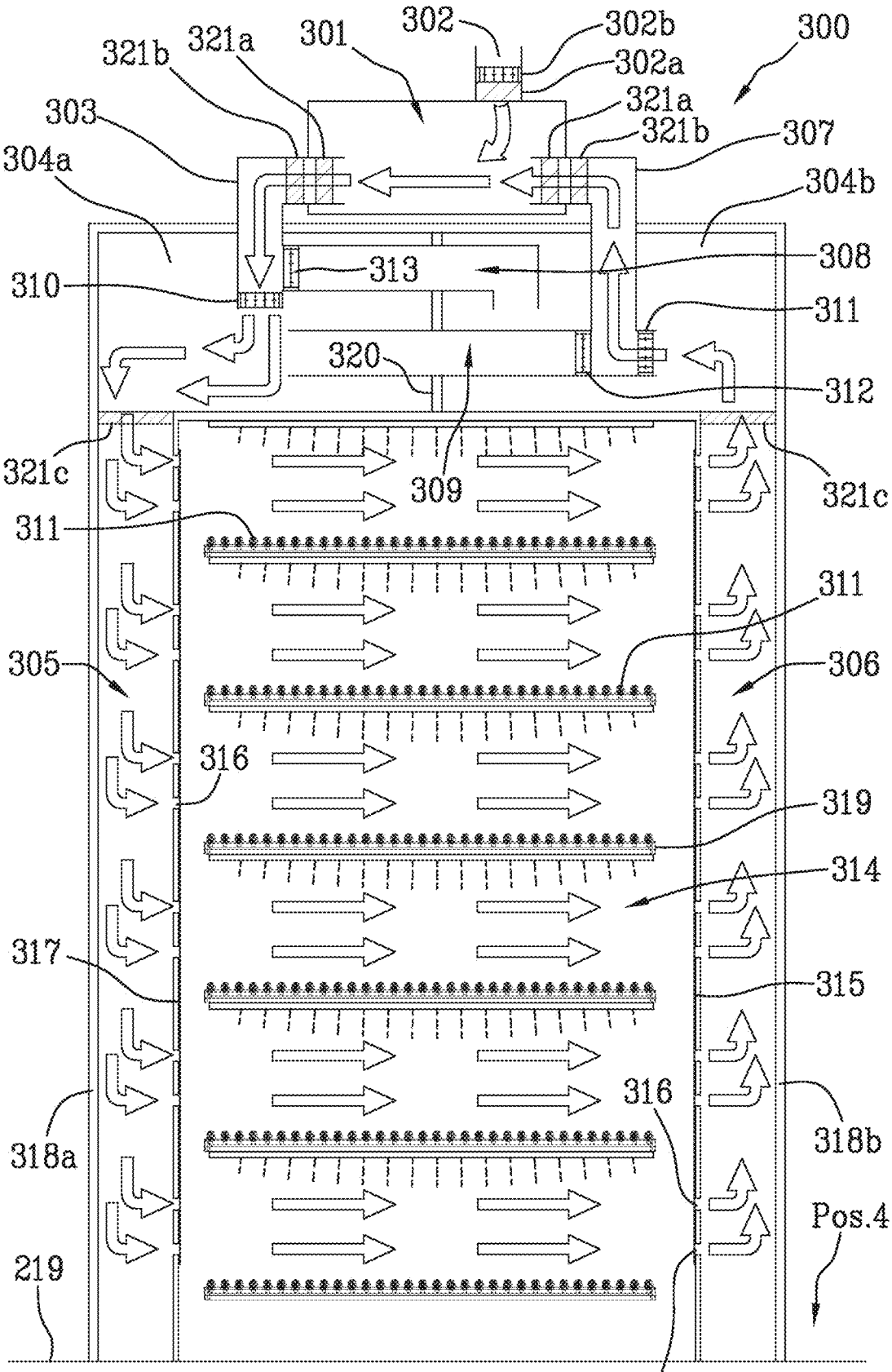
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Fig.14

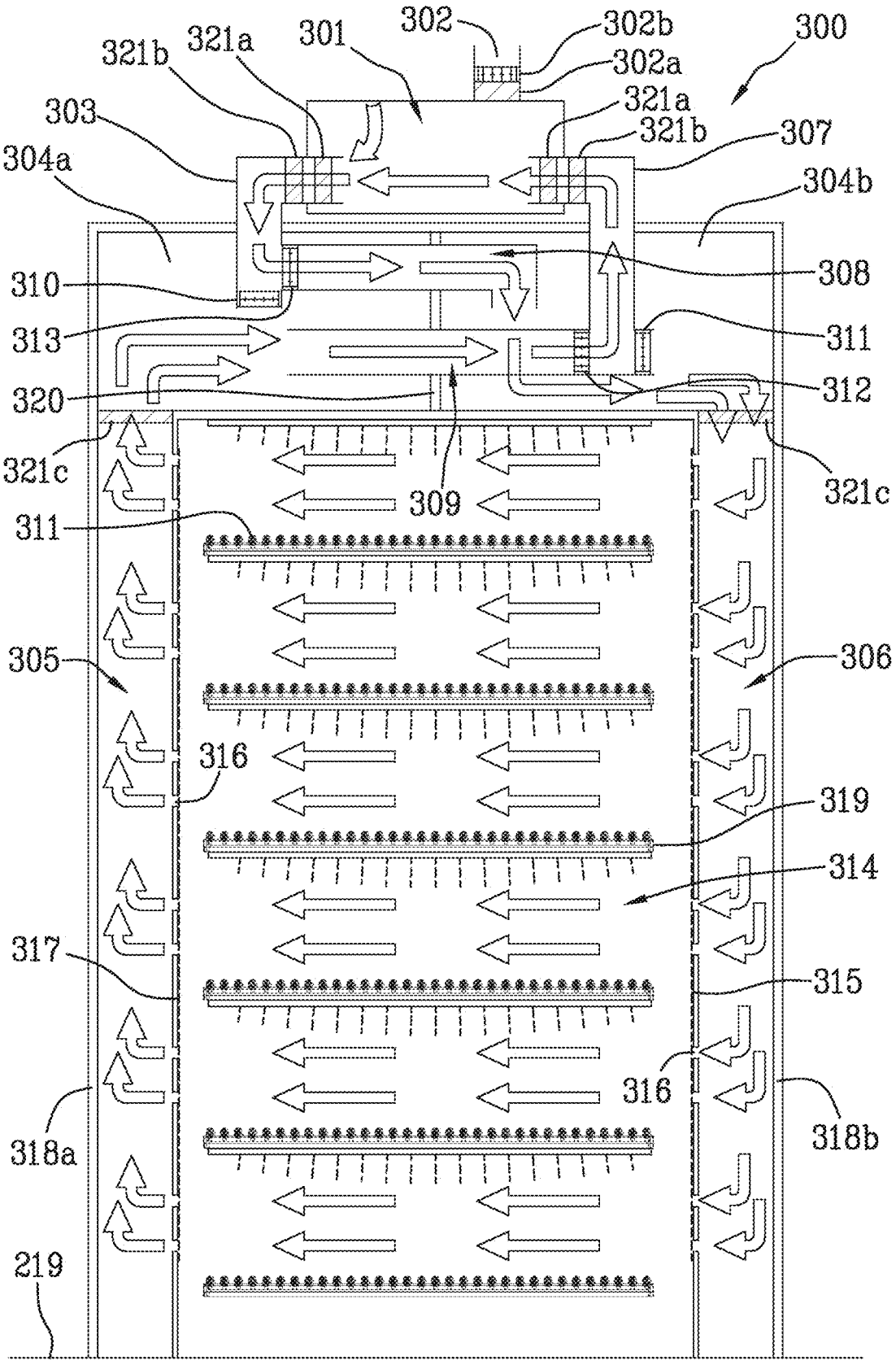
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Fig.15

