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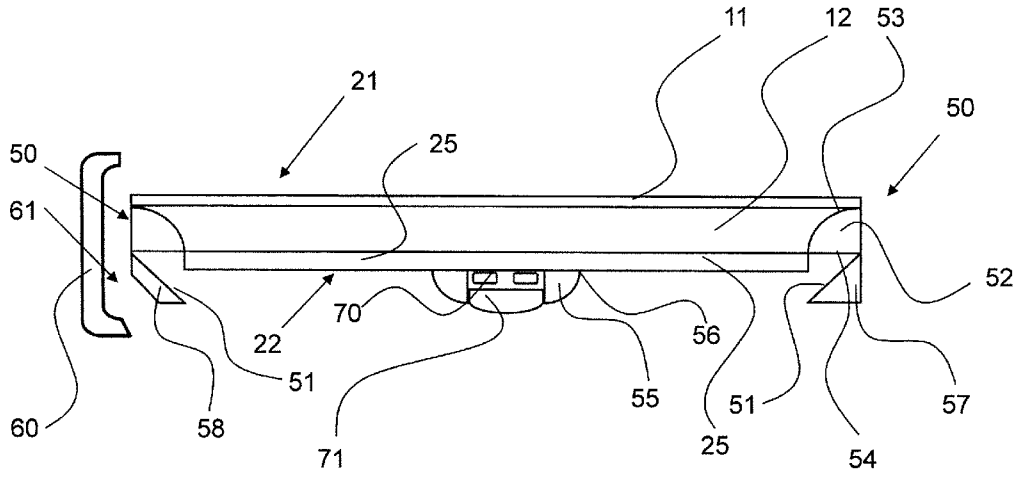


Fig. 3

(57) Abstract: A solar panel assembly (10) comprises a stand (30) to be anchored on or in the ground (31), a solar panel platform (20) oriented to the skies and one or more directional mechanisms (40; 404, 414) connecting the upper free end of the stand (30) with the solar panel platform (20), allowing the solar panel on the platform (20) to be directed in a number of favorable orientations towards the sun. One or more optical elements (50; 55) are provided at all or a majority of portions of the edges (24) of the platform around the solar panel directing the gathered light under (22) the platform (20) and then to the ground (31) under or near the solar panel assembly (10).

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TITLE

DIRECTIONAL SOLAR PANEL ASSEMBLY

TECHNICAL FIELD

The present invention relates to a directional solar panel assembly according to the preamble of claim 1.

PRIOR ART

WO 2016/074342 discloses a horizontal single-axis solar tracker support stand and a linkage system. The solar tracker comprises a vertical column, a main beam that is rotatable and is provided on the vertical column. A solar cell assembly is attached at a support frame rotatably fixed to the main beam. The solar cell assembly is arranged so as to form an inclined angle relative to a horizontal plane. The direction of the inclination in a north-south orientation differs between an operation of the support stand and solar cell assembly in the northern or southern hemisphere. The value of the angle is adjustable through a rotation of the main beam.

This installation aims to provide lines of adjustable solar cell assemblies being orientable in an efficient way following the sun.

Directional means rotatable and tiltable to orient the solar panel in an optimum position to gather the most sunlight possible over the day taking into account the path of the sun. Usually, such solar panels are provided in arrays comprising a number of rows and columns, when seen from above, thus covering substantive amount of land, especially useful agricultural areas. Even, if said arrays are provided on roof surfaces of buildings, the surface as such is usually not usable. This is unfortunate, since it has been shown that green roofs have a positive impact on the life of installation of the roof of the building as

well as on the environment of the urban district.

WO 2005/034611 shows a farming module with the features of the preamble of claim 1. Said farming module also collects water which is then distributed to plants below. Furthermore, the module can be covered by photovoltaic modules on the upper structure. Then lights, especially LEDs are provided on the lower side of the modules in order to illuminate the plants was well with the energy collected through said photovoltaic modules. The LED lights are powered by the photovoltaic modules.

