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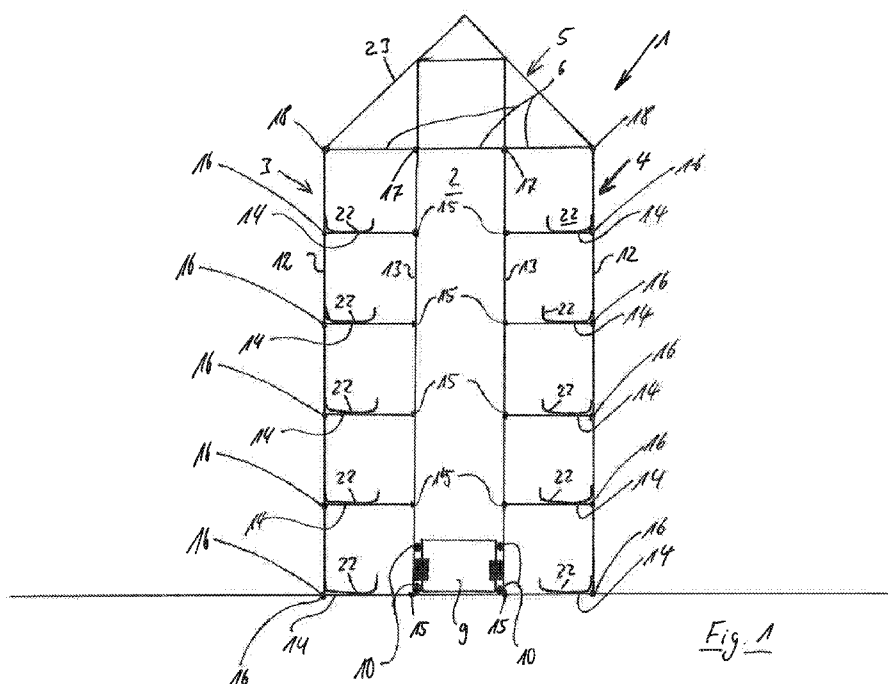
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(54) Title: FARMING SYSTEM



(57) **Abstract:** The invention pertains to a vertical farming system consisting of a center frame and at least one rack, wherein the rack is mounted side by side to the center frame, and wherein the rack is hingeably mounted to the center frame to move the rack at one end in a lateral direction away from the center frame, so that the rack is moved from a parallel orientation to an inclined orientation. The vertical farming system is further characterized in that the center frame comprises a roof structure with a roof basis, wherein the rack is connected to the roof basis in a hingeable manner. In addition, a scissor lift may be movably mounted within the center frame. Also disclosed is a method for increasing exposure of plants on the racks to sunlight, by extending hydraulic, pneumatic or motorized means to cause the racks to pivot around hinges.



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Declarations under Rule 4.17:

- *as to the identity of the inventor (Rule 4.17(i))*
- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *of inventorship (Rule 4.17(iv))*

Published:

- *with international search report (Art. 21(3))*
- *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

Farming system

FIELD OF THE INVENTION

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The invention provides a vertical farming system and a method for vertical farming which allows the efficient use of space.

BACKGROUND

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From the PCT/FI20019/050690 a plant growing apparatus is known which comprises an at least partly light permeable and for treatments or like openable growth space that can be kept closed when needed from the environment during a growing situation. Inside the growth space there is arranged an endless track for moving of plants, being planted
15 preferably on loose growth basis, inside the growth space at least for part of the track essentially vertically for light treatment of the plants actuated by a preferably motor-driven power transmission assembly, such as a drive, idle wheel assembly and/or like, by means of endless power transmission means, such as chains, wire ropes and/or like, being arranged on opposite sides of the growth space, the plants being placed on support bases that are
20 coupled with the power transmission means. This device is characterized in that the plant growing apparatus is arranged collapsible/folding in that it comprises a cover structure made of transparent material in connection with which the plants are being moved for light treatment thereof in an essentially vertically passing section of the track that moves the plants.

25

From the EP 0352031 and US 4,255,897 growing apparatuses, particularly for growing of plants, are known. These solutions are for very large sized constructions because the plants are arranged to move in a vertical direction by means of drive and idle wheel assemblies provided with the growth space. In these solutions the plants are being moved in two
30 draughts, and in the latter for its part in several successive vertical lines. This is why the capacity of these apparatuses is very modest, because the plants are being moved inside the growth apparatus only in two vertical lines.

From the GB 1160512 multiple storage units are known to increase the plant holding
35 capacity of greenhouses. From that document it is known, that for increasing the plant

holding capacity of greenhouses storage units are present wherein each of these units comprise two end supports rotatable about a common axis there being a plurality of trays, baskets or pots pivotally suspended between said end supports such that said trays, baskets or pots are maintained in an upright condition whilst the end supports are rotated by suitable drive means. According to the document, the multiple plant storage unit comprises a rotatable unit comprising end supports rotatable about a common axis, a plurality of trays, baskets or pots pivotally supported by said end supports such that plants carried in or by the trays, baskets or pots are maintained in an upright condition whilst the end supports rotate, means for rotating said end supports and means carried by said rotatable unit or forming part of said rotatable unit for directing a flow of liquid into said trays, baskets or pots.

From EP 2600708 A1 a rotating vertical racking system and a method which allows for the efficient use of space for growing plants of all types is known. This system comprises a frame, a drive mechanism coupled to said frame, a plurality of racking trays coupled to said drive mechanism, each of said racking trays being capable of supporting at least one plant; and an elevated tank providing a source of water to water said plants via conduits mounted to the frame, wherein said drive mechanism is configured to rotate said plurality of racking trays and comprises a water drive wheel configured to be connected to the conduits such that at least a portion of water supplied from the source of water is usable to drive said water drive wheel.

From the WO 2015 122849 A1 a rotatable rack system for growing plants is known which has a frame, a plurality of mobile trays arrayed around the frame where each mobile tray contains at least one plant and a chain linking that plurality of mobile trays together supported by the frame with the drive mechanism configured to drive the chain wherein the frame is configured to support the plurality of mobile trays encircling an enclosed space. Several configurations of the frame that are equally energy-efficient are also disclosed along with a method of growing plants using this system.