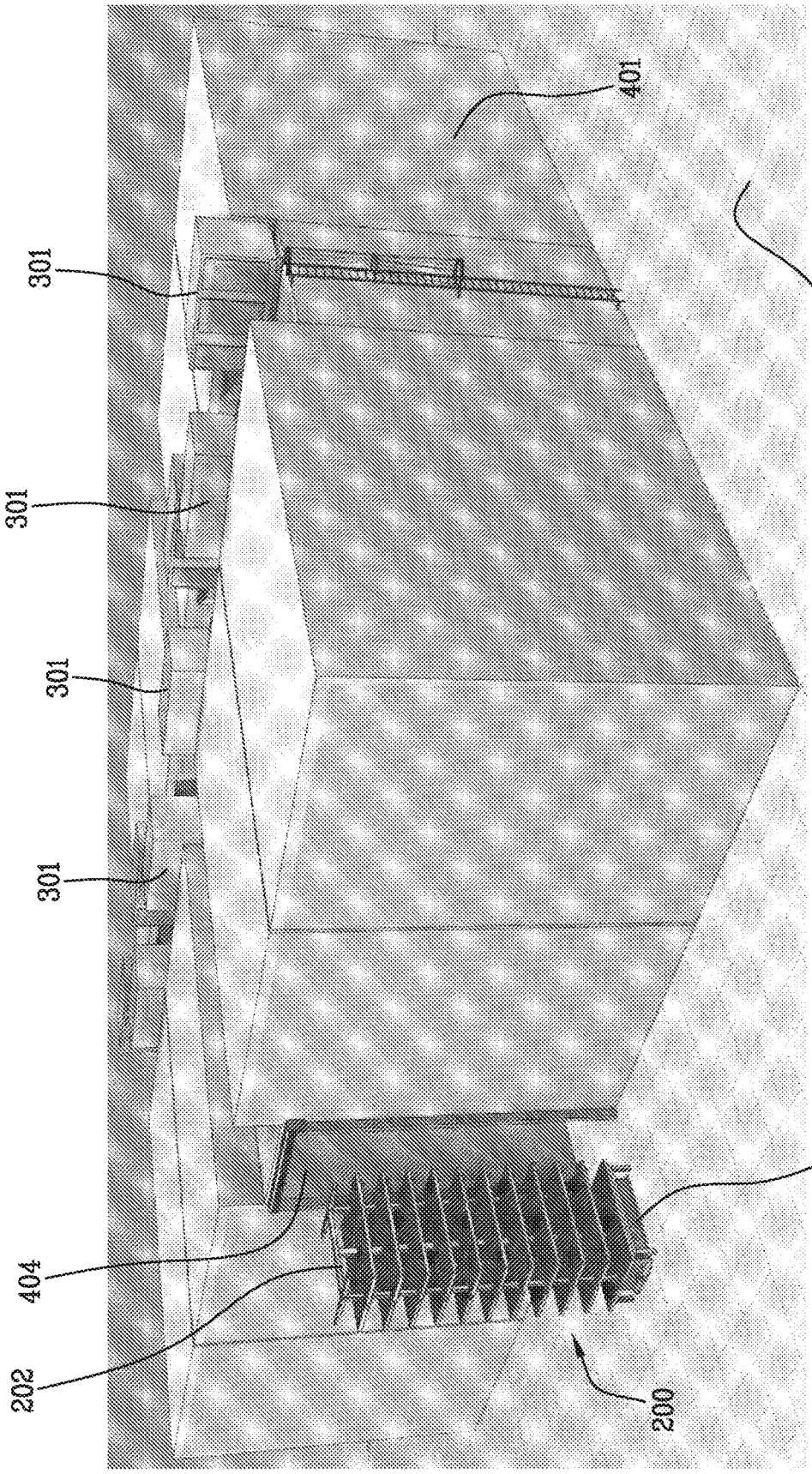
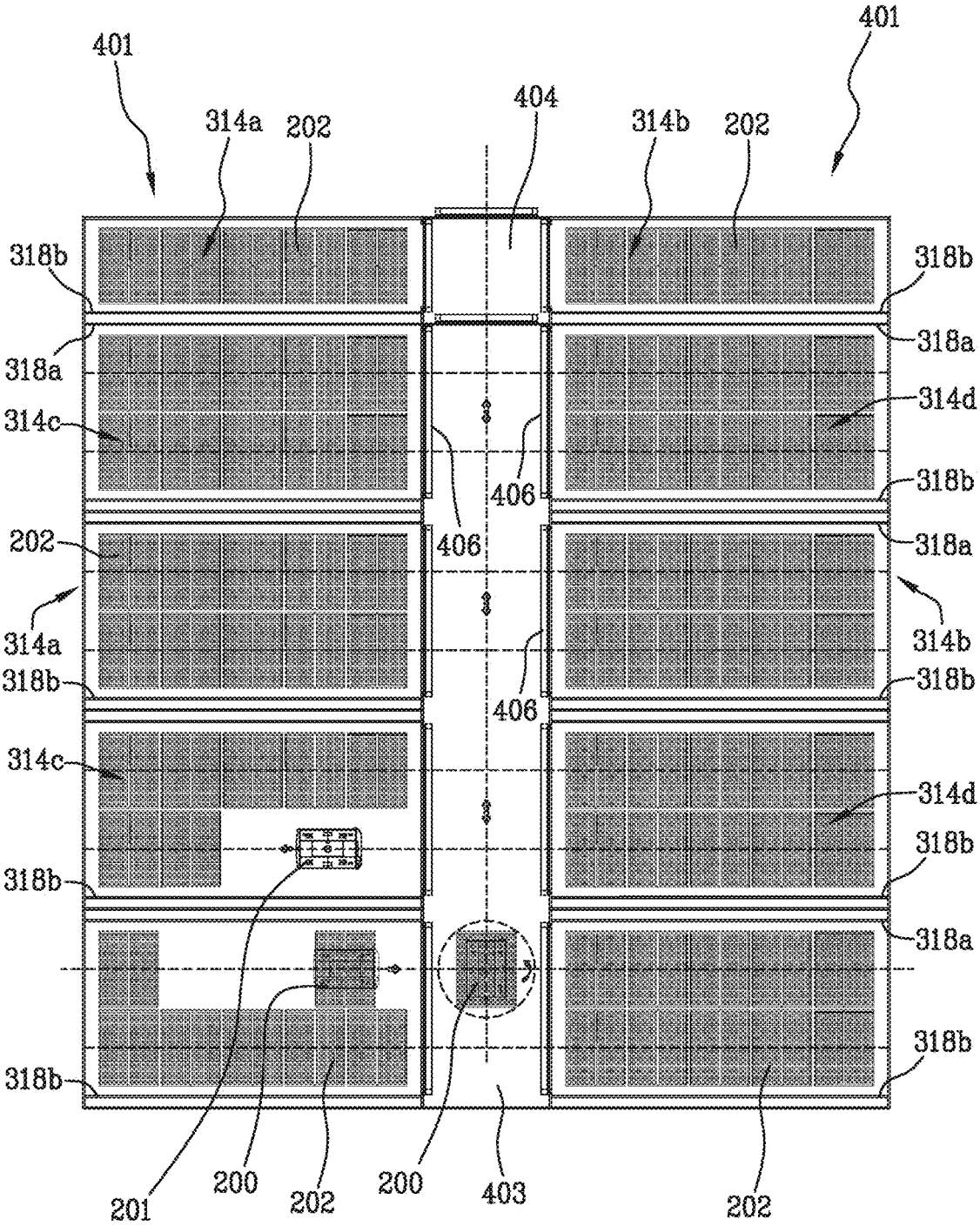


Fig.16

Fig.17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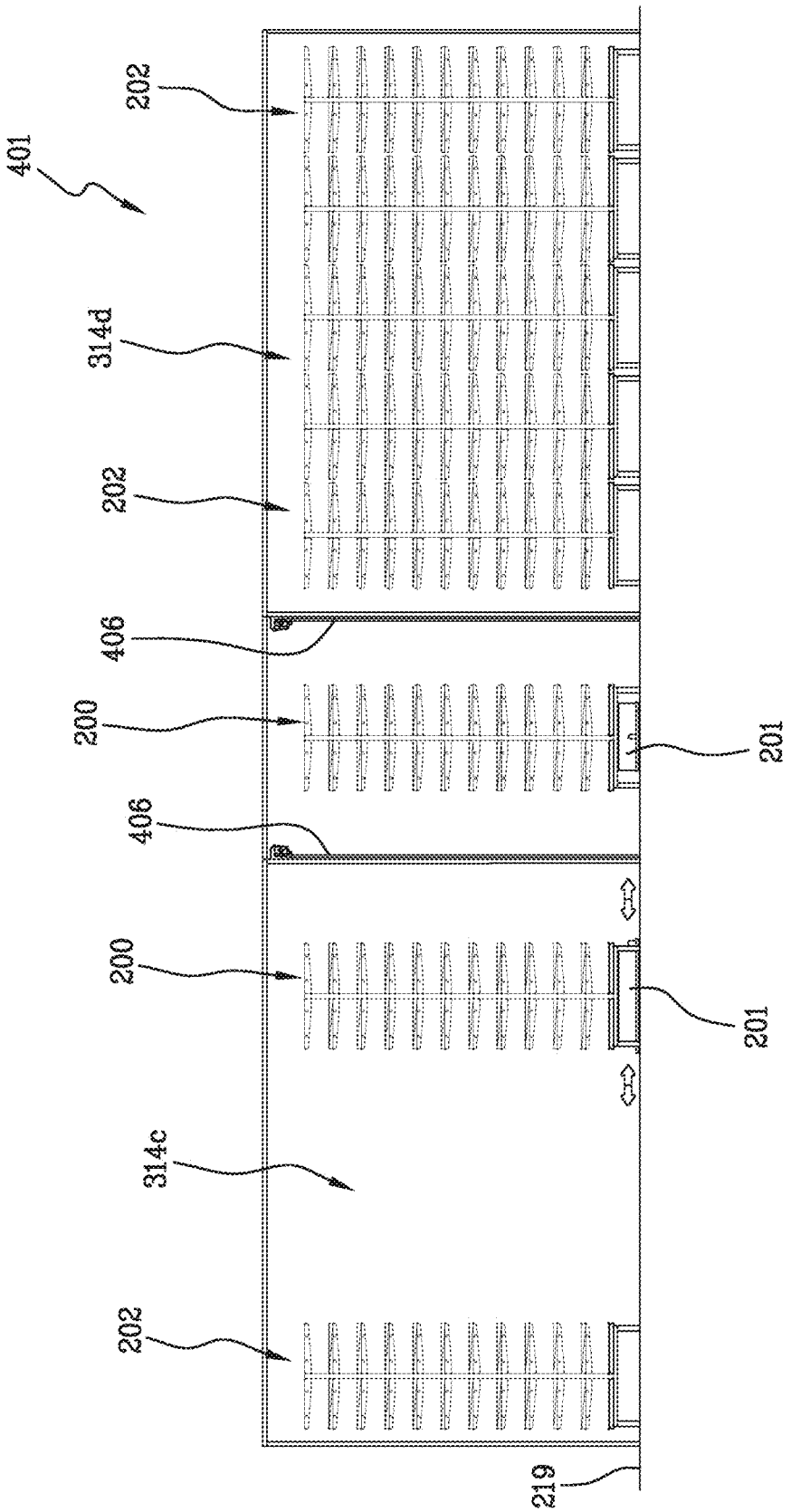

Fig.18

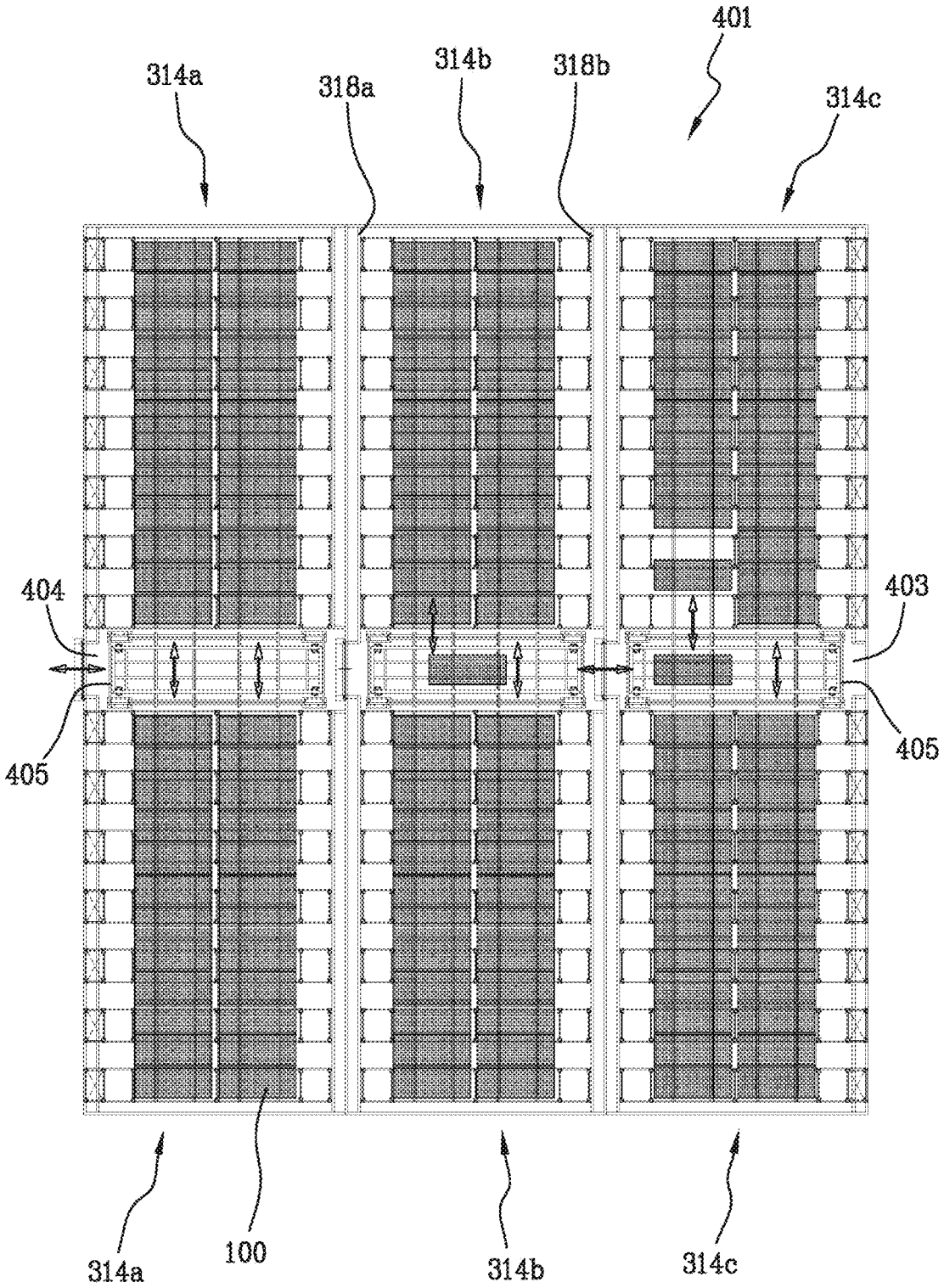
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Fig.19