DE 10 2013 002 825 shows an installation with several poles which are horizontally spaced apart mutually to form a pole area, and are each adapted to support photovoltaic modules aligned on a substructure. They can be aligned to the respective position of the sun over pivot axes. A network-independent water supply is provided with rainwater collection system, an irrigation system for the irrigation of agricultural soil and a cooling system for cooling the photovoltaic modules. The collection tank serves also as water reservoir.

KR 2010-0130115 shows an installation of photovoltaic modules on substructures on a pole, which substructure can be pivoted in the direction of the sun. On the substructure are provided a plurality of photovoltaic modules comprising holes between them and passing through the substructure within which optical elements are fixed to distribute sunlight as thoroughgoing elements to illuminate the soil under the substructure with natural sunlight. Furthermore reflective side flaps are provided at the edges of the substructure to reflect sun light from above to the reflective underside of an adjacent substructure to bring additional light via these two reflections under the adjacent module.

SUMMARY OF THE INVENTION

The prior art devices provide a number of features to propose a directional solar panel assembly. The present disclosure is aimed at resolving at least one of the technical problems in the prior art. Therefore, an objective of the present disclosure is to provide an improved directional solar panel assembly allowing the agricultural use of the area beneath or more general avoiding the loss of vegetation beneath such solar panel structures.

Furthermore, it is an aim of the invention to provide a solar panel assembly having simpler elements and being better adapted to withstand the elements.

A solar panel assembly comprises a stand to be anchored on or in the ground, a solar panel oriented to the skies and one or more directional mechanisms connecting the upper free end of the stand with the solar panel, allowing the solar panel to be directed in a number of favorable orientations towards the sun.

According to one embodiment of the invention said solar panel assembly is provided with optical light guiding elements around the perimeter arranged to gather and guide incoming light towards the underside of the solar panel to be directed directly or indirectly towards the ground. The redirection at the edges can be provided in a way that the reflected beams are directly directed to the ground, which can – in all embodiments – being the ground under the same solar panel assembly or near this solar panel assembly, which means that the light can be redirected into zones adjacent to this solar panel assembly comprising ground areas under adjacent solar panel assemblies.

Optical light guiding elements around the perimeter can be provided at all edges and only at parts of the edges. It is preferred that these optical light guiding elements are provided on the solar panel base and together with a clear polymer substrate or glass panel, optionally covered by a oleophilic layer to provide molecular properties on the surface of the panel decreasing active particle engagement, a smooth upper surface is provided, wherein the optical light guiding elements are integrated into the upper surface of the solar panel. Then any water pouring onto the surface can directly – in the case of an inclined solar panel – flow to the lower adjacent edges. However, it is also possible that the optical light guiding elements extend beyond the upper surface of the solar panel. Then preferably, rain draining through holes are provided either through the solar panel or through the optical light guiding elements or these optical light guiding elements have traverse grooves going down to the surface of the solar panel surface allowing rain water to be gathered at the opposite mouth of the groove.

According to another embodiment of the invention said solar panel assembly is provided with a plurality of LED's on the underside of the solar panel arranged to generate so called

grow light being directed directly or indirectly towards the ground. The wavelength of the generated grow light or plant light can be predetermined according to the plants which growth is to be promoted on the ground. It is suggested that at least a light level, given in Photosynthetic Photon Flux Density (PPFD), between 100 and 800 micromol/m^2s is provided. For a daylight-spectrum (5800 K) lamp, this would be equivalent to 5800 to 46,000 lumen/m^2. The LED's can be arranged in a predetermined pattern on or in the underside of the solar panel assembly. They can comprise light guiding and focusing lenses to guide the emitted light of the plurality of LED's onto the ground taking into account that the light of each solar panel assembly combined with light emitted from adjacent solar panel assemblies should cover the entire ground under the solar panel assemblies. It is also possible to provide a central group of LED's under the solar panel assembly, not necessarily but preferredly in the center, wherein light reflecting elements are provided around these LED's to direct light redirected from the edges is then directed to the ground and providing space for imaging lenses for the LED's. The predetermined pattern can simply comprise an arrangement of single or bundled LED's in a number of rows and columns under the solar panel assembly.

