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(54) **A RACKING SYSTEM FOR STORAGE ROOMS, STORAGE ROOMS WITH SAID RACKING SYSTEM AND A METHOD FOR ASSURING UNIFORM TEMPERATURE IN SAID STORAGE ROOM**

(57) A cooling storage room (1) for storage, preservation and/or ripening of food, more precisely tropical fruit like bananas with controlled uniform temperature and a method for assuring uniform temperature in said cooling storage room. A racking system (2) is arranged to be installed between two lanes of pallets (3) with produce or around/above at least one lane of stacked pallets (3), wherein it is provided with air fans (5) that create a pressure differential inside the racking system (2), thus determining air distribution, which ensures stable, uniform air flow through all product pallets (3) or boxes, regardless of their position in the storage room (1). Therefore, air (6) flows not only around the boxes, but also through them.

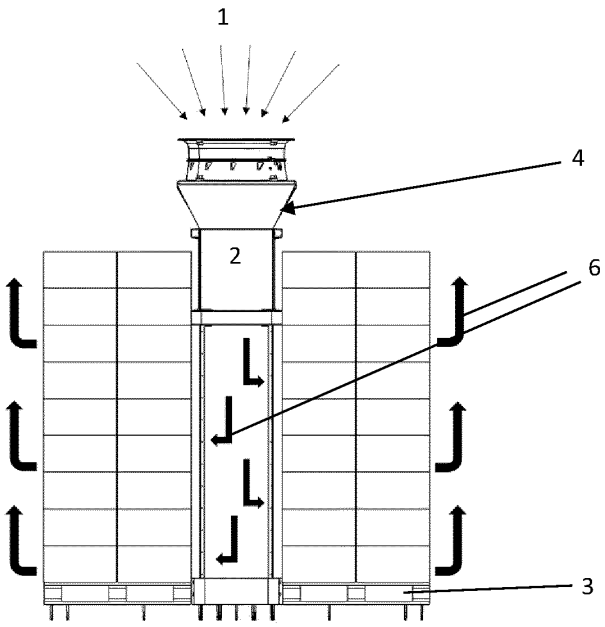

Figure 3

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Description

Field of the invention

[0001] The present invention belongs to the field of devices and methods for preserving and/or ripening foodstuff, more precisely tropical fruit like bananas. The invention also belongs to the field of refrigeration and cooling, more particularly to the field of cold rooms and arrangements for circulating gas, e.g. air, within refrigerated spaces. The invention relates to a racking system for storage rooms, storage rooms with said racking system and a method for assuring uniform temperature in said storage room.

Background of the invention and the technical problem

[0002] Storage rooms, including rooms, chambers, or truck containers, have been used for many years in the fruit industry for storing fruit, especially tropical food such as bananas. Storage rooms are generally supplied with air, which is cooled by a refrigeration system, in order to maintain a predetermined fruit temperature. The cooled air is circulated throughout the substantially enclosed room at discretely controlled temperatures for a fixed length of time, until the produce achieves adjusted temperature. It is of utmost importance that storing room construction allows uniform air pressure and air flow throughout the air flow circuit in the room in order to enable uniform ripening of all fruit stored in the room.

[0003] In conventional storage chambers, however, fruit is stacked on pallets and/or in boxes in several different configurations, which are generally known as a pyramid stack, inline stack, block stack, compact stack and tight stack. The latter is a configuration, in which more rows of tightly stacked boxes separated by a corridor are spaced-apart from the side walls of the chamber and from each other. Compact pallets with produce are loaded on pallets directly on the floor or on special racks in storage rooms, so that there is no free space between boxes loaded on a single pallet. The pallets inside the storage room are located in lines along the air flow in 20 to 40 cm free space between pallets for better and more easy vertical air penetration around pallets. The problem is that the cooling air does not penetrate to individual boxes. Furthermore, due to respiration heat of fruit and more difficult transfer of the heat from center of the pallets, so called hot spots form in center of pallets (boxes). These hot spots result in an uncontrolled temperature rise in the center of the tight stack and upon longer storage initialization of natural ripening process. This in turn leads to reduced fruit quality and shortage of a green life of the particular fruit.

[0004] In such tight stack configurations, a typical air flow circuit is the following:

- air is supplied from the air cooler (refrigeration system) hanging under the ceiling of the storage room close to back wall of the storage room,
- air flows into an operational area above the stacked pallets to the front of the storage room due to a small overpressure area, and
- then back along corridors between the pallets towards the air cooler (refrigeration system).

[0005] The cooling air has to pass a long way along boxes and pallets where it gradually takes up respiration heat energy from the boxes, so that at the end of such passage the air has a temperature around 1,0 K higher as the air supplied from the air cooler. This difference in temperature may be further increased in the air returning from the front of the storage room towards the air cooler.

[0006] Another problem associated with conventional cooling systems used for storage rooms is that they operate in an ON/OFF mode, where the temperature is controlled merely by turning the cooling (refrigeration installation) either full ON or full OFF, rather than adjusting the amount or temperature of cooled air. Another shortcoming of the conventional ripening room processes and designs is that the cooling systems run inefficiently, thereby expending excessive energy.