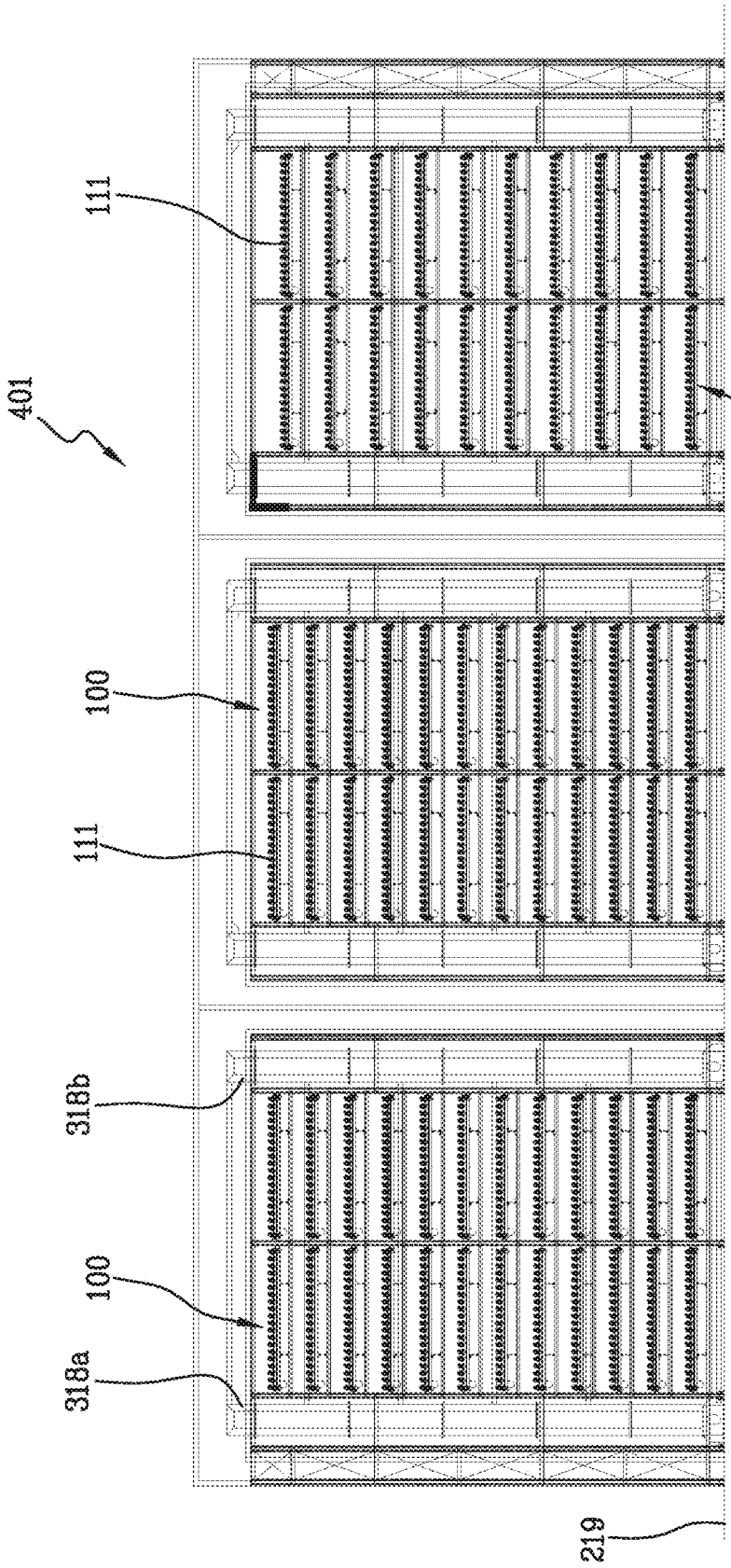

Fig.20

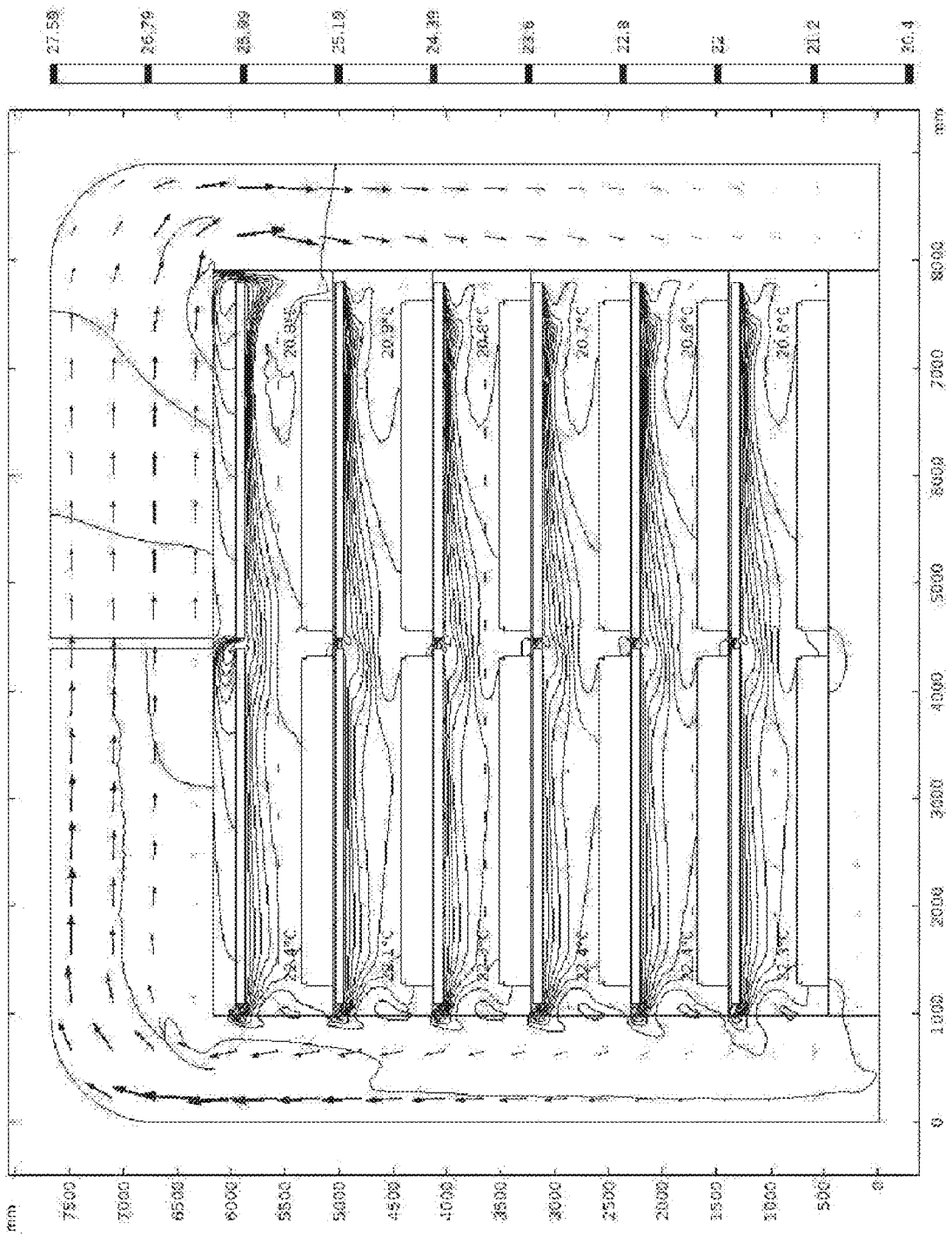
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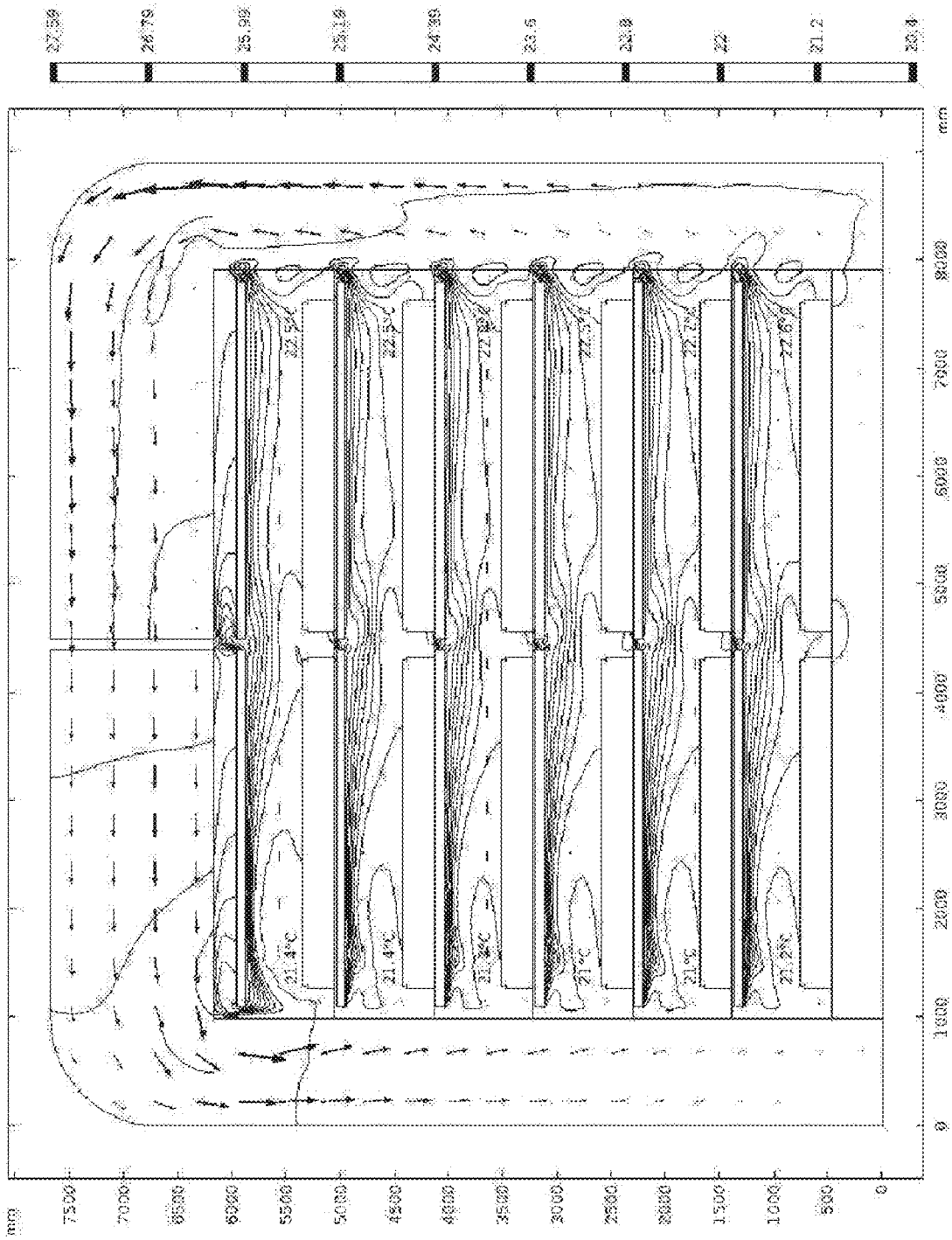
Fig.21