Furthermore it is preferred that at least one rainwater gutter is provided at one edge of the solar module with corresponding distribution elements. Such distribution elements can be a conduct running along the stand to distribute collected water around the stand. The rainwater gutter can be integrated into a possible light gathering structure at the perimeter structure of the solar panel frame, especially along one edge of the solar panel frame. The preferred edge is the edge which stays low when the solar panel frame is positioned in an angle to be oriented perpendicular to the sun or at least positioned in an angle that the axis of the incoming sun light is as close as possible to these 90 degrees. It is possible to provide additional gutter elements on the adjacent edges of this lower edge avoiding a sideways spilling of rain water.

For an efficient use of such ground areas covered by a plurality of solar panel assemblies according to the invention it is possible to include a battery or a series of battery banks in every solar panel assembly creating a distributed system. On the other side it is possible to provide electrical lines connecting the array of solar panel assemblies in between and with the external world. Since usually agricultural use is executed in lines, the electric lines can

be positioned parallel to the agricultural plough lines.

An array of isolated solar panel assemblies can comprise wireless communication means. Then each solar panel assembly can be an access point of a distributed computer network, not needing further infrastructure.

The one or more optical elements of the solar platform can be mounted on the inner side of a profile, wherein the profile is connected via at least one web to the solar platform. Preferably, there are two connecting rods at the side edges of the profile. The at least one web is connected with a drive mounted within the solar platform, wherein the connection of the at least one web is adapted to extend the profile from the solar platform creating a passage between the profile and the platform. The passage allow the collecting of light to be guided below the platform as well as collecting rainwater. In case of strong winds, the profile can be retracted towards the body of the platform not leaving the profile exposed to the winds.

The outer surface of the body of the substructure facing the inner surface of the profile is therefore preferably complementary to this inner surface so that the inner surface of the profile is mainly in direct two-dimensional contact with this outer surface when the profile is fully retracted, thus closing the above mentioned passage for collecting light and water completely in this case.

The upper section of the profile is curved, especially covering an angle of 60 to 90 degrees, with a complementary curvature within the body of the substructure of the platform. The lower section of the profile can be a plan profile having an angle between 30 and 60 degrees to the plan of the platform surface, optionally having a raised gutter edge at the lower free edge. This allows extended capture of sunlight which can be partly reflected directly under the platform partly directed to a central reflecting ridge to be distributed indirectly.

Further embodiments of the invention are laid down in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention are described in the following with reference to the drawings, which are for the purpose of illustrating the present preferred embodiments of the invention and not for the purpose of limiting the same. In the drawings,

Fig. 1 shows a schematic perspective view from below of a mechanism for directing a solar panel according to an embodiment of the invention,

Fig. 2 shows a schematic perspective view from below of a further mechanism for directing a solar panel according to an embodiment of the invention,

Fig. 3 shows a cross-section view of a solar panel platform of Fig. 1 or Fig. 2 with light diverting elements and light generating elements according to an embodiment of the invention;

Fig. 4A shows light paths in a detail view of Fig. 3 for an embodiment without light generating elements;

Fig. 4B shows light paths and light generating elements in a detail view of Fig. 3 for an embodiment comprising light generating elements;

Fig. 4C shows a schematical detail view of prismatic grated surfaces as reflecting surfaces as used in the embodiments of Fig. 4A and 4B;

Fig. 5A shows a schematical view from above on an array of solar panel assemblies according to Fig. 2 according to an embodiment of the invention;

Fig. 5B shows a schematical view from above on an array of solar panel assemblies according to Fig. 2 according to a further embodiment of the invention having a staggered pattern of solar panel assemblies;

Fig- 6A shows a front view (left) and a side view (right) of an array of staggered solar panel assemblies;

Fig. 6B shows the front view and side view of the cluster of Fig. 6A with a small angle from the vertical orientation;

Fig. 6C shows the front view and side view of the cluster of Fig. 6A with a great angle from the vertical orientation;

Fig. 6D shows the front view and side view of the cluster of Fig. 6A with a horizontal orientation of all solar panel assemblies;

Fig. 7A shows a frontal diagram of a gutter arrangement with three flexy drain pipes;

Fig. 7B shows a partial side view of a further gutter arrangement similar to Fig. 7A;

Fig. 8 shows a schematic perspective view of a solar panel platform in a retracted position according to a further embodiment;

Fig. 9 shows a schematic perspective view of the solar panel platform of Fig. 8 in an extended position;

Fig. 10 shows a schematic perspective view from below on the solar panel platform of Fig. 9 within its extended position;

Fig. 11 shows a perspective view from above on the substructure of the solar panel platform of Fig. 10 without the solar panel mounted on it;

Fig. 12 shows an enlarged view of a corner of the solar panel platform of Fig. 8; and

Fig. 13 shows an enlarged view of the underside of the solar panel platform of Fig. 8.