[0007] Hence, there is an urgent need in the art for an improved storage room construction and a cooling system for storage rooms intended for use in storage of products such as bananas or other tropical fruits, which will allow uniform distribution of cooling air, precise control of the air temperature with regard to the temperature in the boxes, thereby improving the quality of the stored products located throughout the storing room and reducing energy consumption.

State of the art

[0008] Patent US5899084 discloses a ripening room for ripening perishable products, such as fruits and vegetables, and more particularly bananas, in which the air flow and temperature are closely controlled by the room construction and by a cooling control system that achieves uniform ripening of the fruit regardless of the physical location of the fruit within the room. This document does not disclose a racking system ensuring uniform temperature in all parts of the storage room.

[0009] European patent EP0742887 discloses cool rooms or sea containers designed for frozen goods to handle produce requiring more precisely controlled temperatures and conditions, e.g. vegetables and fruits requiring temperatures in the chilling range and often also needing control or modification of the atmosphere. Each load of produce (e.g. of pallet size) is held in the container or cool room but is sealed from the air of the refrigerated environment by, for example, a plastics bag. The atmosphere within the bag is then circulated by a fan (or by convection currents from a heating element) so as to pass through the load and around it via ducts provided adjacent the bag. Heat exchange between the circulating gas and the refrigerated environment, via the plastics film,

serves to cool the load.

Description of the solution to the technical problem

[0010] The present invention is directed to a racking system for storage rooms and storage rooms with the racking system for storing produce, including fruit and vegetables, more particular for bananas, and a method for ensuring uniform temperature throughout the said storage room.

[0011] The cooling storage room is generally designed as a room or a chamber having a volume defined by a floor, a ceiling, a rear wall, sidewalls and a door. The door may be a hinged panel, removable panel, vertical or horizontal sliding panel. These elements of the storage room are air tight against leakage when the door is closed, wherein the room may also be insulated. The length and width of the storage room are a matter of design choice, depending on the desired capacity, which affects the number of rack units and tiers per rack of palletized food product. The height of the room is preferably no more than two meters above the top of the palletized product. The present invention is applicable to chambers with single or multiple rows and single or multiple tiers per row. Any refrigeration system is installed in the storage room, usually below the ceiling on one side of the storage room. Said refrigeration system commonly comprises a heat exchanger (air cooler), cooling installation inclusive all needed auxiliary units and components and a control system allowed control of the temperature inside the said room. These components are known to the person skilled in the art. Circulation of the air through the room is enabled by the air fans of the air cooler and the control unit responsible for and mounted inside or outside the room. By mounting the control unit in this manner, it may be serviced without removing food product from the room. The external mounting allows easier handling and resulting also in a lower cost of constructionand operation.

[0012] The essence of the invention is a racking system to be installed between two lanes (corridors) of pallets with produce (i.e. inner racking system) or around/above the stacked pallets (i.e. outside racking system),the mentioned racking system is provided with air fans that create a pressure differential and is arranged to determine air distribution, which ensures stable, uniform air flow through all product pallets or boxes, regardless of their position in the storage room, thus leading to uniform cooling of products in the storage room. The racking system is designed to accept a load of product such as palletized food product that includes a number of pallets placed in rows, also referred to as lanes. Pallets are of a standard size used in the food industry, for example tropical, chemical or euro pallets type. Product boxes (called also containers) may vary in size, though preferably boxes of the same size are used on each pallet, so that openings in the sides, front and back of the boxes are aligned with each other when the boxes are stacked on the pallet. These openings allow air to flow freely and uniformly pass the food product within the product boxes for maximum effect.

[0013] The inner racking system is a framework comprising:

- A bottom part for covering one side of the pallets placed on the floor of the storage room, said pallet side facing the corridor between two lanes and thus the racking system installed in the corridor,
- an upper part arranged to extend above the highest level of boxes on pallets, said upper part having
    - ◦two long sides,
    - ◦two short sides,
    - ◦a roof comprising at least one fan and
    - ◦an open bottom side,

  wherein the open bottom side allows flow of air towards or from the fan connectable to a control unit for setting the rotation speed of the fan or its blades,
- two carrier sides connecting the bottom part with the upper part,
- at least one intermediate supporting side for connecting the bottom part with the upper part along the long sides of the upper part, and
- at least two stabilizers connecting the carrier side with one intermediate side or connecting two adjacent intermediate sides,

  wherein the space between carrier sides and intermediate sides is open to allow flow of air from boxes stacked on pallets towards the fan or from the fan to the mentioned boxes.

[0014] The outer racking system is designed in a similar way with the difference that the racking system is not installed in the corridor between two lanes of pallets, but encases one, two or more lanes of pallets. Such framework comprises:

- a bottom part for covering an outer side of the pallets placed on the floor of the storage room,
- an upper part arranged to extend above the highest level of boxes on pallets, said upper part having:
    - ◦two long sides, preferably covering at least a part of the highest boxes on pallets,
    - ◦two short sides,
    - ◦a roof comprising at least one fan and
    - ◦an open bottom side,

  wherein the open bottom side allows flow of air towards or from the fan connectable to a control unit for setting the rotation speed of the fan or its blades,
- two carrier sides connecting the bottom part with the upper part,
- at least one intermediate supporting side for connecting the bottom part with the upper part along the long sides of the upper part, and

- at least two stabilizers connecting the carrier side with one intermediate side or connecting two adjacent intermediate sides,

wherein the space between carrier sides and intermediate sides is open to allow flow of air from boxes stacked on pallets towards the fan or from the fan to the mentioned boxes.