Fig.22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CULTIVATION METHOD OF AGRICULTURAL PRODUCTS

TECHNICAL FIELD

[0001] The present invention relates to a method for growing agricultural products in closed environments, in particular for vertical farms, comprising a plurality of air conditioned growing rooms containing therein a plurality of structures, each of which comprises a plurality of trays for growing agricultural products.

PRIOR ART

[0002] A vertical farm is characterised by a closed environment able to contain all the functions necessary for farming indoors, which has many advantages:

[0003] reduces the consumption of soil, as the farming is carried out on several levels;

[0004] avoids the impoverishment of the soil and the loss of minerals;

[0005] avoids run-off which carries potentially harmful substances to the sea or aquifers;

[0006] creates a closed and controlled farming environment, a structure which is productive 12 months per year, regardless of the seasons or the weather;

[0007] prevents the entry of parasites, insects or weeds, thereby eliminating any need for pesticides and herbicides;

[0008] drastically limits the consumption of water (up to 95% compared to crops in soil), which is recovered and reused in these systems several times;

[0009] increases productivity compared to conventional crops.

[0010] Farming plant products in closed environments with artificial lighting is currently organised by means of a plurality of fixed metal shelvings on which the individual farming trays are inserted and moved.

[0011] The necessary systems for the plant products' growth are mounted on said shelvings. Such systems can comprise a lightening system, certain monitoring and control systems of the environment and the crop, an irrigation and fertilisation system, and possibly a water analysis system.

[0012] Currently, agricultural products grown in closed environments (whether greenhouses, vertical greenhouses or "vertical farms") with artificial lighting employ fluorescent lamps and/or lamps based on light emitting diodes ("LED") of maximum intensity and with high emissions in units $\mu mol/m^2/sec$.

[0013] Depending on the type of plants and their relative growth stages, it is known that the artificial light sources are switched on or off to increase or decrease the amount of $\mu mol/m^2/sec$.

[0014] Certain known vertical farms and research laboratories use expensive artificial light sources equipped with systems that regulate the intensity of the light (said "dimmers"), which are able to increase or decrease the absorbed power and consequently also the quantity of light that touches the plants.

[0015] A drawback of the artificial lighting systems currently used in vertical farms, as described above, is that they involve a high initial economic investment, a greater waste of materials (wiring, mounting accessories, electric control units, etc.) and greater electrical leakage due to the presence of the dimmers.

[0016] A further drawback of lighting systems for known vertical farms is given by the inhomogeneity of the life cycle of the artificial light sources present in the same growing rooms, given that some of the artificial light sources are not always used and remain off, thereby making it impossible to determine the average decay of artificial light within a room.

[0017] A further drawback of known growing systems is that the artificial light sources with thousands of working hours can be in the same growing room, side by side with others with only a few hundreds of working hours, creating uneven irradiation on the plants.

[0018] An object of the present invention is to provide a method for growing agricultural products in closed environments comprising a plurality of rooms, each optimised for a certain type of agricultural product or for a specific growth phase of agricultural products.

[0019] An object of the present invention is to diversify the luminous power installed in each room depending on the growth phase and type of plant. This differentiation makes it possible to optimise both the electrical consumption of the lighting system, and the power consumption due to the action of the air conditioning system which must dissipate less heat produced by the lamps.

[0020] A further object of the present invention is to provide a method for growing agricultural products in closed environments, wherein the growing rooms are air conditioned through air treatment systems of a size corresponding to a certain growth phase of the agricultural products.

[0021] A further object of the present invention is to provide a method for growing agricultural products in closed environments that guarantees the homogeneity of the life cycle and uniform irradiation of the artificial light sources present in the same growing room.

[0022] A further object of the present invention is to provide a method for growing agricultural products in closed environments wherein it is always possible to determine the average decay of the artificial light within a growing room. A further object of the present invention is to provide a method for growing agricultural products in closed environments that allows the optimum growth of plant products.

[0023] A further object of the present invention is to provide a method for growing agricultural products in closed environments that is competitive from a purely economic point of view.

[0024] A further object of the present invention is to provide a method for growing agricultural products in closed environments that is simple and efficient.

Object of the Invention

[0025] The present invention describes a method for growing agricultural products in closed environments, particularly for vertical farms, as described in the appended claim **1**.

[0026] Other advantageous aspects of the method for growing agricultural products in closed environments are described in dependent claims from 2 to 11.

[0027] The present invention also describes a system for growing agricultural products in closed environments, particularly for vertical farms, as described in the appended claim **12**.

[0028] The invention gives the main technical effect of providing a method and a system for growing agricultural products in closed environments comprising a plurality of rooms with differentiated environmental conditions that is able to reproduce the ideal conditions for the different growth phases of the agricultural product.

[0029] In particular, the invention, as described, achieves the following technical effects:

[0030] provide growing rooms set up with artificial light sources which are differentiated in order to optimise both consumption and the growth of agricultural products;

[0031] avoid non-uniform irradiation on the plants present in the same growing room;

[0032] avoid inhomogeneity in the life cycle of the artificial light sources in the same growing room;

[0033] minimise the use of electrical equipment for the installation of artificial light sources;

[0034] minimise the electrical leakage from artificial light sources;

[0035] give a specific air conditioning system for a room a certain size calculated on the basis of the heat produced by the type and power of the lamps installed therein.

[0036] provide a system for the distribution of conditioned air optimised for a certain growth phase of the agricultural products, by minimising the differences in temperature, humidity and air flow on cultivated surfaces;

[0037] minimise contamination from the external environment and contact with staff;

[0038] grow plant products while maintaining a harmful bacteria level minimum or even absent;

[0039] grow plants without the use of pesticides, plant protection products and other products considered harmful to human health, to the plant itself and for the environment.

[0040] The technical effects mentioned, advantages cited and other technical effects/advantages of the invention will emerge in further detail from the description provided herein below of an example embodiment provided by way of approximate and non-limiting example with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0041] FIG. **1** shows a structure for farming and moving agricultural products according to a second embodiment of the present invention.

[0042] FIG. **2** shows a detail of the structure for farming and moving agricultural products of FIG. **1**, wherein the movement means are below the base of the rigid structure.

[0043] FIG. **3** shows a detail of the rigid structure.

[0044] FIG. **4** shows a detail of the rigid structure of FIG. **3** with the trays and various accessories.

[0045] FIG. **5** shows the connection between the electrical system and water system of the rigid structure respectively with the electrical distribution grid and the water system of the fertirrigation system.

[0046] FIG. **6** shows a detail of the electrical coupling between the rigid structure and the electric distribution grid.

[0047] FIG. **6***a* shows a sectional front view of the electrical coupling of FIG. **6**.

[0048] FIG. **7** shows a detail of the water coupling between the rigid structure and the water network of the fertirrigation system.

[0049] FIGS. **7***a*, **7***b*, and **7***c* show a sectional front view of the various phases of water coupling of the rigid structure of FIG. **7** with the water network of the fertirrigation system.

[0050] FIGS. **8***a* and **8***b* show a tray for vertical farms according to a first embodiment of the present invention.

[0051] FIG. **9** shows a sectional view of the tray of FIGS. **8***a* and **8***b*.

[0052] FIGS. **10***a*, **10***b*, **10***c* show a sectional view of various embodiment examples of the tray of FIGS. **8***a* and **8***b*.

[0053] FIGS. **11***a*, **11***b*, **11***c*, **11***d* show a sectional view of the tray of FIGS. **8***a* and **8***b* with the plant products.

[0054] FIG. **12** shows a sectional view of a plurality of stacked trays.

[0055] FIG. **13** shows a view from above of a plurality of trays joined laterally.

[0056] FIG. **14** shows an air conditioning system for vertical farms according to a third embodiment of the present invention.

[0057] FIG. **15** shows the air conditioning system of FIG. **14**, with the flow direction of the conditioned air from right to left.

[0058] FIG. **16** shows a climate-controlled environment for vertical farms according to a fourth embodiment of the present invention.

[0059] FIG. **17** shows a sectional view from above of the air conditioning system of FIG. **16** according to a first embodiment example.

[0060] FIG. **18** shows a front section of the air conditioning system of FIG. **16**.

[0061] FIG. **19** shows a sectional view from above of the air conditioning system of FIG. **16**, according to a second example embodiment.

[0062] FIG. **20** shows a section of the air conditioning system of FIG. **16**.

[0063] FIGS. **21** and **22** show a map of the temperature and speed of the flow of conditioned air, shown respectively in FIGS. **14** and **15**.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

[0064] The invention describes a tray for farming agricultural products, particularly for vertical farms, comprising a rigid single-block structure having a base adapted to contain agricultural products, constituted by a hollow body hermetically sealed towards the external environment.

[0065] In a first embodiment, the present invention describes a tray **100** for farming agricultural products, particularly for vertical farms, comprising a rigid structure having a base **101** and made by means of a single-block structure.

[0066] The base **101** is adapted to contain special supports **110***a*, **110***b*, **110***c* for agricultural products **111**. As shown in FIG. **11***d*, the agricultural products **111** can also be arranged directly on the base of the tray **101**, with the roots contained in a substrate **114**.

[0067] The base of the tray **101** is closed on all the perimeter sides by a containment edge **104**. The tray **100** is hermetically sealed (water or fertiliser or other liquids) if filled with a fluid within the height of the containment edge **104**.

[0068] Furthermore, as shown in FIG. **9**, the base **101** and the containment edge **104** form a single body which is hollow and hermetically sealed toward the outside of the tray **100**.

[0069] The tray **100** is made of plastic material. For example, the tray can be made of plastic material such as PE (polyethylene) and other thermoplastic and thermosetting polymers and copolymers as well as elastomers adapted to be modelled through extrusion and injection moulding. It can also be made of synthetic or organic material, as well as of all those composite materials (matrix and reinforcing/filler) adapted to produce a single piece generated by means of a mould for series production.