As it is mentioned in WO 2015 122849 A1 vertical farming is a new concept for many, which comprises the growing of plants and vegetable by stacking them vertically in shelves in order to conserve the amount of land required. This is especially important as cities get more urbanized and land becomes scarcer. Further, by reducing the distance and number of steps between the farms the consumer is able to purchase fresher and better-quality produce with less wastage and smaller carbon footprint.

The present invention seeks to provide a vertical farming system and method which lowers the energy consumption and makes vertical farming more efficient, simplifies the device and makes the harvesting even more effective.

5 SUMMARY OF THE INVENTION

In accordance with the invention there is no rotatable rack system but a rack system with two racks which are mounted pivotally in such a way that the racks which are mounted in a parallel manner to each other diverge from each other at a lower bottom side of the system
10 around pivoting hinges or axes which are positioned at an upper end or top of the racks (or vice versa). By this means it is possible to widen the system at one end, e.g. the basis, so that the parallel racks converge in the extended mode from the basis to the top. This provides the possibility for all containers for plants to be exposed to sunlight without another container above to block sunlight.

15

In a side-sectional view, therefore, it is possible to achieve a pyramidal figure of the extended or reeled out system with the extended or reeled out racks in comparison to the more prismatic appearance in a non-extended or reeled out state.

20 As it can easily be understood such a construction of a racking system is less complex than known systems and is therefore working in an easy and reliable manner.

In accordance with an aspect of the invention between the extendable racks a space or passage is formed in which an automated harvesting system can be moved in a vertical
25 direction to harvest the plants and/or fruit growing in the containers.

According to yet another aspect of the invention the harvesting system is movable in a lateral direction along with the extension of the containers to successively harvest the fruit or plants in each container.

30

In a further embodiment the extending of the basis of the racks is achieved by a belt drive, pneumatic arms, hydraulic arms or with other motorized means.

In yet another embodiment the energy for driving the harvesting device and/or the extending system is solar energy produced by solar panels which are part of the system and/or win energy or the like.

5 BRIEF DESCRIPTION OF THE DRAWING

The present invention will now be described by way of example only with reference to the accompanying drawings in which a schematic exemplary view of the embodiment of the invention showing the system with two frames and containers within the frames is shown.

10

Other arrangements of the inventions are possible and, consequently, the accompanying drawing is not to be understood as superseding the generality of the preceding description of the invention.

15 PREFERRED EMBODIMENT OF THE INVENTION

Particular embodiments of the present invention will now be described as reference to the accompanying drawing. The terminology used herein is for the purpose of describing particular embodiments only and is not intended to limit the scope of the present invention.

20

Figure 1: shows a sectional view of the vertical growing system 1 for growing plants, e.g. tomatoes or the like, with non-extended racks;

Figure 2: shows the vertical growing system with extended racks;

Figure 3: another embodiment of the invention;

25 Figure 4: the embodiment according to Figure 3 with extended racks;

Figure 5: another embodiment showing a scissor lift with robotic fruit pickers;

Figure 6: an embodiment showing a non-extracted scissor lift with a scissor lift based on the scissor lift based a bin and to harvesting devices;

Figure 7: The scissor lift according to figure 6 in a raised situation;

30 Figure 8: The scissor lift according to figure 6 in more detail;

Figure 9: The end effector of a robotic manipulator.

The vertical farming system 1 essentially consists of a center frame 2 and two racks 3, 4, which are mounted side by side to the center frame 2. The center frame 2 further may

comprise a roof structure 5, wherein the roof structure consists of a roof basis 6, wherein the roof basis 6 extends beyond the center frame 2.

5 In an advantageous embodiment the racks 3, 4 are connected to the roof basis 6 in a hinged manner.

The center frame extends in a vertical direction with a vertical supporting structure 7, for example vertical columns 7 or the like.

10 The vertical supporting structure, i.e. the vertical columns are mounted to the ground 8 in a suitable manner and extend vertically, preferably towards the roof structure 5, in order to support the roof structure.

15 In a lateral direction a plurality of supporting structures may be present which are interconnected in a lateral direction with a framework (not shown). With this construction the supporting structures 7 define two parallel laterally extending frameworks.

Between the supporting structures 7 or the frameworks (not shown) a scissor lift 9 is movably mounted moving up and down.
20

The scissor lift can be a commonly used scissor lift in which the scissor parts are moved for example by a common scissor drive e. g. a driven threaded rod.

25 The scissor lift 9 may have wheels or rollers which are moveably supported at the scissor lift and which are in contact with the supporting structure in such a way that they can roll along the columns 7.

The wheels 10 can be driven by a motor or the like within the scissor lift (not shown).

30 In an alternative embodiment the scissor lift 9 is connected (Fig. 2) to a winding motor within the roof structure 5.

In yet another alternative embodiment (Figures 3 to 5) the scissor lift is an elevating platform car or truck.

Scissor lifts are harvesting automats which are well known from the state of the art.

In an embodiment of the invention the scissor lift 9 comprises automatic fruit pickers 9a. For example, the harvesting pickers are automatic cherry or tomato pickers.

5

The robotic harvesting system architecture consists of the scissor lift 9.

The scissor lift comprises of a scissor lift base 30, which for example is formed as a platform 30. On the scissor lift base 30 at least one bin 31 is located. In the bin 31 harvested fruits
10 can be stored.

On the scissor lift base 30 at least one robotic manipulator 32 or a robotic arm 32 is located and attached.

15 Each robotic manipulator 32 is freely rotatable around the vertical axis and extendable in a radial direction. By these movements the robotic manipulator 32 is able to move an end effector 33, movable mounted to the free end of the robot manipulator 32 into the racks 3, 4 to harvest fruit.

20 The robotic manipulator 32 is mounted to the platform 30 of the scissor lift 9 based with a manipulator base 32a which is fastened to the scissor lift base 30 and which bears the robotic manipulator 32 in a rotational manner around a vertical axis.

The end effector 33 is mounted to a hinge 34 of an end arm 35 of the robot manipulator.