[0015] Air fans located above the racking system suck or blow the cooling air through the boxes on pallets from a high-pressure plenum and a low-pressure plenum (inside and outside the racking system). This results in that air is not only blown or suck around pallets and boxes, but also through the boxes stacked on pallets, so that the respiration heat is removed from the product to the air. Almost 100% of the air in the cooling room according to the invention flows through the boxes with food, where in conventional design of storage rooms less than 50% of air reaches the products in the boxes. In case the bottom part is not present, the air flow is less uniform, as it is more likely to pass below the boxes, through the pallets. The cooling air is then mixed with a cold air supplied by the refrigeration system in the open space of the storage room above the racking system with pallets. Air temperature may be measured in order to allow temperature adjustment with the control unit. Furthermore, at least one sensor may be arranged in any of the boxes stacked on the pallets, preferably in the middle of the stack, in order to sense the temperature and detect any possible hot spots. In addition, other sensors may be located anywhere in the racking system or the boxes, the sensors preferably sensing the amount of CO_2 and/or ethylene in order to estimate respiration activity of the food.

[0016] The racking system according to the invention is made from steel, but can be also made from any other suitable metal material.

[0017] The storage room is operably connected to a cooling and/or heating source for achieving a predetermined temperature within the storage room. The said air cooler or refrigeration system is placed above the racking system and is provided with integrated air fans. A control system is provided in the storage room, which can be any suitable control system able to detect properties of the cooling air and uses information relating to stored products, ambient temperature, ambient CO_2 concentration and preferably ethylene concentration, in order to set the required temperature, control the pressure, temperature, and fan operation. Consequently, the air fans and the refrigeration system operate at a higher efficiency, as they only cool the air to the required level. Setting of the fans is done in any suitable way known to a skilled person. Smooth and gradual variation of the set point for fans speed during the entire storing process while also providing smooth control of evaporation temperature by a gradual change of evaporation pressure is ensured with suitable sensors placed in the boxes stacked on pallets, wherein the sensors follow temperature, CO_2 and ethylene concentration. During cooling of the produce in boxes stacked on the pallets, the heat is removed and transferred by cold air to the air cooler located under ceiling in the open space of the storage room, while during heating up of the produce the heat is transferred from the heat exchanger (air cooler) by warm air to the produce on stacked on pallets.

[0018] The circulating air may follow a continuous path from the open space of the storage room, through boxes of produce stacked in tight stack manner together with the racking system, the intermediate space of the racking system and finally blown up through the air fans of the racking system back to the open space of the storage room. Air can also circulate vice versa: from the open space above the racking unit, through the fans of the racking unit, the intermediate space in the racking unit, through the boxes on pallets and back to the open space of the storage room. The circulating air to be provided to cool the food products in boxes is cooled by the refrigeration system.

[0019] The control system and the control unit are conventional devices that control the temperature and composition of air circulated within the room or the chamber.

[0020] The storage room according to the invention is generally designed as a room or a chamber having a volume defined by a floor, a ceiling, a rear wall, sidewalls and a door and comprises the refrigeration system, the control unit and at least one racking system as described above, preferably more if the storage room is larger and more rows (lanes) of pallets with food products are stored inside it. The storage room according to the invention may have a combination of inner and outside racking systems, depending on the size, construction and stored products. The invention is not limited to a single steel rack unit of palletized product. It is also possible that more racking systems units are build in the storage room. Presence of a second, third or additional racking system loaded with a palletized product does not change the functionality of the system as described above.

[0021] A method for assuring uniform temperature in the storage room according to the invention comprises the steps of:

a) providing a controller that accepts as input a predetermined setpoint temperature, temperature of stored products and temperature of the air provided by the refrigerator (supply air) and air leaving the boxes (return air), wherein said controller is arrange to smoothly change the rotation speed of air fans in the racking system;
b) sensing the temperature in boxes;
c) sensing the temperature of supply and return air;
d) using said controller to calculate the required speed of air fans of the racking system; and
e) adjusting the refrigeration system if needed.

[0022] The speed of air fans forms a smoothly changing curve as a function of time or the slowly changing speed of the air froms a substantially straight line when

graphed as a function of temperature versus time.

[0023] A method of controlling the operation of the storage room according to the invention, said room comprising a cooling system that includes a compressor, a condenser, an evaporator, refrigerant, and at least one refrigerant line, said method comprising the steps of:

a) providing a logic controller having the function of at least two proportional-integral controllers (controller cascade);
b) providing a pre-determined product temperature set point;
c) measuring the temperature of the product inside boxes;
d) measuring the temperature supply air and return air after passing the boxes with products;
e) the first of said proportional-integral controllers receiving as inputs actual value from product temperature and product set point, thereby creating a first output signal that acts as a set point for air volume, and
f) the second of said proportional-integral controllers receiving as inputs said first output signal (set point for air volume) and actual value from air volume (pressure drop over pallets), thereby creating a second output signal that controls a proportional value for speed of air fans.