[0070] On the inner surface of the base **101** of the tray **100**, a plurality of conduits **102** can be provided. The conduits **102** can be fashioned directly on the upper surface of the base **101**, as shown in FIG. **10***c*, or on a plurality of protruding reinforcements **115** fashioned on the base **101**, as shown in FIG. **8***a*.

[0071] The possible presence of conduits **102** facilitates the distribution of the flow and drainage of water and nutrients for the agricultural products **111**.

[0072] The tray **100** comprises means **103***a*, **103***b* adapted to stack two or more trays **100**.

[0073] The means **103***a*, **103***b* adapted to stack the trays **100** are constituted for example by a protrusion **103***a* present in the upper part of at least two opposite sides of the containment edge **104**.

[0074] At the protrusion **103***a*, on the underside of the base **101** of the tray **100**, a cavity **103***b* is present which is adapted to removably engage with the upper protrusion **103***a* of a second tray **100**, as shown in FIGS. **9** and **12**. Preferably, the means **103***a*, **103***b* adapted to stack the trays are present on the perimeter edge of the tray **100**.

[0075] As shown in FIG. **13**, each tray **100** can comprise an engagement system **105** for engaging trays of the male-female, positive-negative or slot-pin type. This makes it possible to engage with a plurality of laterally adjacent trays **100** on the same plane of reference.

[0076] Preferably, the tray **100** comprises special supports **110***a*, **110***b*, **110***c* for agricultural products, able to maintain the agricultural products **111** in position inside the tray, distancing them from the base **101** of the tray **100**, as shown in FIGS. **8***b*, **11***a*, **11***b* and **11***c*.

[0077] The supports **110***a*, **110***b*, **110***c* can be removed from the tray **100** and can directly contain the roots of agricultural products or the pots which themselves contain agricultural products.

[0078] In the example embodiment shown in FIG. **11***d*, the agricultural products **111** can also be arranged directly on the base **101** of the tray **100**, possibly with the roots contained in a substrate **114**.

[0079] The tray **100** can comprise one or more sensors **109** adapted to detect environmental parameters and parameters regarding the contents of the tray **100**. Moreover, the tray **100** can contain one or more load cells **107** able to detect the weight of the product **111** contained in the tray **100**.

[0080] Preferably, the tray **100** comprises means **106** adapted to heat or cool the contents of the tray **100** and a connection **112** to the electricity distribution grid capable of supplying it.

[0081] On the base **101** of the tray there can be one or more inputs/outputs **108** of the fertirrigation liquid of the plants **111**.

[0082] Advantageously, the heating and cooling means **106**, the load cells **107**, the inputs/outputs **108** and the sensors **109**, can be included inside the hollow and hermetically sealed body toward the environment outside the tray **100**. In this way, it is possible to wash the tray after use without the water penetrating therein, thus avoiding damage to the various devices mentioned above.

[0083] On the upper surface of the base **101** of the tray **100** a plurality of grooves **102** are present which are also adapted to convey the excess liquids (not absorbed by the seedlings) toward a discharge area.

[0084] Preferably, below the lower surface of the tray **100** a plurality of ribs or reinforcements **106***a* adapted to provide rigidity and stability to the trays can be fashioned.

[0085] Preferably, on the surface of the base **101** of the tray, both internally and externally, localised reinforcements **113** can be present which are adapted to the mounting of accessories and equipment.

[0086] In a second embodiment, the present invention describes a structure for growing and moving agricultural products, particularly for vertical farms, comprising a rigid frame able to house a plurality of trays for growing agricultural products and movement means adapted to move the rigid frame.

[0087] Preferably the trays are those described in the first embodiment.

[0088] With reference to FIG. **1**, a structure is shown for growing and moving agricultural products, particularly for vertical farms.

[0089] The structure **200** for growing and moving agricultural products comprises a rigid frame **202** able to house a plurality of growing trays **100** for agricultural products and movement means **201** adapted to move the rigid frame **202**.

[0090] In particular, the rigid structure **202** comprises a base **203** that rests on the floor **219** of the vertical farm, at least two vertical uprights **204** and at least one pair of cross members **205** constrained to the uprights **204**.

[0091] Preferably, the rigid structure **202** comprises three vertical uprights **204**, one of which is central and two lateral.

[0092] At least two vertical uprights **204** are hollow inside and can be adapted to contain a canalization **216** for the fertirrigation fluid of agricultural products contained in the trays **100** and electric cables **222** adapted to supply the various electrical devices present in the rigid structure **202**, such as for example sensors and/or an artificial lighting system. The electric cables **222** and the canalization **216** are preferably housed inside separated uprights, for safety reasons.

[0093] These water and/or electrical connections can be created outside the frame of the trolley and have the supply point on the floor, wall or ceiling. The cross members **205** are adapted to support one or more growing trays **100**, containing a plurality of agricultural products and are arranged substantially perpendicular to the vertical uprights **204**.

[0094] Preferably, the rigid structure **202** comprises a plurality of pairs of cross members **205**, each pair of cross members can be arranged at a variable height which can be modified as desired, in order to be able to thereby adapt to the type of crop present in the trays **100** in such a way as to optimise the space between the trays.

[0095] Each pair of cross members **205**, located at the same height and able to support a specific tray **100**, comprises a plurality of through holes **208** aligned in such a way

as to be able to house and support longitudinal elements **209**, perpendicular to the cross members **205**, containing the artificial lighting and means for connection to the electric supply grid, passing inside one of the vertical uprights **204**.

[0096] The base **203** of the rigid structure **202** is preferably constituted by four tubular elements, defining a substantially rectangular shape.

[0097] The base **203** of the rigid structure **202** comprises a plurality of support feet **203***a* for the floor **219** of the vertical farm.

[0098] The structure **202** comprising the support feet **203***a* and the base **203**, has a geometry that is adapted to allow the input, placement underneath it, coupling, lifting and output of movement means **201**.

[0099] As shown in FIGS. **1**, **2** and **3**, the base **203** comprises a plurality of elements **206** for the self-alignment, coupling and lifting of the rigid structure **202** from the floor **219** of the vertical farm.

[0100] Preferably, the alignment and lifting elements **206** are four elements, arranged in pairs on two opposite sides of the tubular elements that constitute the base **203**.

[0101] The movement means **201** comprise movable elements **226** on the upper surface adapted to couple with the alignment and lifting elements **206** present in the base **203** of the rigid structure **202**. In particular, the movable elements **226** can be operated by jacks.

[0102] In particular, the movement means **201** move on the floor **219** of the vertical farm, until they are positioned below the base **203**. Once positioned below the base **203**, the movable elements **226** are raised up to align and couple with the corresponding fixed elements **206** and are able to lift the entire rigid structure **202** upwards, of a height such that it can be moved on the inside or outside of the vertical farm, while at the same time ensuring its stability. In this way, all the trays and agricultural products contained therein, hosted in the rigid structure **202**, are moved at the same time. These movable lifting elements can have different shapes and geometries, as well as be a single element such as a platform. Where necessary, the same lifting elements **216** can operate mechanisms that constrain the movement means **201** at the base **203**.

[0103] Once the movement means **201** have moved the rigid structure **202**, from a first departure position to a second position of desired arrival, the movable elements **226** of the same are lowered inside the upper surface of the movement means **201**, in this way uncoupling from the corresponding fixed elements **206** present in the base **203** of the rigid structure **202**.

[0104] The movement means **201** can comprise automatic vehicles capable of automatically moving between a plurality of planned positions and autonomously couple with the base **203** of the rigid structure **202**.

[0105] The automatic vehicles can be magnet-guided, laser-guided, wire-guided and GPS-guided ("Global Positioning System").

[0106] Alternatively, the movement means **201** can be manual or self-propelled.

[0107] The movement means **201** can move freely on the floor of the vertical farm or be designed to move on rails, tracks or guides placed on the floor, wall or ceiling of the vertical farm.

[0108] The movement means **201** can be positioned below the base of the rigid frame **202**, lift it and move it wherever desired. For example, the rigid structure can be moved between two different rooms within the same shed with different lighting and air conditioning conditions, or in an area allocated to the performance of maintenance operations.

[0109] The movement means **201** comprise a device for connection to the electrical supply grid in order to carry out charging operations.

[0110] In one non-limiting embodiment, the system of FIGS. **5**, **6** and **6***a* shows at least one support foot **203***a* of the rigid structure **202** comprising a device below for connection to the electrical supply grid placed on the floor **219** of the vertical farm.

[0111] In particular, the power supply cables **224** are made to slide inside the floor and, at one of the support feet **203***a*, a coupling element **220** is fixed comprising a plurality of centering and fixing holes or slots **220***a* and two through holes in the surface of the central upper portion.

[0112] The coupling element **220** is fixed in the desired position and at a predetermined position on the floor **219** of the vertical farm.

[0113] The coupling element **220** has a substantially convex shape, with its convex side facing upwards, in such a way as to facilitate the alignment and centering with the lower surface of the foot **203***a*.

[0114] One or more electrical contacts protrude through the two through holes of the coupling element **220** and supply power from the electrical distribution grid. The means for connection to the electrical distribution grid also include a ground **225**.

[0115] As shown in FIG. **6***a*, below the foot **203***a* of the rigid structure **202**, a portion **221** is present which is complementarily shaped and adapted to coupling with the convexity of the coupling element **220** fixed on the floor **219** and comprising one or more elements **223** able to couple with corresponding elements **224** connected to the electrical distribution grid.

[0116] The mechanical coupling between the elements **220** and **221** is of a male-female type and allows the electrical coupling of the elements **223** with the elements **224** protruding from the two holes present on the coupling element **220**.

[0117] In the coupling shown in FIGS. **6** and **6***a*, the element **223** present in the support foot **203***a* is the "female" connector, while the one present in the coupling element **220** present on the floor is the "male" connector.

[0118] In an alternative embodiment, the connecting element **223** can be of a "male" type and the coupling element **220** for the floor of a "female" type.

[0119] The electrical distribution grid within the rigid structure **202**, continues from the support foot **203***a* inside one of the vertical uprights **204**, and the electric cable exits near the cross members **205** to connect through a suitable connector to the lamp or other equipment that requires electrical supply.

[0120] The electrical distribution grid serves, for example, to supply the lighting system present on the rigid frame **202** and to supply any sensors, for example sensors for the temperature of the air, the relative humidity, the concentration of CO_2, the parameters of the "plants' nutrient liquid" (pH, temperature, level of parts per million "PPM" or electrical conductivity "EC" of the essential nutrients of farmed plants), cameras, anemometers, pressure sensors, flow meters, valves, pressure regulators.

[0121] The water system is configured to distribute the water required for the irrigation of the plants present in the trays **100** and possibly to distribute along with it the fertilisers needed for the growth of the same (fertirrigation system). As shown in FIGS. **5**, **7** and **7***a*-**7***c*, at least one support foot **203***a* of the rigid structure **202** comprises a device **211** below for connection to the fertirrigation system placed on the floor **219** of the vertical farm.