DESCRIPTION OF PREFERRED EMBODIMENTS

The following describes in detail embodiments of the present disclosure. Examples of the embodiments are shown in the accompanying drawings, where reference signs that are the same or similar from beginning to end represent same or similar components or components that have same or similar functions.

Fig. 1 is a schematic perspective view from below of a mechanism for directing a solar panel according to an embodiment of the invention. The solar panel assembly 10 comprises a platform 20. On the upper surface 21 of the platform 20 is mounted a photovoltaic panel (not shown) as well as optional sensors of a tracking device. In an alternative embodiment, the platform 20 can also comprise the solar cell module and a corresponding perimeter frame. It is only important that an upper surface 21 is oriented to the sky and the upper surface 21 provides the solar panel surface. The underside 22 comprises one or more attachment points 23 for the adjustment mechanisms 404 and 414.

In a different embodiment (not shown in the drawings) the solar panel could comprise a passivated emitter rear contact solar cell, a so called PERC cell, where the surface 21 would be the primary collector and the surface 22 the secondary collector or any other

collector whether dual faced or arrange back-to-back, i.e. facing the sun as well as the read of the front face. The PERC or alternate dual facing collector would maintain platform 20 but would have a dual aspect whether the layers 11 or polymer 12 on the rear face to accommodative the outer prism that reflects daylight to the rear section of the panel.

An arm 403 projects from the attachment point 23 and connects the platform 20 with the first mechanism 404 for adjusting the tilt of the platform 20, here illustrated as a first drive motor 406 actuatable to rotate the arm 403 and therefore the platform 20 around a horizontal axis 410. The platform 20 is further operably connected to a second mechanism 414 for adjusting the rotational position of the platform 20. The second mechanism 414 comprises a second drive motor 416 actuatable to rotate the rotate the first mechanism 404 and therefore the platform 20 about a vertical axis 420. The drive motor 416 of the embodiment of Fig. 1 is fixedly connected with a vertical stand 30 shown in Fig. 2, anchored firmly in the ground 31 below. Motors 406 and 416 are connected to a battery of the solar panel charged by the solar panel.

Fig. 2 shows a schematic perspective view from below of a further mechanism for directing a solar panel according to an embodiment of the invention. The solar panel assembly 10 comprises a platform 20 which is centrally connected via a driven universal joint 40 to a stand 30, especially a cylindrical stand, being firmly anchored in the ground below. Preferably, the length of the stand 30 is sufficient to allow persons to work unimpeded independent from the orientation of the platform 20; thus the stand 30 usually has a length of more than 2 meter plus the half of the platform diameter, if the stand is attached centrally. The edges 24 of the platform should not be tilted lower than said free user height. If the agricultural use of the ground 31 is intended to be worked e.g. ploughed with machines, then the height of these machines has to be taken into consideration for the free height to be predetermined. It is also possible to provide the panels at lower heights. Then, in case of service, the panels 10 would usually be folded to stand up right thereby producing lowest energy levels in order to render the ground below clear of obstacles for free height ploughing, sowing, fertilizing ad generally working the land. Under such conditions airplanes can be used and watering systems can be moved across the field.

Fig. 3 shows a cross-section view of a solar panel platform 20 of Fig. 1 or Fig. 2 with light

diverting elements 50 provided at the edges 24 of the solar panel platform 20 according to an embodiment of the invention. Usually the exterior light diverting elements are provided at the surrounding edges 24.