[0024] The invention solves the technical problem and ensures closely controlled air flow and temperature in all parts of the storage room resulting in uniform product temperature of the fruit regardless of the physical location of the pallets (boxes). Further, a minimum quantity of energy and cooling capacity is needed, as the cooling and/or heating elements is controlled with regards to the real-time sensed temperature and thus the optimal temperature may be set. By using the principles of the present invention, the shortcomings of the prior art are overcome and better quality of stored food is achieved.

[0025] The invention will be further described based on exemplary embodiments and figures, which show:

Figure 1 The racking system according to a first embodiment
Figure 2 Cut view of the racking system shown in figure 1 along the fans (a) and in cross-section (b)
Figure 3 Front view of the racking system according to the first embodiment and downwards airflow
Figure 4 Front view of the racking system according to the first embodiment and upwards airflow
Figure 5 Front view of the racking system according to the first embodiment and downwards airflow
Figure 6 Front view of the racking system according to the second embodiment and upwards airflow

[0026] Figure 1 is a view of the racking system according to a first embodiment. The rack 4 shown in figure 1 is an inside rack, which is build between two lanes of the stacked pallets 3. The pallets 3 stacked in two rows of pallets build a kind of air tight wall on both sides of the rack, so that air fans can blow or such the process air 12 through the pallets and boxes stacked on pallets and in this way transfer the heat from the produce to the air cooler 13 (cooling) or from the air cooler 13 to the produce (heating). Figure 2a is a cut view along A-A and figure 2b is a cut view along the E-E shown in figure 1.

[0027] Figures 3 to 6 are front views of embodiments of the racking system (inside and outside racking system) with different air flow patterns through the palletized boxes with food products.

[0028] Figure 3 is a schematic front view of the rack 4 unit loaded with pallets 3, the racking system is the inside rack with row of pallets stacked close each other and building kind of air tight rows where process air blowed by air fans integrated in racking system through the pallets and boxes. Air 6 is flowing downwards, from the open space of the storage room 1 to the space inside the racking system 2, between boxes on pallets 3 and then back to the open space inside the storage room 1.

[0029] Figure 4 shows the inside racking system with air fans, but with the opposite air flow 6a, as air is flowing upwards, i.e., from the air fans 5 to the open space of the storage room 1 where it is mixed with the air stream 12 produced by the air cooler under ceiling 13, then passes the boxes on pallets 3, the intermediate space in the racking unit and returns upwards back to the air fans 5.

[0030] Figure 5 is a schematic drawing of the racking system according to a second embodiment, wherein with so called outside rack 4a where the rack is located around the pallets 3a. The air flow presented here is so called downward flow, which is the same as described in figure 3.

[0031] Figure 6 shows the outside racking system with the opposite air flow if compared to figure 5 and thus the same as described in figure 4.

[0032] The illustrated embodiments should be considered exemplary only and not as a limitation on the meaning of the claims. Having described and illustrated the principles of the invention with reference to several preferred embodiments, it is apparent that such embodiments can be modified without departing from such principles. For example, the product may be mounted on supports other than pallets or stored without pallets within the storage room. The product may be food or a non-food product.

Claims

1. A racking system for storage rooms arranged to be installed between two lanes of pallets with produce (i.e. inner racking system) or around/above at least one lane of stacked pallets (i.e. outside racking sys-

tem), the mentioned racking system is provided with air fans that create a pressure differential inside the racking system, thus determining air distribution.

2. The racking system according to claim 1 designed as the inner racking system comprising:

- A bottom part for covering one side of the pallets, said pallet side facing the space between two lanes and the racking system installed in the said space,
- an upper part arranged to extend above the highest level of boxes on pallets, said upper part having:

◦two long sides,
◦two short sides,
◦a roof comprising at least one fan and
◦an open bottom side,

wherein the open bottom side allows flow of air towards or from the fan connectable to a control unit for setting the rotation speed of the fan or its blades,
- two carrier sides connecting the bottom part with the upper part,
- at least one intermediate supporting side for connecting the bottom part with the upper part along the long sides of the upper part, and
- at least two stabilizers connecting the carrier side with one intermediate side or connecting two adjacent intermediate sides,

wherein the space between carrier sides and intermediate sides is open to allow flow of air from boxes stacked on pallets towards the fan or from the fan to the mentioned boxes.

3. The racking system according to claim 1 designed as the outside racking system comprising:

- a bottom part for covering an outer side of the pallets,
- an upper part arranged to extend above the highest level of boxes on pallets, said upper part having:

◦two long sides, preferably covering at least a part of the highest boxes on pallets,
◦two short sides,
◦a roof comprising at least one fan and
◦an open bottom side,

wherein the open bottom side allows flow of air towards or from the fan connectable to a control unit for setting the rotation speed of the fan or its blades,
- two carrier sides connecting the bottom part with the upper part,
- at least one intermediate supporting side for connecting the bottom part with the upper part along the long sides of the upper part, and
- at least two stabilizers connecting the carrier side with one intermediate side or connecting two adjacent intermediate sides,

wherein the space between carrier sides and intermediate sides is open to allow flow of air from boxes stacked on pallets towards the fan or from the fan to the mentioned boxes.