[0122] In particular, a canalization **217** for the fertirrigation fluid is made to flow inside the floor **219** and, at one of the feet **203***a*, a coupling element **210** is fixed comprising centering and fixing holes or slots **210***a* and at least one through hole placed in the surface of the upper portion.

[0123] The coupling element **210** is fixed in the desired position and at a predetermined position on the floor **219** inside the vertical farm.

[0124] Similarly to element **220**, the coupling element **210** for the water network has a substantially convex shape, with its convex side facing upwards, in such a way as to facilitate the alignment and centering with the lower surface of the foot **203***a*.

[0125] Through the through hole present in the element **210**, it is possible to carry out the coupling of the rigid structure with the canalization **217** of the fertirrigation water network.

[0126] As shown in FIGS. **7***a*, **7***b* and **7***c*, under the foot **203***a* of the rigid structure a portion **211** is present which is complementarily shaped and adapted to be mechanically coupled with the convexity of the coupling element **210** fixed on the floor **219**.

[0127] At the hole present in the element **210** fixed on the floor, in the portion **211** below the support foot **203***a*, there is a coupling element present inside which a poppet valve **213** is arranged, with a stem that extends downwards and along a direction substantially parallel to the longitudinal axis of the foot **203***a* of the rigid structure.

[0128] The poppet valve **213** is able to move upwards if it receives a thrust from the bottom, and move downwards by gravity or per the action of elastic means.

[0129] The poppet valve **213** moves inside the coupling element in such a way as to open or close the fluid connection with the water system of the rigid structure.

[0130] In this way, when the rigid structure **202** is located in a position raised from the ground, wherein the feet **203***a* do not touch the floor **219**, the poppet valve **213** by the force of gravity or per the action of elastic means is in a fully lowered position, thus keeping the fluid connection closed inside the rigid structure itself. In this way, the dripping of any residual fertirrigation liquid is avoided, which should remain inside the canalization **216** present inside the rigid structure **202**.

[0131] As shown in the lowering sequence of the rigid structure **202** in FIGS. **7***a*, **7***b* and **7***c*, when the movement means **201** lower the rigid structure toward the floor **219**, at the connection **210**, the push-valve **214** present inside acts on the lower part of the stem of the valve **213** and causes it to move upwards, in a direction parallel to the longitudinal axis of the foot **203***a*, opening the fluid connection. In this way, when the rigid structure **202** touches the ground at the element **210**, the valve **213** is completely raised from the closed position, allowing fluid communication with the fertirrigation network of the vertical farm.

[0132] The poppet valve **213** is able to move upwards if it receives a thrust from the bottom, thereby opening the fluid connection with the water canalization present inside the rigid structure, and move downwards by gravity or per the action of elastic means (e.g. springs), closing the fluid connection with the water canalization.

[0133] The mechanical coupling between the elements **210** and **211** is of the male-female type and, through the opening of the valve **213**, allows the water coupling between the canalization **216** present in the rigid structure **202** and the canalization **213** present inside the coupling element **210**.

[0134] In the coupling shown in FIGS. **7***a*, **7***b* and **7***c*, the poppet valve **213** is present in the element **211** placed inside the support foot **203***a*, while the push-valve element **214** is present inside the element **210** placed on the floor **219**.

[0135] In an alternative embodiment, it is possible to have the poppet valve **213** arranged in the coupling element **210**, and the push-valve element **214** present inside the element **211** inside the foot **203***a*, so that when the foot **203***a* of the rigid structure is raised from the floor, the channel **217** of the centralised water network is closed, while when the foot **203***a* is coupled to the element **210** placed on the ground, the poppet valve **213** puts it in fluid communication with the canalization inside the rigid structure.

[0136] The system for supplying electricity and water to the entire trolley can occur by means of connections which are not necessarily integrated in the structure, but connected to it.

[0137] The water distribution network present inside the rigid structure **202** extends from the support foot **203***a* to the floor, continues inside one of the vertical uprights **204**, and near the cross members **205** holding the trays **100**, an attachment preferably in the shape of a "T" **207** is present, at the ends of which the pipes that carry the fertirrigation fluid can connect to agricultural crops present on each tray **100**.

[0138] The rigid structure **202** can be made of different steel alloys that also include stainless steels. It can also be made of composite materials (matrix and reinforcing/filler), thermoplastic and thermosetting polymers and copolymers and elastomers with reinforcements of varying composition and material. They can also be made by joining metal alloys with plastic materials (thermoplastic and thermosetting polymers and copolymers) and/or composite materials.

[0139] In a third embodiment, the present invention describes a system and a method for climate control in closed environments, in particular for vertical farms.

[0140] FIG. **14** shows an air conditioning system **300** for a closed environment **314**, particularly a vertical farm.

[0141] The closed environment **314** to be conditioned comprises a floor **219**, a ceiling and is delimited by at least two opposite, lateral side walls **318***a*, **318***b*, substantially perpendicular to the floor and to the ceiling.

[0142] Agricultural products are arranged on trays **100**, in turn supported by shelvings **200** placed inside the closed environment **314** to be conditioned. The closed environment **314** can contain therein a plurality of shelvings **200**.

[0143] The closed environment **314** is also delimited by a front vertical wall, provided with an access and by a rear vertical wall.

[0144] The vertical walls, the ceiling and the floor of the closed farming environment **314** can be insulated.

[0145] Inside the closed environment **314** there are artificial lighting elements **319** oriented toward the farmed agricultural products. The plurality of elements of the artificial

lighting system **319** is arranged on each shelving **200**, so as to adequately illuminate the agricultural products housed on each shelf.

[0146] The air conditioning system **300** is composed of an air treatment unit **301** (called "UTA"), a system of canalizations **303**, **305**, **306**, **307**, **308**, **309** for the distribution and return of air, and a system of opening and closing means of the canalizations **310**, **311**, **312**, **313** which allow, on command, the reversal of the delivery direction of the conditioned air inside the closed environment (called "alternating cycle" or "CA"), from a vertical wall **318***a* toward the opposite vertical wall **318***b* and vice versa. The direction of the air flow is such as to be substantially parallel to the floor of the closed environment, so that it can flow into the space existing between the trays **100** and reach the agricultural products **111**. In particular, the flow of conditioned air (indicated by arrows between the shelves of FIGS. **14** and **15**) in output from the vertical walls **318***a* and **318***b* is perpendicular thereto and arranged between two successive shelves of the shelvings, in such a way as to have a constant horizontal temperature gradient.

[0147] The air treatment unit **301** comprises an outside air intake **302** to insert an amount of external air which makes it possible to maintain the grow room **314** under positive pressure with respect to the surrounding environment.

[0148] In particular, the canalization system **303**, **305**, **306**, **307**, **308**, **309** comprises a pair of first vertical canalizations **303**, **307** that put the air treatment unit **301** in fluid communication with second, opposite vertical canalizations **305**, **306** arranged parallel to the opposite vertical walls **318***a*, **318***b* of the closed environment **314**.

[0149] The second vertical canalizations **305**, **306** are arranged adjacent and substantially parallel to the opposite vertical walls **318***a*, **318***b*.

[0150] In particular, each vertical canalization **305**, **306** is constituted by a cavity fashioned between the vertical wall **318***a*, **318***b* of the closed environment **314** to be conditioned and the vertical panels **315** and **317** comprising a plurality of openings **316**. In this way, a plenum is created between the vertical wall **318***a* and **318***b* and the micro-perforated vertical panel **315** and **317**.

[0151] Preferably, the openings **316** are arranged at the existing front space between two trays **100** arranged vertically, one above the other, in the structure **200**, and are distributed uniformly over the entire surface of the panels **315** and **317**. The elements **316** can be of the perforated, micro-perforated or fissured type.

[0152] The plurality of openings **316** is uniformly distributed over the entire surface of each panel **315** and **317** in such a way that the conditioned air flows homogeneously inside the closed environment **314** along a plurality of surfaces which are substantially horizontal and parallel to the floor of the environment, flowing through the space present between the trays **100** of the trolleys **200** present in the closed environment.

[0153] The panels **317** and **315** can be made of metal material, as well as plastic or composite material (matrix and reinforcing/filler) or in fabric.

[0154] In particular, the micro-perforation of the vertical panels **315** and **317** is of a high level and percentage, with small surfaces for the passage of the conditioned air. Preferably, the percentage of holes in each panel **315** and **317** is comprised in the range from 2% to 10%, more preferably in the range from 2% to 6%. The optimum value is a micro-perforation equal to 4% of the surface of the panel.

[0155] The panels **315** and **317** can be made in fabrics of various types and weaves (texturing/pattern) or in rigid materials compatible with the food sector (for example polyethylene).

[0156] Preferably, the horizontal distance between the shelves or trolleys **200** positioned behind the panels **317** and **315** is reduced to a minimum, more preferably the shelves **200** are in contact with the vertical panels **315** and **317**, in such a way that the flow of conditioned air is fed horizontally directly into the vertical space present between the trays **311** and flows horizontally between the same.

[0157] In this way, as a vertical space is not present between the panel **315** or **317** and the vertical lateral surface defined by the shelving **200** positioned adjacent to the opposite vertical panels of the closed environment, the dispersion of the conditioned air flow in a substantially vertical direction (from floor to ceiling) is avoided, eliminating the risk of creating a damaging "chimney" effect.

[0158] Furthermore, by keeping the shelvings **200** in contact with the vertical panels **315** and **317**, inputting a greater flow rate of conditioned air to reach the agricultural products is not necessary, avoiding the delivery of a flow of damaging and violent air. Thus the positioning of the shelvings **200** in close contact with the opposite vertical panels **315** and **317** makes it possible to convey the entire flow of conditioned air in a horizontal and uniform manner within each layer (space between two trays). In this way, a mass of uniform conditioned air is created which covers the agricultural products without shaking or damaging them.

[0159] FIGS. **21** and **22** schematically show the temperature trend in centigrade or Celsius degrees in the space between two successive shelves and the direction and speed of conditioned air (the surface of the arrows represents the speed). As shown in these figures, the temperature gradient in each layer is kept substantially constant in the horizontal direction (parallel to the floor and ceiling), enabling maximum uniform growth of agricultural products along the entire surface of the relative level. Preferably, all the shelvings or trolleys **200** housed in the same closed environment are arranged laterally adjacent to each other, not merely the shelves **200** adjacent to the vertical panels **315** and **317**. In this way, the trays arranged at the same height on multiple shelvings **200** constitute a sort of seamless channel for the passage of conditioned air fed from a first vertical panel **315** toward the second vertical panel **317** and vice versa. In this way it is possible to avoid having "empty" spaces or vertical "chimneys" between adjacent shelvings and the flow of conditioned air is distributed horizontally in a uniform manner.

[0160] The air conditioning system **300** comprises an overpressure system, called plenum **304**, divided into two distinct parts **304***a* and **304***b* by a separator element **320**, which is arranged between the first vertical canalizations **303**, **307** and the second vertical canalizations **305**, **306**, and is configured for the uniform distribution of the conditioned air inside the closed environment **314**.