The solar panel platform 20 comprises preferably an oleophilic layer 11 at the upper surface 12, which function is to provide molecular properties on the surface of the panel decreasing active particle engagement, i.e. dust, oil and water based particles glide off the surface without adhesion. A clear polymer substrate or glass panel 12 covers the solar panel 25 itself. Within this embodiment, the solar panel provides as such the platform structure, but could also be included into a frame connecting the optical elements 50 at the edge 24 together and/or the optical element 55 at the centre. The clear polymer or glass 12 comprises at the edges 24 an recess filled completely by the light gathering lenses 52 being long profiles with the cross-section as shown in Fig. 3. two transparent layers 11 and 12.

On the right side of the cross-section view of Fig. 3, a triangular reflecting profile 57 is provided to deflect incoming light passing the exterior of edge 24 of panel 25 towards the centre.

The first light diverting elements 50 provided at the edge 24 are provided preferably essentially around the entire edge 24 of the platform 20. They comprise a reflecting surface 51 provided in an angle of between 30 and 60 degree, 45 degree in the embodiment of Fig. 3 against the plan of the platform 20. A transparent light gathering lens 52 is provided above the upper surface 21 and reaches onto the reflecting surface 51. It comprises an arcuate upper entry surface 53 and a lower perpendicular outgoing surface 54. The upper arcuate upper entry surface 53 starts with a 45 degree angle at the edge of the platform 20 and raises about 35 millimetres for an edge distance of 70 millimetres. These measurements are mentioned as basic reference for a tested embodiment, although other measurements may also be applied depending on the incarnation of the panel being manufactured. However, the width and height of the light gathering structures around the edge 24 of the solar panel will usually be chosen to be between 0.5% and 10%, preferably 1% to 5% of the lateral dimensions of the solar panel or frame itself.

Most of the gathered light leaving the light diverting element 50 through the surface 54 is

directed onto the reflecting light diverting element 55, being provided near the center of the underside 22 of the platform 20. The light reflected by the reflecting surface 56 is directed to the ground. In this context "center of the underside" 22 can either mean a central part with e.g. two times two LED's 70 and a torus-like reflecting element 58 or the light gathering elements 57 and 58 are only provided at opposite edges of the platform e and redirect the light in parallel beams 102 towards two opposite central longitudinal reflecting surfaces 58 with a single of double band of light LED 70 in between.

On the left side of Fig. 3, the triangular element 57 with the reflecting surface 51 is replaced by the trapezoid element 58 with a similar front reflecting surface 51. A gutter wall 60 is provided in a predetermined distance behind the optical element 50 at the edge 24 and behind the trapezoid profile 58. This creates a conduit line 61 or cavity section collecting any humidity arriving on the oleophilic surface 11 and thus guided to its borders. The gutter wall 60 has the form of a "C" encompassing the entire sandwich of the platform between upper surface 21 and lower surface 22 providing an upper border edge and a lower border edge, wherein the trapezoid element 58 provides more space for the conduit line 61 for a greater water flow passage. The gutter is of course fastened to the solar panel platform or the frame encompassing the solar panel 20. It can be built as a pivot slide that runs partially behind the panel and acts as a waterfall guide for water to dissipate from the channel 60. The gutter wall can be provided on the "lower" part of the solar array as well as (optionally) up the adjacent walls running up either side. There is no point in providing an upper gutter wall as there would be no functional advantage. Also, it can be provided as an optional upgrade for existing arrays.

It is also possible to change the reflecting angle of the reflecting surface 51 for a direct illumination of the ground 31 shadowed by the platform. When the platform 20 is tilted and turned, the beam path between the element 50 and 55 remains the same, but the plane of the platform in view of the ground changes and the light will be directed partly underneath of one of the eight nearby adjacent solar assemblies. It is possible that an array of platforms is acceded or staggered rather than in a regimental organization with one assembly simply behind the other.

Fig. 4A shows light paths in a detail view of Fig. 3 for an embodiment without light

generating elements and without the transparent cover layers. Incoming light beam 101 traverses the light gathering lens 52 of the optical elements at the edge and is reflected at the reflecting surface 51 essentially in parallel to the lower surface 22 as reflected beam 102.

According to the embodiment of Fig. 4B the solar panel assembly 10 is provided with a plurality of LED's 70 on the underside of the solar panel arranged to generate so called grow light being directed directly or indirectly towards the ground. The LED's are preferably attached from the underside of the platform 20 at the lower surface 22 and are connected to a control unit either provided in the platform 20 or in the stand 30, wherein any electrical connections are provided in or at the platform 20 (not shown).