25 With the hinge 34 the end effector is hingeable about the hinge axis.

Further, the end effector 33 can be rotated around the longitudinal axis of the end arm 35 of the robotic manipulator 32 either by way of rotating the end arm 35 around that axis or by have a rotational bearing between the hinge 34 and the end effector 33.

30 Within the bearing (not shown) between the end arm 35 or the hinge 34 and the end effector 32 a force torque sensing system is present so that the torque force between the end effector 32 on one hand and the end arm 35 on the other side can be sensed.

Further, at the free end of the end effector 33 the end effector 33 has a pneumatic universal
35 gripper 36 which is pneumatically connected to a vacuum system so that the pneumatic

universal gripper is able to suck on a fruit to be harvested and to hold it for harvesting it and to release it into the bin 31.

5 For the positioning of the end effector 33 and for the identification of fruit to be harvested the end effector 33 has a vision and depth sensing system 37 which is for example a stereo camera system which is able to detect a fruit to be harvested for example by its form and/or color and to do the depth sensing for the positioning of the pneumatic universal gripper in relation to the fruit. To loosen the fruit from the plant the end effector can move sideward or upwards or oscillate after having fixed the fruit to the pneumatic universal gripper.

10

Instead of a stereo or mono camera the vision and depth sensing system can use infrared or radio waves or something comparable for ranging and detecting harvestable fruits.

15 The racks 3, 4 consist of an outer framework 12 and an inner framework 13 which are extending vertically in their unextended state (Fig. 1). The outer framework and the inner framework are connected through a plurality of platforms 14 wherein the platforms 14 are hingeably mounted to the inner and outer framework with hinges 15, 16.

20 The racks 3, 4, i.e. the respective outer and inner framework 12, 13, are mounted to the roof basis 6 with hinges 17, 18.

Due to the hinges 17, 18 and the hinges 15, 16 it is possible to move the basis 19 of the racks 3, 4 away from the center frame 2 to the outside in the direction 20.

25 Due to the hinges 15, 16 the platforms 14 stay in an almost horizontal orientation, even when the inner framework and outer framework 12, 13 are inclined in relation to the vertical direction of center frame 2.

30 The vertical farming system 1 comprises means 21 which are hingeably mounted between at least a rack 3, 4 and the center frame 2 wherein the means 21 are for example a pneumatic or hydraulic piston cylinder unit.

In further embodiments the movement can be achieved by a conveyor belt or other well-known means for the linear movement like motorized tracking bearings.

On the platforms 14 plant trays 22 are mounted which may contain the plants i.e. tomato plants.

The vertical farming system 1 further may comprise means for the generating of energy.

5

Means for generating energy may be solar panels 23 which are mounted to the roof structure or, if the roof structure has a roof made of glass or translucent materials, the solar panels may be mounted off to the side of the system 1. In a further embodiment, wind energy turbines or the like may be mounted to generate energy for the means 21 and for the movement of the scissor lift 9.

10

According to the invention in the trays 22 plants, i.e. tomato plants, are grown.

15

To increase the exposure to sunlight and to increase the daily sunlight intake for photosynthesis of the plants the racks 3, 4 are moved from a first position (or night/rain/storm harvesting position) (Fig. 1, 3, 5) to an operating position (Fig. 2, 4) by extending for example the hydraulic or pneumatic means 21 which causes the racks 3, 4 to pivot around the hinges 17, 18. By this operating step the trays 22 and the plants in the trays 22 can be exposed equally to sunlight.

20

To provide the plants in the trays 22 with water and/or fertilizer conduits may be provided respectively.

25

For the harvesting, i.e. cherry or tomato picking, the racks 3, 4 are drawn in by the means 21 so that the scissor lift 9 can move in a vertical x-y direction wherein the scissor lift 9 is an automatic harvesting system based on the state of the art robotic system which will harvest the fruit or vegetables in a generally well-known way.

Claims

1. Vertical farming system consisting of at least one center frame (1) and at least one rack (3, 4), wherein the at least one rack is mounted side by side to the at least one center frame (2), wherein the at least one rack (3, 4) is hingeably mounted to the center frame (1) to move the rack at least at one end in a lateral direction away from the center frame so that the at least one rack is moved from a parallel orientation to the center frame to an inclined orientation.
2. Vertical farming system according to claim 1, characterized in that one center frame (2) and two racks (3, 4) beside the center frame (2) are present, wherein the two racks (3, 4) are mounted side by side next to the center frame (2).
3. Vertical farming system according to claim 1, characterized in that the center frame (2) further comprises a roof structure (5) with a roof basis (6), wherein the racks (3, 4) are connected to the roof basis (6) in a hingeable manner.
4. Vertical farming system according to claim 1, characterized in that the center frame extends in a vertical direction with the vertical supporting structure (7), wherein the vertical supporting structure (7) is mounted to a ground (8) in a suitable manner and extends vertically towards the roof structure (5) in order to support the roof structure.
5. Vertical farming system according to claim 4, characterized in that in a lateral direction a plurality of supporting structures are present which are interconnected in a lateral direction with a framework, wherein the framework construction of the supporting structure (7) define two parallel, laterally extending frameworks.
6. Vertical farming system according to claim 1, characterized in that between the supporting structures (7) or the frameworks a scissor lift (9) is movably mounted and upwards and downwards movable.
7. Vertical farming system according to claim 1, characterized in that the scissor lift (9) comprises at least one automatic fruit picker (9a).
8. Vertical farming system according to claim 7, characterized in that, at least one automatic fruit picket (9a) consists of at least one robotic manipulator (32) or robotic arm (32) which is located and attached on a scissor lift base (30).

9. Vertical farming system according to claim 8, characterized in that, the robotic manipulator (32) is freely driver rotatable around the vertical axis and extendable in a radial direction so that the robotic manipulator (32) is able to move an effector (30) which is mounted at a free end of the robotic manipulator (32) into the racks (3, 4) to harvest fruit.

5

10. Vertical farming system according to claim 9, characterized in that, the robotic manipulator (32) is mounted to the platform (30) of the scissor lift (9) with a manipulator base (32a) which is fastened to the scissor lift base (30) and which bears the robotic manipulator (32) in a rotational manner around the vertical axis.