[0161] The first vertical canalizations **303**, **307** put the air treatment unit **301** in fluid communication with the plenum **304**.

[0162] The first vertical canalizations **303**, **307** selectively put the air treatment unit **301** in fluid communication, respectively with each of the two parts **304***a* and **304***b* of the plenum **304**.

[0163] For example, the vertical canalization **303** puts the air treatment unit **301** in fluid communication with the first part **304***a* of the plenum, while a horizontal canalization **308**, exiting from the end of the canalization **303** present in the section **304***a*, selectively puts the air treatment unit **301** in fluid communication with the second part **304***b* of the plenum **304**.

[0164] Similarly, the vertical canalization **307** puts the air treatment unit **301** in fluid communication with the second part **304***b* of the plenum, while a horizontal canalization **309**, exiting from the end of the canalization **307** present in the section **304***b*, selectively puts the air treatment unit **301** in fluid communication with the second part **304***a* of the plenum **304**.

[0165] Preferably, the selective fluid communication with the two distinct parts **304***a*, **304***b* of the plenum **304** is obtained through shutters **310**, **311**, **312**, **313**, placed for example at the ends of the first canalizations **303**, **307** present in the plenum **304**.

[0166] The plenum **304** is in fluid communication with the second vertical canalizations or gaps or plenum **305**, **306** fashioned between the opposite lateral walls **318***a*, **318***b* of the closed growing environment **314**.

[0167] In this way, as shown in FIG. **14**, the presence of the gap **305** advantageously makes it possible to convey the conditioned air in output from the plenum **304***a* distributed in a uniform manner over the entire vertical surface of the panel **317** and, therefore, inside the closed environment **314**.

[0168] Advantageously, the conditioned air is introduced inside the closed growing environment **314** under pressure, so that the pressure inside the closed environment **314** is greater than the external pressure. This overpressure prevents potential pollutants from penetrating inside the closed growing environment.

[0169] Preferably, the closure elements **310**, **311**, **312**, **313** of the conditioned air flow inside the canalizations **303**, **305**, **306**, **307**, **308**, **309** consist of shutters.

[0170] Advantageously, the closure elements **310**, **311**, **312**, **313** of the conditioned air flow are arranged at the ends of the first vertical ducts **307**, **303**

[0171] Preferably, the first and the second vertical canalizations **303**, **305**, **306**, **307** can comprise one or more air filtering elements **321***a*, **321***b*, **321***c*.

[0172] The air conditioning system **300** can comprise a distributor element of the flow rate of conditioned air for sending the same with controlled proportions which gradually variate in time through the air canalizations **303**, **305**, **306**, **307**, **308**, **309**.

[0173] The shutters **310**, **311**, **312**, **313**, have a degree of opening which can be controlled in a cyclic manner by a microprocessor and/or by a control unit, not shown in the figures.

[0174] The shutters can preferably be of the type with opposite flaps.

[0175] Preferably, sensors can be provided for controlling the temperature, pressure, speed and humidity of the air present in the closed growing environment **314**.

[0176] The air treatment unit **301** can be made of conventional materials such as steels of various types and finishes, as well as composite materials (matrix and reinforcing/filler) to increase the sanitisation possibilities of the system. The conditioned air, filtered and sanitised by filtering elements **302**, **321***a*, **321***b*, **321***c*, is delivered into the pre-chamber plenum **304** wherein the flow loses part of its speed to the benefit of uniform distribution inside the closed environment **314** of the vertical farm.

[0177] Preferably, the canalizations **303**, **305**, **306**, **307**, **308**, **309** which extend from the plenum **304** of transport and air intake, are appropriately treated with insulating material, and are made of galvanised steel, stainless steel, textile material or composite material (matrix and reinforcing/filler).

[0178] The canalizations **303**, **305**, **306**, **307**, **308**, **309** for delivering and the return of air at the entry areas are made with traditional canalizations, such as a single-block of composite material (matrix and reinforcing/filler) or by means of insulated panels.

[0179] The alternate cycle system of conditioned air inside the closed growing environment **314** allows, through the system of shutters suitably positioned at the extension points, to alternate the delivery and collection from one side and the other of the environment. An automatic command and control system will adjust the cycle according to a fixed time or logic defined by the user and relating to the type of crop.

[0180] The aeration circuit can be equipped with HEPA filters (**302***a*, **321***a*, **321***b* and **321***c*) capable of making it possible to obtain a level of airborne contamination compatible with the expected values for rooms in class ISO 9, ISO 8, ISO 7, ISO 6 up to ISO 5 (with reference to that which is defined in ISO 14644-1/2015).

[0181] The filters can be inserted in different positions of the circuit depending on the configuration of the system and the availability of spaces.

[0182] Preferably, the air treatment unit **301** is positioned above the ceiling of the closed environment.

[0183] Using the alternate cycle of the conditioned air according to the present invention makes it possible to cover the crops alternately from one direction and then from the opposite direction (FIG. **14** and FIG. **15** show the two possible directions of air), allowing the maximum reduction of the horizontal temperature gradient in the space present between the growing trays **100**.

[0184] Preferably, the inversion of the conditioned air flow direction between a vertical wall and the opposite wall occurs with a frequency comprised between 1 and 12 times per hour, more preferably comprised between 6 and 10 times per hour.

[0185] Advantageously, the combined effect of the frequency of the inversion of the conditioned air, the shelvings laterally adjacent to each other and with the opposite vertical panels **315** and **317**, makes it possible to obtain a substantially constant horizontal temperature gradient.

[0186] Through the walls of the room by means of surfaces such as those described, the distribution system makes it possible to reduce or drastically eliminate vertical temperature gradients.

[0187] The possible presence of the air expansion plenum **304** also ensures perfect uniformity in the flow along the entire air conditioning system.

[0188] As a function of the geometry of the closed environment **314** to be conditioned and the availability of adjacent spaces, the air conditioning system **300** can have many configurations:

[0189] air treatment unit **301** located above the closed environment **314** to be conditioned;

[0190] air treatment unit **301** located at the side or at the base of the closed environment **314**;

[0191] air treatment unit **301** integrated in the insulating structures and panels;

[0192] the air canalizations can be made of zinc-plated steel, stainless steel, textile material or composite material (matrix and reinforcing/filler) and placed:

[0193] outside the closed environment **314**;

[0194] integrated in the closed environment **314**;

[0195] inside the closed environment **314**.

[0196] The position of the absolute filters can be localised in the canalizations, as well as inside the air treatment unit **301** or, alternatively, can be placed only at the external overpressure air intake circuit **302**.

[0197] The vertical air diffusion areas can affect the entire vertical wall or only portions of the same, to even be reduced to certain points of delivery/collection possibly equipped with return nozzles and/or grids.

[0198] The air conditioning system **300** can also be applied to small environments (such as automated warehouses, containers, etc.) inside which the growing and/or manual/automatic movement of growing trays **100** is envisaged. In these environments, even if the application of an alternate cycle is not always possible due to the confined spaces, absolute HEPA filters can instead be used to put the room under positive pressure.

[0199] In a non-limiting embodiment, in the third embodiment of the invention the movement of agricultural products, particularly for vertical farms, can be managed by a control unit that independently decides (or informs the user) how to manage the crops. Thanks to a special system of sensors, the control unit is able to recognise the plants' state of growth and thus move them autonomously. By way of example: if once a vegetable has reached a certain stage of growth it requires different climatic conditions and light, the control unit controls the automatic movement that moves the crops by means of trolleys or single trays from one room to another. The crop can also be sent to the harvesting area once it has ripened.

[0200] In the perspective of optimising production, rooms can be used which are dedicated to germination, growth and ripening of the same plant or different agricultural products which require equal climatic conditions and light intensity. These batches or the individual trolleys or trays can follow a logic for loading and unloading of the type LIFO (Last In First Out) or a FIFO logic (First In, First Out).

[0201] In a fourth embodiment, the present invention describes a closed growing environment **401** for agricultural products **111**, particularly for vertical farms, comprising therein a plurality of climate controlled grow rooms **314***a*, **314***b*, **314***c*, **314***d*. Each climate controlled grow room **314***a*, **314***b*, **314***c* is equipped with artificial lighting and has the suitable climatic conditions for a particular growth phase of agricultural products **111** and internally comprises a plurality of rigid shelvings **202** (as described in the second embodiment), in turn able to house a plurality of growing trays **100** of agricultural products **111** (as described in the first embodiment). The growing trays **100** or the rigid structures **202** containing the trays can be moved between the various grow rooms **314***a*, **314***b*, **314***c*, **314***d* by means of movement means **201** (as described in the second embodiment).

[0202] FIG. **16** shows a closed environment **401** internally comprising a plurality of rooms **314***a*, **314***b*, **314***c*, **314***d* for growing agricultural products.

[0203] In the first example embodiment of FIG. **17**, the closed environment **401** comprises at least one intake area **404** adapted to let rigid structures **202** pass comprising a plurality of trays **100** with agricultural products **111**, as respectively described in the first and second embodiment of the present invention.

[0204] In particular, access inside the closed environment **401** takes place through an airlock **404** adapted to allow the passage of rigid structures **202** (moved by the means **201**) between the external environment and the internal environment and to prevent the entry of potential germs or pollutants into the closed environment **401**. Preferably, the closed environment **401** is kept in overpressure with respect to the outside environment.

[0205] The closed environment **401** includes at least one corridor **403** adapted to let the rigid frame **202** transit, for example, from a first grow room **314***a*, **314***b*, **314***c*, **314***d* to a second room **314***a*, **314***b*, **314***c*, **314***d*.

[0206] Each grow room **314***a*, **314***b*, **314***c*, **314***d* contained inside the closed environment **401** is equipped with an air treatment system **301** as described above in the third embodiment of the present invention. In particular, the opposite vertical walls **318***a*, **318***b* of each grow room **314***a*, **314***b*, **314***c*, **314***d* will be equipped with a plurality of openings connected to the air treatment unit **301** by means of a system of air canalizations in such a way as to allow, on command, the reversal of the direction of delivery of the conditioned air inside each growing room (called "alternate cycle"), from a vertical wall **318***a* toward the opposite vertical wall **318***b* and vice versa (as shown in the third embodiment of the invention). The air flow direction is such as to be substantially parallel to the floor of the closed environment, so that it can flow into the existing space between the trays **100** of each rigid structure **202** and reach the agricultural products.

[0207] Each grow room **314***a*, **314***b*, **314***c*, **314***d* will be equipped with an air conditioning system and an artificial lighting system suitable for a certain type of plants and for a given phase of growth, e.g. for plant products **111** having the same irradiation needs and air conditioning parameters. The grow rooms **314***a*,**314***b*,**314***c* and **314***d* can have different pressures.

[0208] The grow rooms **314***a*,**314***b*,**314***c* and **314***d* are mutually climatically isolated, separate and independent such to avoid the possibility that the pathogenic elements or contaminants in one of them can propagate inside the closed environment **401** that contains them or within other grow rooms **314***a*,**314***b*,**314***c* and **314***d* present therein. These grow rooms are not in communication with each other, as they are separated by solid walls, preferably of the insulating type, and preferably by an "anteroom" or corridor.