4. The racking system according to any of the preceding claims, wherein the boxes are stacked so that openings in the sides, front and back of the boxes are aligned.

5. The racking system according to any of the preceding claims, wherein it is made from any suitable metal, preferably steel.

6. A storage room having a volume defined by a floor, a ceiling, a rear wall, sidewalls and a door and comprising

- at least one racking system according to any of the preceding claims,
- a refrigeration system placed above the racking system, said refrigeration system arranged for providing cooling air for achieving a predetermined temperature within the storage room,
- a control unit arranged to detect properties of the cooling air and use information relating to stored products, ambient temperature, ambient CO_2 concentration and preferably ethylene concentration, in order to set the required temperature, control the pressure, temperature, and operation of the fan inside the racking system.

7. The storage room according to the preceding claim, wherein air flows in a continuous path from the open space of the storage room above the racking system, through boxes of produce stacked in a tight stack manner, the intermediate space of the racking system and finally blown up through the air fans of the racking system back to the open space of the storage room.

8. The storage room according to the preceding claim, wherein air flows in a continuous path from the open space above the racking unit, through the fans of the racking unit, the intermediate space in the racking unit, then through the boxes on pallets and back to the open space of the storage room.

9. The storage room according to any claim from 6 to 8, wherein the circulating air to be provided to cool

the food products in boxes is cooled by the refrigeration system.

10. The storage room according to any claim from 6 to 9, wherein the cooling air provided by the refrigeration system is mixed with the air leaving the boxes or the racking unit in the open space of the storage room above the racking system.

11. The storage room according to any claim from 6 to 10, wherein air temperature is measured by at least one sensor arranged in any of the boxes stacked on the pallets, preferably in the middle of the stack.

12. The storage room according to any claim from 6 to 11, wherein additional sensors are provided anywhere in the racking system or the boxes, the sensors preferably sensing the amount of CO_2 and/or ethylene in order to estimate respiration activity of the food.

13. The storage room according to any claim from 6 to 12 having only inner racking systems, only outside racking systems or a combination of inner and outside racking systems, depending on the size, construction and stored products.

14. A method for assuring uniform temperature in the storage room according claim from 6 to 13, said method comprising the steps of:

a) providing a controller that accepts as input a predetermined setpoint temperature, temperature of stored products and temperature of the air provided by the refrigerator (supply air) and air leaving the boxes (return air), wherein said controller is arrange to smoothly change the rotation speed of air fans in the racking system;
b) sensing the temperature in boxes;
c) sensing the temperature of supply and return air;
d) using said controller to calculate the required speed of air fans of the racking system; and
e) adjusting the refrigeration system if needed.

15. A method of controlling the operation of the storage room according to any of the claims from 6 to 13, said room comprising a cooling system that includes a compressor, a condenser, an evaporator, refrigerant, and at least one refrigerant line, said method comprising the steps of:

a) providing a logic controller having the function of at least two proportional-integral controllers (controller cascade);
b) providing a pre-determined product temperature set point;
c) measuring the temperature of the product inside boxes;
d) measuring the temperature supply air and return air after passing the boxes with products;
e) the first of said proportional-integral controllers receiving as inputs actual value from product temperature and product set point, thereby creating a first output signal that acts as a set point for air volume, and
f) the second of said proportional-integral controllers receiving as inputs said first output signal (set point for air volume) and actual value from air volume (pressure drop over pallets), thereby creating a second output signal that controls a proportional value for speed of air fans.