10

11. Vertical farming system according to claim 10, characterized in that, the end effector (33) is mounted via a hinge (34) to an end arm (35) of the robotic manipulator (32).

15

12. Vertical farming system according to claim 11, characterized in that, the end effector (33) is rotatable around the longitudinal axis of the end arm (35) of the robotic manipulator (32) by way of rotating the end arm (35) around that axis or by having a rotational bearing between the hinge (34) and the end effector (33).

20

13. Vertical farming system according to claim 12, characterized in that, between the end arm (35) and the end effector (33) a torque force sensing system is present to determine the torque force between the end effector (32) and the end arm (35).

25

14. A vertical farming system according to claim 13, characterized in that, at the free end of the end effector (33) has a pneumatic universal gripper (36) which is pneumatically connected to a suction system so that the pneumatic universal gripper is able to grip on the fruit to be harvested to hold it for harvesting it and release it into the bin (31).

30

15. Vertical farming system according to claim 14, characterized in that, for the positioning of the end effector (33) and for the identification of fruit to be harvested the end effector (33) has a vision and depth sensing system (37) which is able to detect the fruit to be harvested for example by its form and/or color and to do the depth sensing for the positioning of the pneumatic universal gripper (37) in relation to the fruit wherein the vision and depth sensing system (37) consists of an optical system and/or an infrared and/or a radio wave or a laser ranging system.

35

16. Vertical farming system according to claim 1, characterized in that the racks (3, 4) consist of an outer framework (12) and an inner framework (13) which are extending vertically in their unextended state, wherein the outer framework and the inner framework

are connected through a plurality of platforms (14), wherein the platforms (14) are hingeably mounted to the inner and outer framework with hinges (15, 16), wherein the racks (3, 4) i.e. the respective outer framework (12, 13) are mounted to the roof basis (6) or to the center frame (2) near the ground (8) with hinges (17, 18).

5

17. Vertical farming system according to claim 16, characterized in that due to the hinges (17, 18) and the hinges (15, 16) to the basis (19) of the racks (3, 4) or the top of the racks (3, 4) can be moved away from the center frame (2) to the outside, wherein due to the hinges (15, 16) the platforms (14) stay in an almost horizontal orientation, even when the inner framework and outer framework (12, 13) are inclined in relation to the vertical direction of the center frame (2).

18. Vertical farming system according to claim 1, characterized in that the farming system (1) comprises means (21) which are hingeably mounted between at least a rack (3, 4) and the center frame (2), wherein the means (21) are pneumatic or hydraulic piston cylinder units or motorized rods or conveyor belts or linear motors or known means for the linear movement like motorized tracking bearings to move the at least one rack (3, 4) in relation to the center frame (2).

19. Vertical farming system according to claim 1, characterized in that on the platforms (14) plant trays (22) are mounted, which contain the plants to be grown.

20. Vertical farming system according to claim 1, characterized in that the farming system comprises means for the generation of energy like solar panels (23), wind energy turbines or the like.

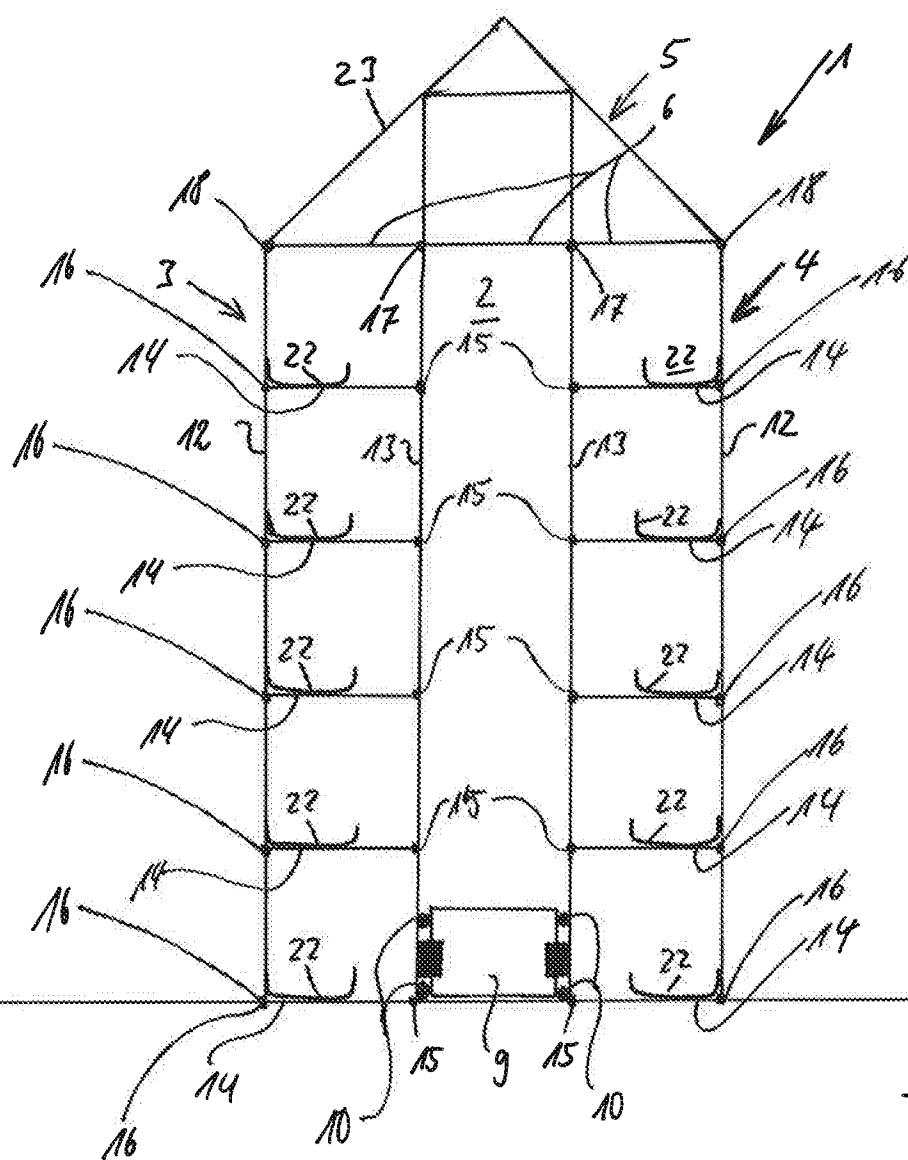
21. Vertical farming system according to claim 20, characterized in that the solar panels are mounted to the roof structure or, if the roof structure has a rood made of glass or translucent materials, the solar panels may be mounted on the side of the system (1).