[0209] In particular, having differentiated, independent, micro-biologically stable growing rooms with ad hoc microclimates makes it possible to grow different types of plants in the same room having different stages of growth, but requiring the same type of environmental conditions. These rooms with different intensities and colour spectrums of light, temperature, humidity, CO_2 and conditioned air delivery speed meet the requirements useful to the fruit or vegetable product in that particular stage of development.

[0210] The method of growing agricultural products in closed environments according to the invention makes it possible to accurately reproduce the alternation of seasons, typically/preferably with germination with more humid and cold climates (in most cases germination occurs at 18° and with 95±5% humidity), while sprouting and ripening occur with warmer or hot climates.

[0211] Moreover, the presence of the overpressure inside each grow room **314***a*,**314***b*,**314***c* and **314***d* makes it possible to protect the agricultural products present within each of them from pathogenic elements and contaminants.

[0212] The product growing system according to the present invention is a dynamic system which adapts the climatic conditions, the height of layers and the intensity of light in a personalised manner in relation to the type of plant and the particular state of growth of the vegetable product.

[0213] Moreover, in the embodiment shown in FIGS. **17** and **18**, each differentiated grow room **314***a*, **314***b*, **314***c*, **314***d* comprises an access **406** adapted to let the rigid frame **202** transit and preserve the air conditioning parameters contained therein.

[0214] The access **406** to each differentiated grow room **314***a*, **314***b*, **314***c*, **314***d* takes place for example through a closing slide adapted to maintain the pressure and air conditioning of each room and open and close to let the moved rigid frame **202** transit.

[0215] Preferably, the rigid frame **202** is moved by movement means **201**.

[0216] Preferably, the plurality of rigid frames **202** is arranged inside the differentiated grow rooms **314***a*, **314***b*, **314***c*, **314***d* in such a way as to facilitate its extraction from the room, through the access **406** to the corridor **403** of the closed environment **401**. For example, the rigid frames **202** can be arranged inside the grow rooms with a longitudinal axis of development of the trays **100** parallel to the access **406** to the differentiated grow room **314***a*, **314***b*, **314***c*, **314***d* wherein they are positioned in such a way as to facilitate the engagement by the movement means **201**.

[0217] In the second embodiment illustrated in FIG. **19**, the corridor is occupied by a plurality of systems for the movement of the trays or "shuttle" **405**, each adapted to move in the vertical direction, perpendicular to the floor **219** of the closed environment **401**, and pick up the individual trays **100** from the inside of one or more differentiated grow rooms **314***a*, **314***b*, **314***c*, **314***d*. In both the example embodiments described in FIGS. **17** and **19**, the differentiated grow rooms **314***a*, **314***b*, **314***c*, **314***d* comprise a plurality of associated environmental sensors in each differentiated grow room **314***a*, **314***b*, **314***c*, **314***d*. Each sensor will be configured to detect a representative signal of the lightening intensity and climate control parameters of the environment inside each climate controlled room **314***a*, **314***b*, **314***c*, **314***d*.

[0218] Preferably, the plurality of associated environmental sensors in each differentiated grow room **314***a*, **314***b*, **314***c*, **314***d* can comprise first sensors adapted to detect a representative signal of the lightening intensity, second sensors adapted to detect the climate control parameters of the environment in the climate controlled rooms **314***a*, **314***b*, **314***c*, **314***d* and third sensors adapted to detect the growth stage of the agricultural products **111**.

[0219] In a non-limiting embodiment, the parameters detected by each sensor present in each differentiated grow room **314***a*, **314***b*, **314***c*, **314***d*, will be sent to a control unit, configured to autonomously decide (or inform the user) how to manage the products grown. In this way, depending on the type of agricultural product and its growth phase, the control unit will be able to recognise the state of growth of the agricultural products and then move them autonomously.

[0220] By way of non-limiting example, if once a vegetable has reached a certain stage of growth it requires different climatic conditions and light, the control unit controls the movement automatisms that moves the crops by means of trolleys or single trays from one room to another. The crop can also be sent to a harvesting area once it has ripened.

[0221] In the perspective of optimising production, rooms can be used which are dedicated to germination, growth and ripening of the same plant or different agricultural products which require equal climatic conditions and light intensity. These batches or the individual trolleys or trays can follow a logic for loading and unloading of the type LIFO (Last In First Out) or a FIFO logic (First In, First Out).

[0222] In particular, the invention also addresses a method for growing agricultural products in closed environments, particularly for vertical farms.

[0223] The method comprises the steps of:

- **[0224]** arranging the agricultural products on a plurality of trays **100**;
- **[0225]** arranging the plurality of trays **100** on a plurality of rigid frames **202**;
- **[0226]** arranging the plurality of rigid frames **202** in a plurality of climate-controlled grow rooms **314***a*, **314***b*, **314***c*, **314***d* inside a closed environment **401**, each room **314***a*, **314***b*, **314***c*, **314***d* having artificial lighting and optimised climatic conditions adapted to a specific growth phase of the agricultural products;
- **[0227]** moving one or more rigid frames **201** from a first grow room **314***a*, **314***b*, **314***c*, **314***d* to a second grow room **314***a*, **314***b*, **314***c*, **314***d* having artificial lighting parameters and differentiated climate control based on a determined growth phase of the agricultural products present in the moved rigid frame **202**.

[0228] In summary, the invention as described in the fourth embodiment, and in particular as shown in FIGS. **19** and **20**, makes it possible to move the agricultural products **111** in rooms with lamps of a greater light intensity (increased emission of μmol/m^2/sec) based on the various stages of plant growth **111**.

[0229] During the stages of plant growth, the plants can be moved in rooms with different climatic conditions which are more appropriate to that particular stage of growth.

[0230] One or more plants of different species can grow inside the same room having suitable climatic conditions.

[0231] In this way, the following advantages are obtained:

- **[0232]** targeted staging of grow rooms with lamps of an intensity suited to the type of plant and its specific stage of growth, thereby improving profit and growth in production;
- **[0233]** considering that the air conditioning serves mainly to counteract the heat (both latent and sensitive) produced by the artificial light sources, having grow rooms with various intensities of artificial light (and therefore different electrical absorption) makes it possible to provide an air treatment unit of ad hoc sizes related to the use conditions. This results in a lower initial investment, and savings in material and energy consumption;

[0234] contrary to the currently existing vertical greenhouses which partially turn off or reduce certain lights in certain phases of growth, equipping these rooms with lights of medium/low power and other rooms with lights of medium/high power, makes it possible to save on the initial investment, energy management and have a lower environmental impact.

[0235] Preferably, the lightening elements are dimmable, in such a way as to be able to adjust the intensity and the colour spectrum of light.

[0236] The method and system for growing agricultural products according to the present invention preferably envisages trays containing a plurality of agricultural products moved by anthropomorphic robots, 3D shuttles, trasloautomatic elevators and high-technology machinery that is not operated by human beings but through accurate software. In this way, the presence of human operators is eliminated in the various grow rooms, thereby minimising the risk of contamination.

[0237] The present invention has numerous advantages.

[0238] lower initial investment;

[0239] flexibility of grow rooms and the possibility to grow multiple different products;

[0240] increased production, more cycles per year, better yield per square metre;

[0241] lower energy consumption;

[0242] uniformity in the decay of the lamps (same functions for all modules);

[0243] constant climate in the rooms and greater uniformity;

[0244] possibility of providing a cooling phase of the plants before cutting to obtain a healthier product with greater shelf-life and suppress pathogenic elements.

[0245] That which has been described above in relation to a plurality of trays arranged on shelves of mobile shelvings or trolleys **200** is intended to be extended also to static shelvings configured to house a plurality of trays that are moved between the various shelvings **200** present in the various closed, air-conditioned environments in relation to the various phenological phases of the agricultural products treated.

1. A method for growing agricultural products in closed environments, particularly for vertical farms, comprising the steps of:

arranging the agricultural products on a plurality of trays;

arranging the plurality of trays (**100**) in a plurality of air conditioned grow rooms inside a closed environment, each room having artificial lighting and optimised climatic conditions for a determined type of agricultural products or for a specific growth phase of the agricultural products;

moving the trays from a first grow room to a second grow room, each grow room having artificial lighting parameters and differentiated climate control based on a certain growth phase of the agricultural products moved.

2. The method for growing agricultural products according to claim **1**, wherein each differentiated grow room is climatically separated and isolated.

3. The method for growing agricultural products according to claim **1**, wherein one or more differentiated grow rooms has an overpressure with respect to the external environment.

4. The method for growing agricultural products in closed environments according to claim **1**, comprising the step of arranging the plurality of trays on a plurality of rigid frames and moving one or more of the rigid frames.

5. The method for growing agricultural products in closed environments according to claim **1**, wherein each differentiated grow room comprises an access adapted for the transit of the rigid frame.

6. The method for growing agricultural products in closed environments according to claim **1**, wherein the closed environment comprises at least one inlet and at least one corridor adapted for the transit of the rigid frame.

7. The method for growing agricultural products in closed environments according to claim **1**, wherein at least two differentiated grow rooms comprise artificial lighting systems with different light intensities adapted for the various growth phases of the agricultural products and the type of agricultural products grown.

8. The method for growing agricultural products in closed environments according to claim **1**, wherein at least two differentiated grow rooms comprise different climate-control parameters adapted for the various growth phases of the agricultural products and the type of agricultural products grown.

9. The method for growing agricultural products in closed environments according to claim **1**, wherein each rigid frame is moved by a movement means.

10. The method for growing agricultural products in closed environments according to claim **1**, wherein each differentiated grow room comprises at least two opposite vertical walls adapted to generate a flow of conditioned air from a first vertical wall towards the opposite vertical wall of the room and to invert alternatively the air conditioned delivery direction along a direction that is substantially parallel to the floor of the room so as to hit the inside of the room alternatively from one direction and subsequently from the opposite direction.

11. The method for growing agricultural products in closed environments according to claim **1**, comprising a plurality of sensors associated in each differentiated grow room, with a control unit associated with said plurality of sensors present in said plurality of rooms configured to determine when to move the agricultural products based on the growth phase.

12. The method for growing agricultural products in closed environments according to claim **11**, wherein said plurality of associated environmental sensors in each differentiated grow room comprises:

first sensors adapted to detect a signal representative of the light intensity;

second sensors adapted to detect climate-control parameters of the environment in the air conditioned room;

third sensors adapted to detect the growth phase of the agricultural products.

13. A system for growing agricultural products in closed environments, particularly for vertical farms, comprising:

a plurality of rooms for growing agricultural products inside a closed environment, each room being adapted to contain a plurality of agricultural products arranged on a plurality of trays, each room having artificial lighting and optimised climatic conditions for a determined type of agricultural products or for a specific growth phase of the agricultural products;

a movement means adapted to move the trays from a first grow room to a second grow room having artificial lighting parameters and differentiated climate control based on a determined growth phase of the agricultural products present in the moved tray.

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