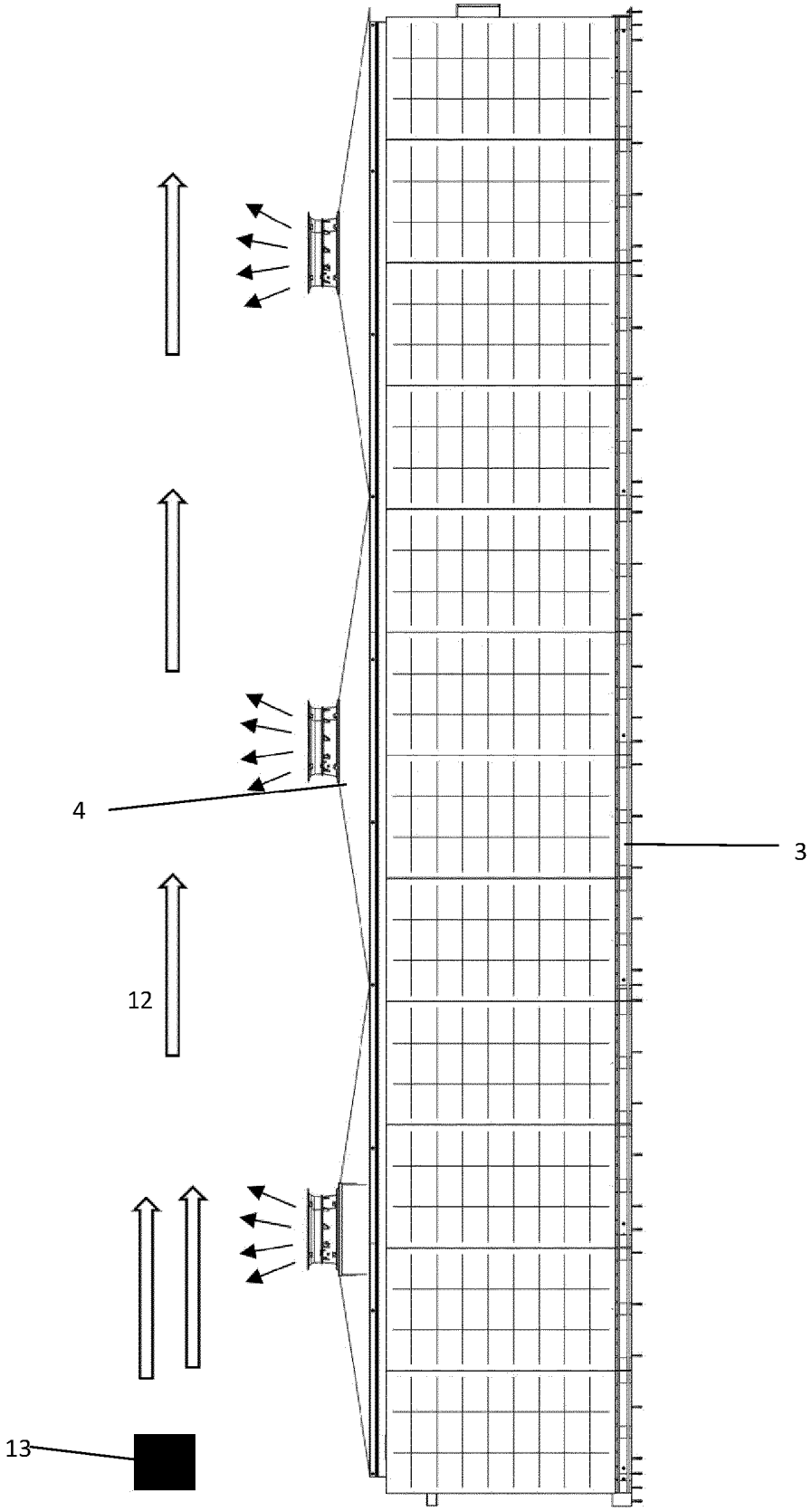

Figure 1

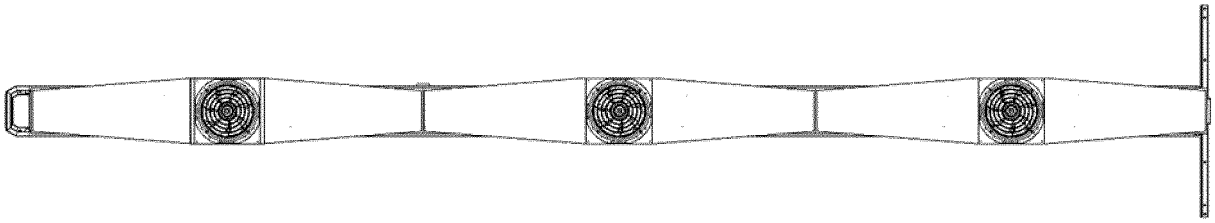

Figure 2a

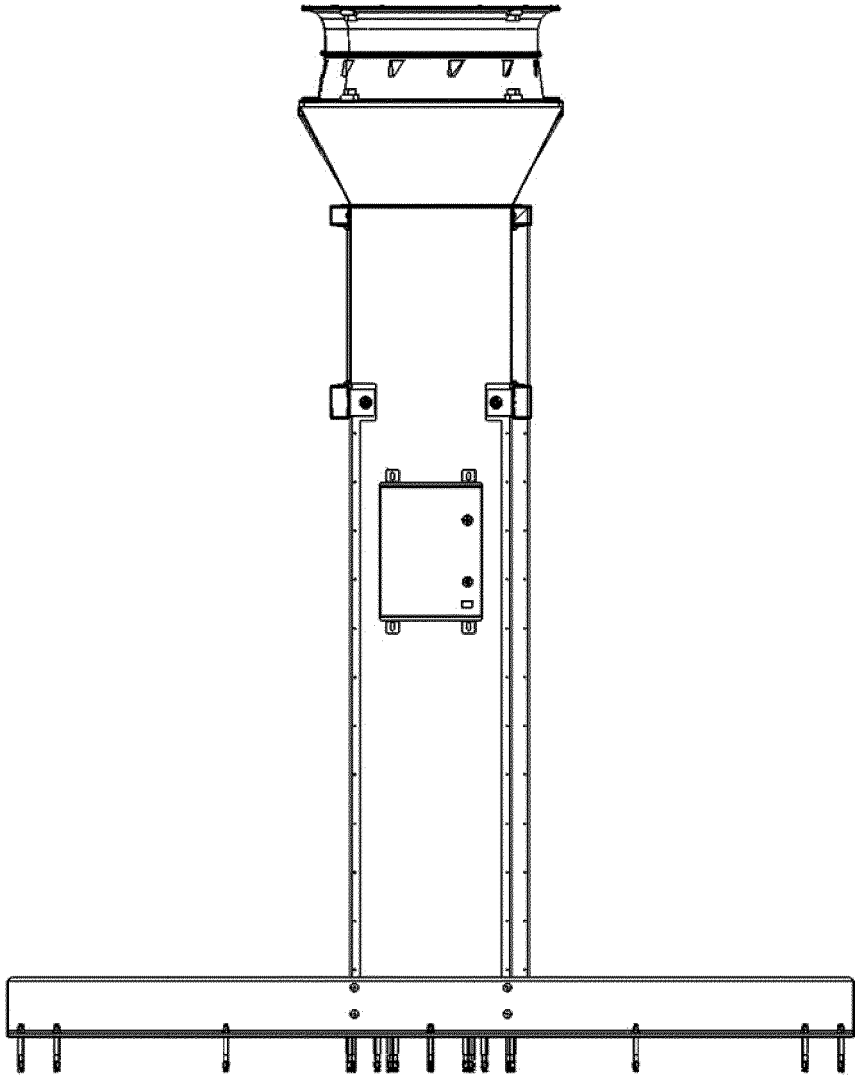

Figure 2b

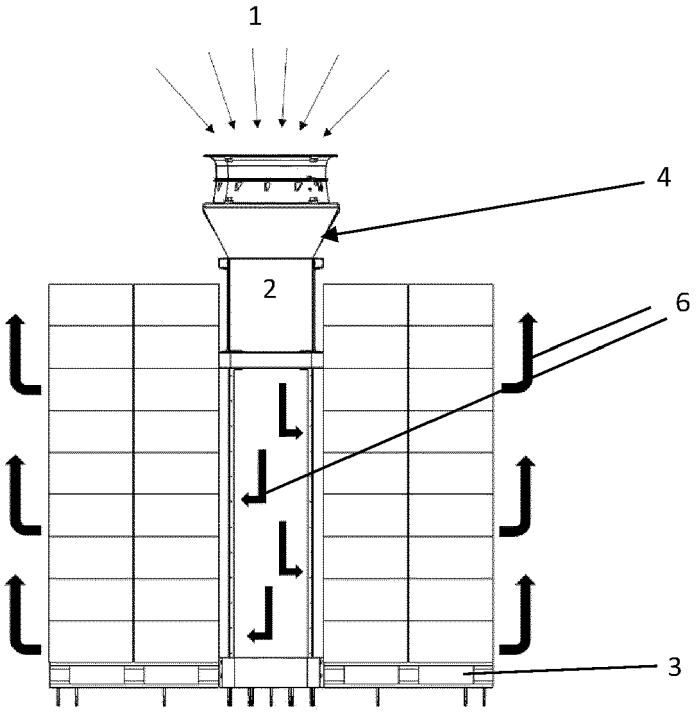

Figure 3

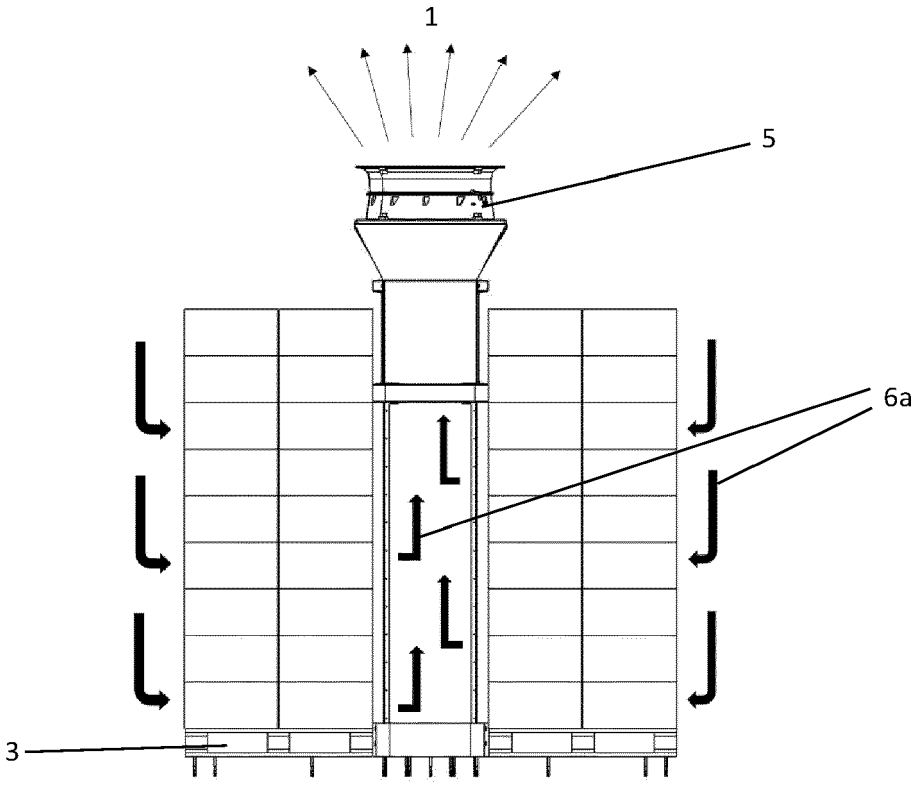

Figure 4

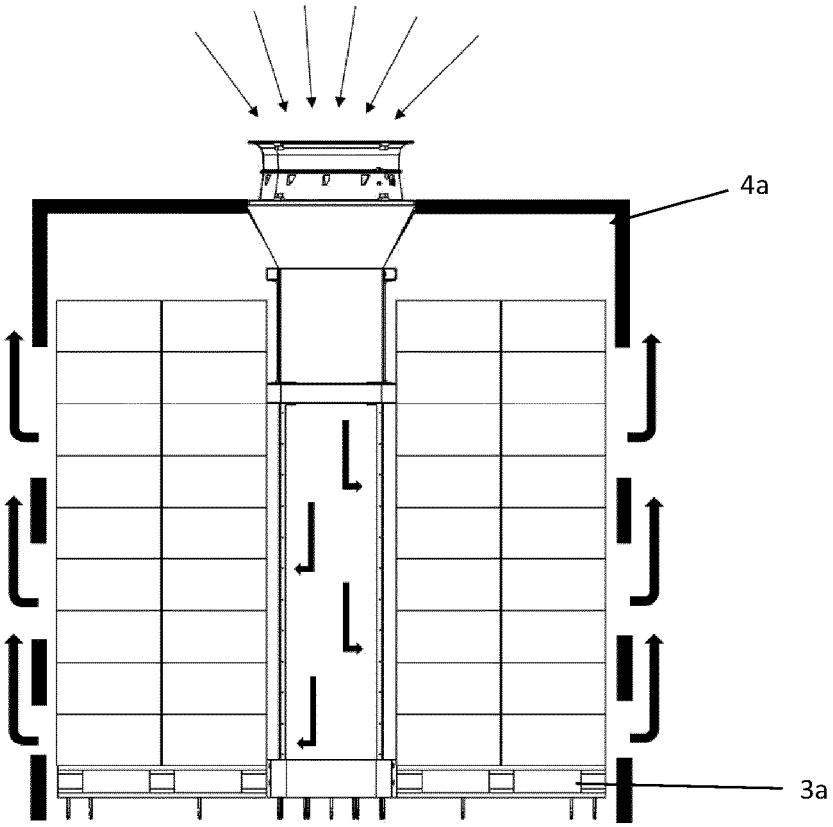

Figure 5

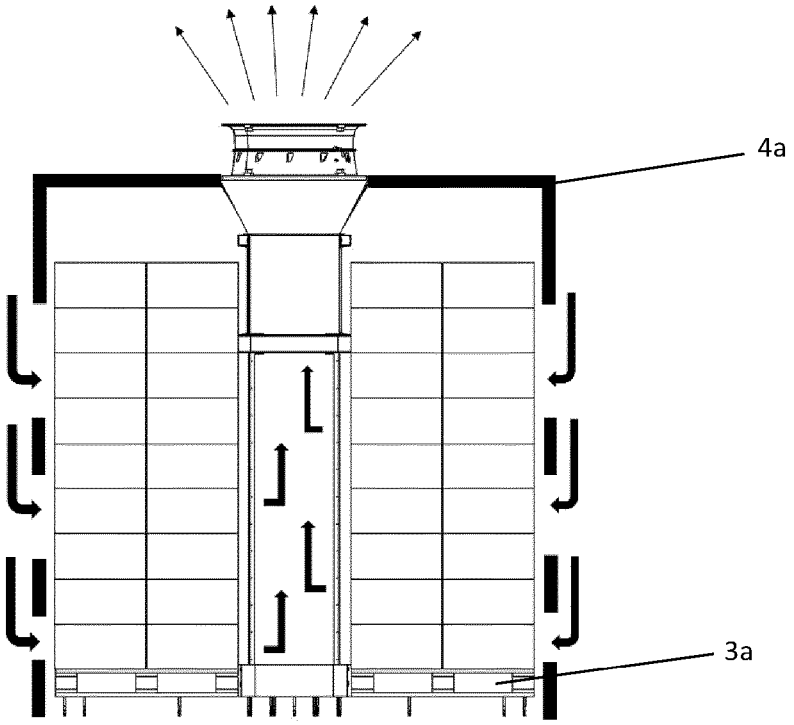

Figure 6

Europäisches Patentamt
European Patent Office
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EUROPEAN SEARCH REPORT

Application Number
EP 22 17 8118

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP 5 268172 B2 (SUMMIT KOBE GODO BUSSAN KK) 21 August 2013 (2013-08-21) * abstract; figures 3,5 *	1,4,6, 8-14	INV. F25D17/00 F25D17/06
X	US 10 955 186 B1 (KENNEALLY KEITH A [US]) 23 March 2021 (2021-03-23) * abstract; figures 1-25 *	1-4,6,7, 9-11, 13-15	
X	KR 101 231 928 B1 (SINSEGAE FOOD CO LTD [KR]) 15 February 2013 (2013-02-15) * abstract; figures 1-7 *	1-10,13	

TECHNICAL FIELDS SEARCHED (IPC)

F25D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	24 October 2022	Yousufi, Stefanie

CATEGORY OF CITED DOCUMENTS

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