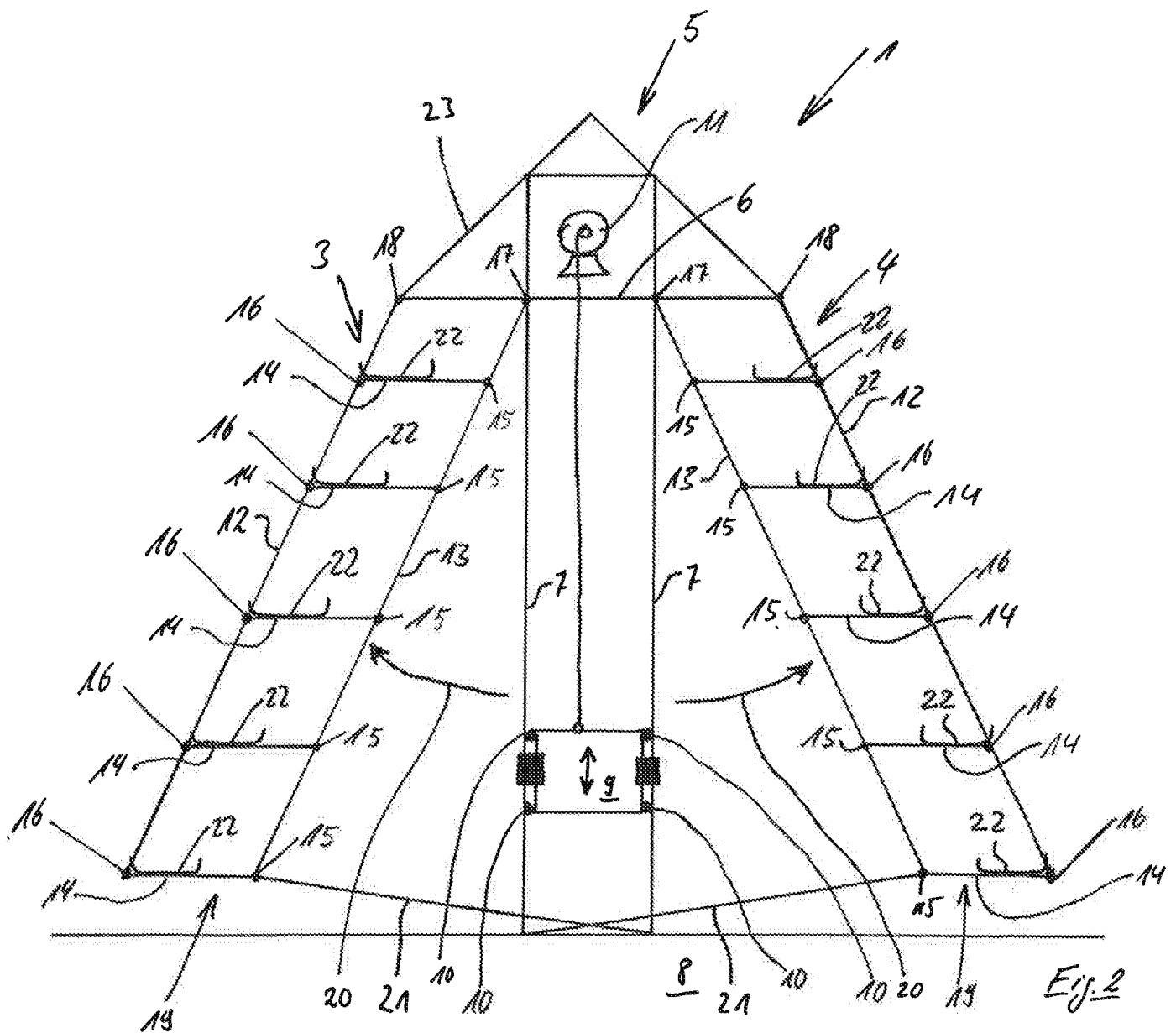
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22. Method for the operating of a vertical farming system, i.e. a farming system according to one of the preceding claims, characterized in that for the increase of the exposure to sunlight and for the increase of the daily sunlight intake for photosynthesis of plants which are mounted in trays (2) on platforms (14) of moveable racks (3, 4) the racks (3, 4) are moved from a first position, in which the racks are parallel to the center frame (2), which is a night, rain, storm or harvesting position to an operating position by extending hydraulic, pneumatic or motorized means to cause the racks to pivot around hinges (17, 18) with which the racks (3, 4) are mounted to a structure of the vertical farming system.

35

23. Method for vertical farming in which the racks (3, 4) are drawn in by the means (21) so that the scissor lift (9) can move in a vertical director, wherein the scissor lift (9) comprises an automatic harvesting system based on a robotic system which picks the respective fruit or vegetables.





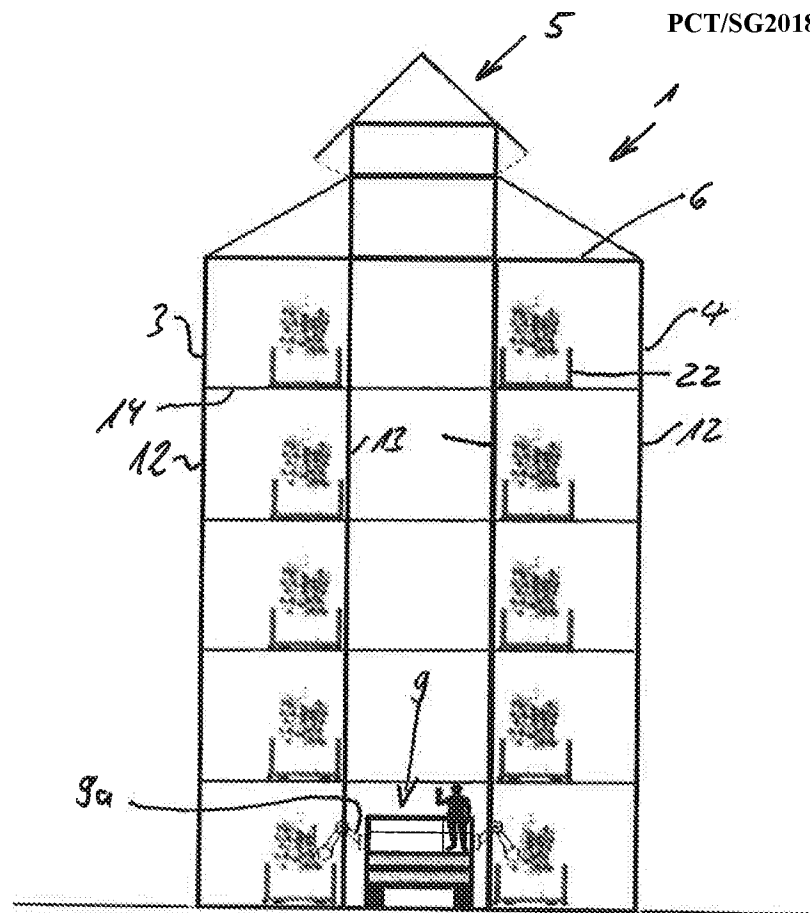


Fig. 3

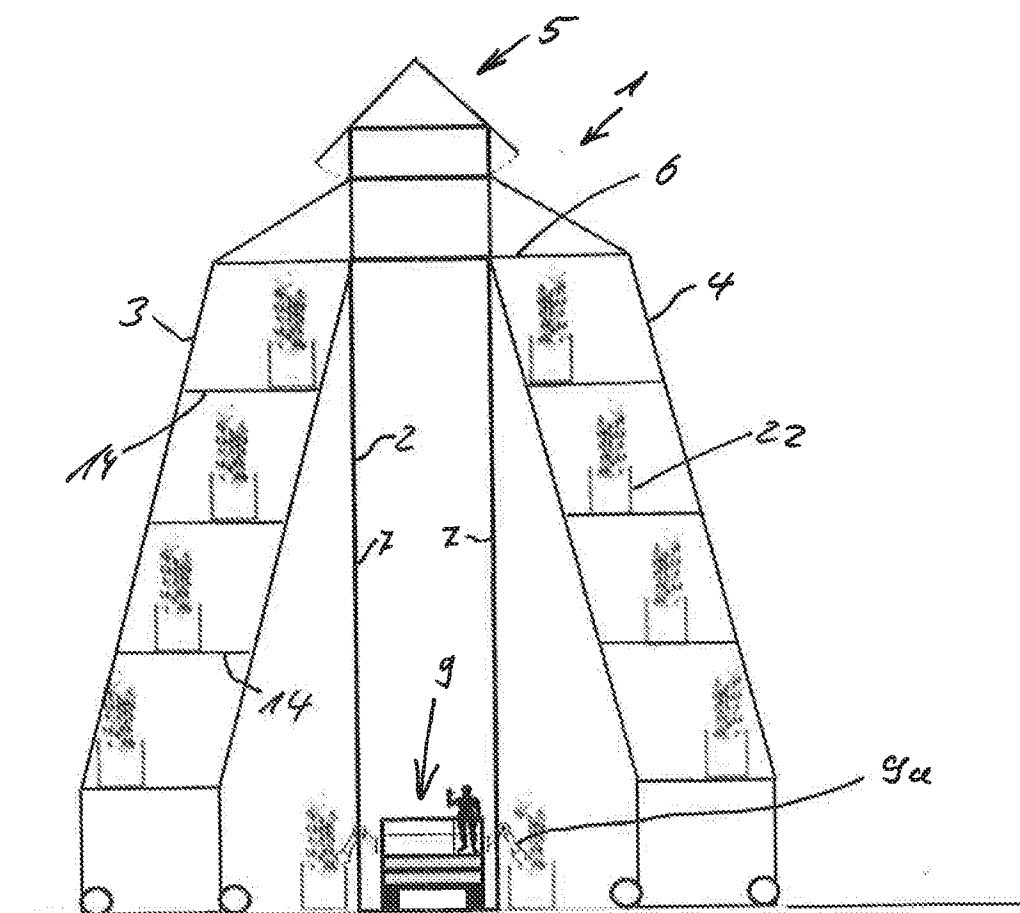
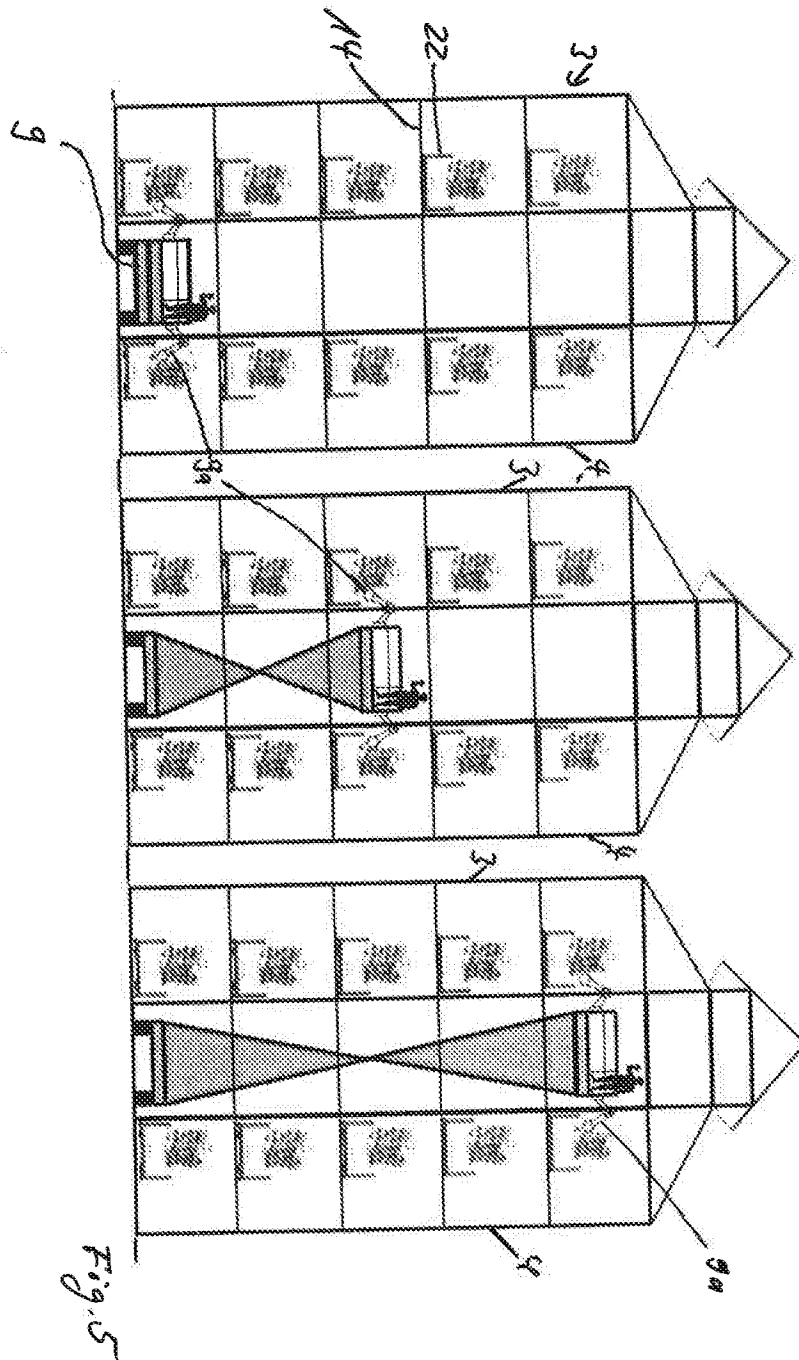


Fig. 4



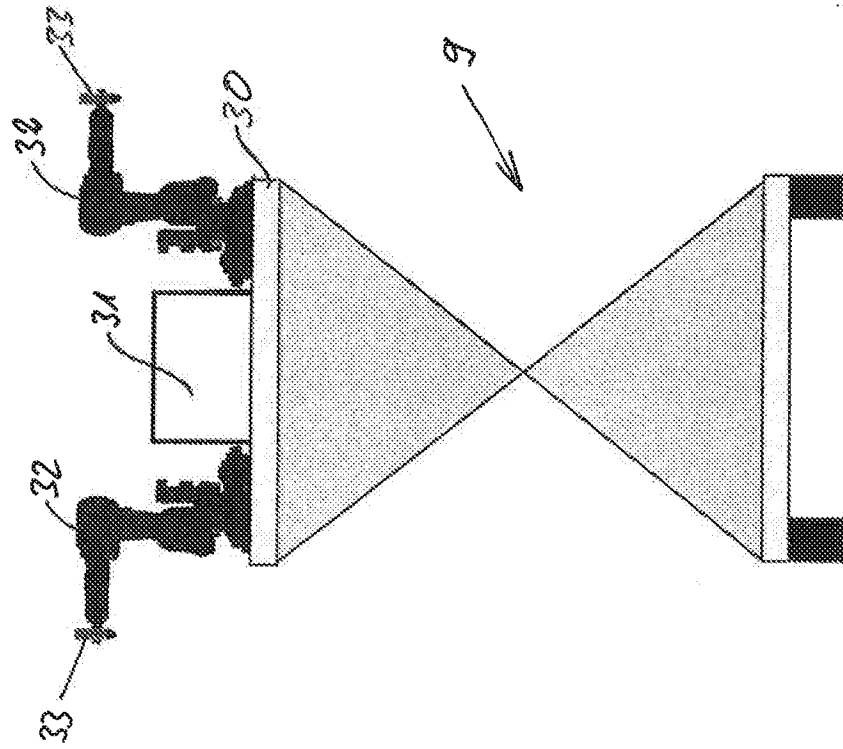


Fig. 7

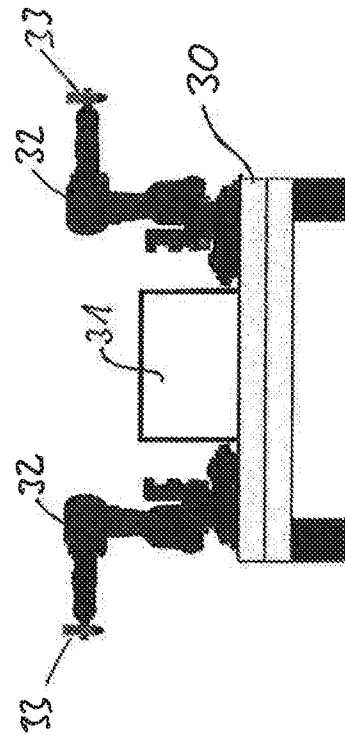


Fig. 6

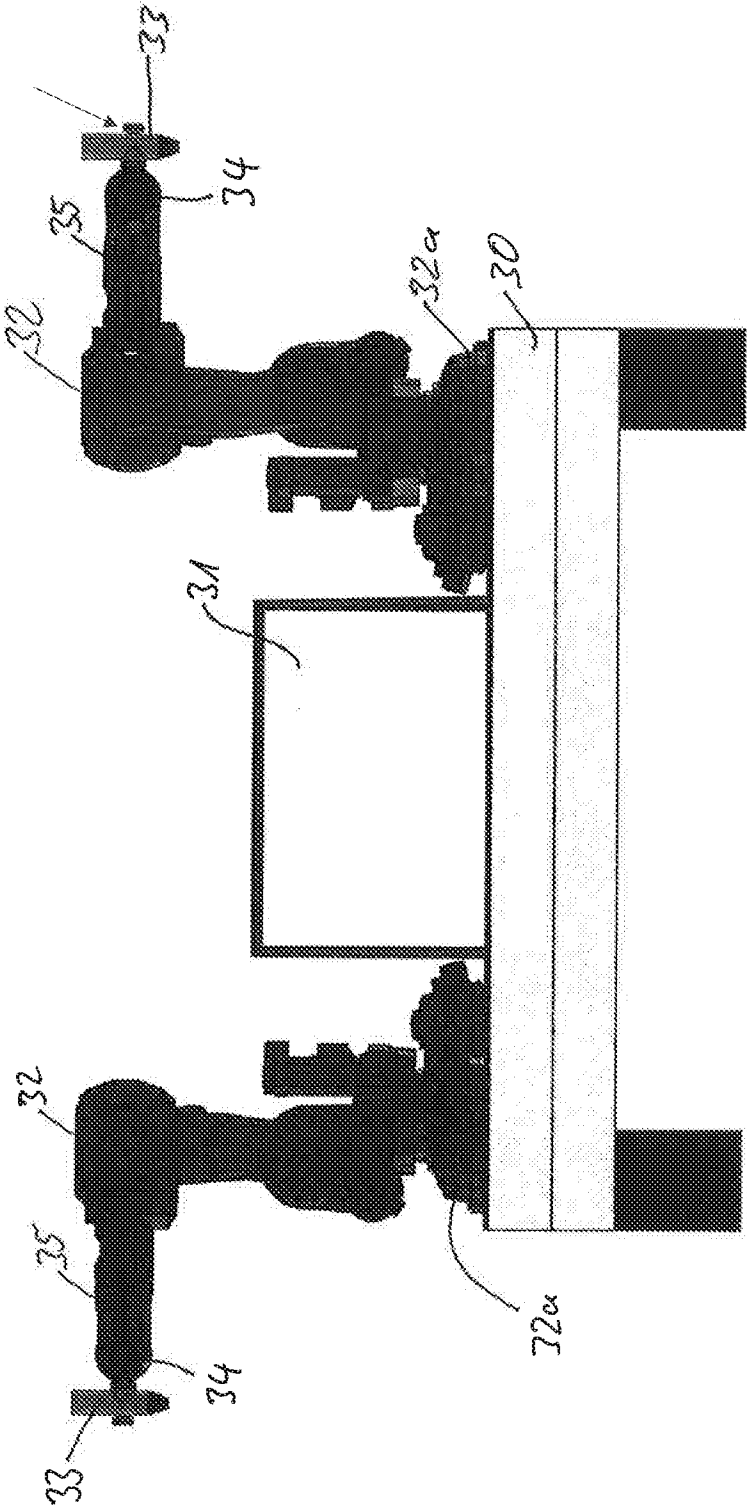


Fig. 8

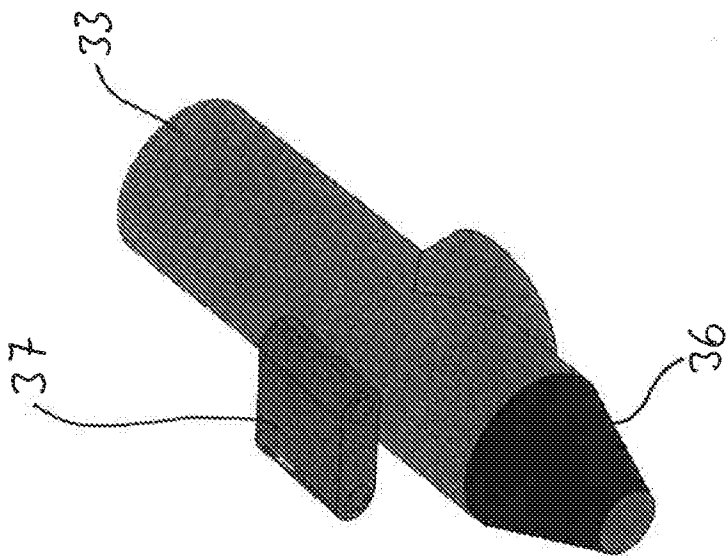


Fig. 9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SG2018/050198

A. CLASSIFICATION OF SUBJECT MATTER**A01G 31/02 (2006.01) A01G 9/02 (2018.01)**

According to International Patent Classification (IPC)

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A01G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC/WPI/FAMPAT: vertical farming, rack, hinge (铰接), inclined (倾斜) and similar terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	CN 201911140 U (BEIJING SOIL AND FERTILIZER WORK STATION) 3 August 2011 <i>Para. [0004] & [0029]; Fig. 1 & 2 of the original non-English language document (a machine translation is enclosed only for your reference)</i>	1, 2, 18, 20 AND 21 3-17, 19, 22 AND 23
X	CN 103053356 A (STAN TECHNOLOGY (HANGZHOU) CO. LTD.) 24 April 2013 <i>Para. [0003]; Fig. 1 & 2 of the original non-English language document (a machine translation is enclosed only for your reference)</i>	1, 2 AND 18
X	CN 107593158 A (SUZHOU XINXUN MACHINERY CO. LTD.) 19 January 2018 <i>Para. [0005] & [0006]; Fig. 1 & 2 of the original non-English language document (a machine translation is enclosed only for your reference)</i>	1, 2 AND 18

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.***Special categories of cited documents:**

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Date of the actual completion of the international search

10/07/2018

(day/month/year)

Date of mailing of the international search report

18/07/2018

(day/month/year)

Name and mailing address of the ISA/SG

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Authorized officer

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PCT/SG2018/050198

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 206776385 U (YONGCHUN PENGHU CHANGXIN OSMANTHUS PROFESSIONAL CO-OP.) 22 December 2017 <i>Para. [0005]; Fig. 1 & 2</i> of the original non-English language document (a machine translation is enclosed only for your reference)	1 AND 2
A	CN 106900534 A (CHEN G.) 30 June 2017 <i>Fig. 1, 2, 4 & 5</i> of the original non-English language document (a machine translation is enclosed only for your reference)	-

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/SG2018/050198

Note: This Annex lists known patent family members relating to the patent documents cited in this International Search Report. This Authority is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 201911140 U	03/08/2011	NONE	
CN 103053356 A	24/04/2013	NONE	
CN 107593158 A	19/01/2018	NONE	
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