The reflected beam 102 is again reflected at the reflecting surface 56 at the central element 55 with as result ground impending light beams 103. It is noted that central element 55 is attached at the underside 52 of the solar panel 25 or at a corresponding frame element (not shown). A primary mesh would be provided to deliver an improved gutter entry point in order to keep the upper surface 21 free from foreign elements out of the passage.

The LED's 70 receive the necessary energy from the solar panel and / or a battery or a battery pack which is charged by the solar panel. The battery is preferably provided in the stand 30. The control unit predetermines via sensing elements that measures light frequency and intensity the grow light control in hours and intensity. Additionally the present embodiment can provide an efficient energy use in choosing an LED illumination of the ground 31 based on the needs on the plants emitting only in a bandwidth selection whereas the incoming light of the sun covers a broader bandwidth thus increasing the light use efficiency. The embodiment of Fig. 4B provides an array of e.g. four LEDs 70 surrounded by a curved optical element 55 or several straight sections attached at the underside 22 or a corresponding frame (not shown). Within this frame of curved optical elements 55 a light diffracting lens 71 is provided below the LEDs 70.

Fig. 4C shows a schematical detail view of prismatic grated surfaces 156 as reflecting surfaces as used with reference numerals 51 and 56 in the embodiments of Fig. 4A and 4B; Fig. 4C shows the reflecting body 55 near the centre of the panel backside with a curved

prismative grated surface 156, but the principle also apply for the essentially plan surface 51. Incoming light beams 102 are reflected as reflected light beams 103. Detail view 109 of Fig. 4C shows an reflective element having the main reflective surface 104 and an acute angle reflective surface 105, partially reflecting light as intermediate light beam 106 to the primary reflective surface 104, In other words, Fig. 4C shows the prismatic grated surface 156 that passes light through a prismatic effect thereby bending and multiplying output light on the rear of the panel 10. The prismatic grating can be micro but is higher in efficiency output using nano grated surface. The diagram of Fig. 4C shows a prismatic grating on a curve surface. Using a similar arrangement it is also possible on a flat surface as surface 51. It is noted that one edge is not perpendicular to the other and is usually less than 90° in order to generate the multiplier effect.

In an alternative embodiment a rain gutter 60 (not shown) is provided ending in a flexible hose attached at the stand 30. The hose can be flexible and be wounded (partially) around the stand 30. The flexible line can uniformly carry water away and deposit it in a reservoir.

Fig. 5A shows a schematical view from above on an array of solar panel assemblies 10 according to Fig. 2 according to an embodiment of the invention. The solar panel assemblies are shown in a schematical way with a representation of the stand 30 and the platform 20 for each assembly 10. The platforms 20 are represented in a horizontal configuration with approximately square surfaces, although mainly the current panel industry provides rectangular platforms 10 due to nature of PV panel arrangements. The opposing edges 24 of solar panel assemblies 10 of adjacent rows and columns are provided in a minimum distance one from another. Said minimum distance is reached in the shown horizontal orientation of the platforms. In any inclined configuration the distance between such opposing edges is higher than in the configuration shown in Fig. 5A. It is preferred that said distance is less than 80% of the width of the solar panel assemblies 10 creating agricultural pathways 85 in between the rows of stands 30 under the solar panel platforms 24. With solar panels of e.g. 2 metres side length on platforms of e.g. 2 metres x 2 metres such a distance can be 160 centimetres. In other words each stand 30 has a distance from center to center in each row and each column of 3,60 metres. A distance of approximately 2*(SQR(2)-1) allows to incline the platforms 24 to about 45 degrees without shadowing neighboring solar panels. It is also possible to take a smaller minimum distance of

opposing edges 24 of solar panel assemblies 10 of adjacent rows; e.g. as a percentage of the width of the adjacent solar panel assemblies 10 taken from the group of values 60%, 40%, 20%, 10% and 5% with increasing shadowing of neighboring solar panels. The above determined distance between rows can also be applied to the distance of neighboring columns of the array.

For an efficient use of such ground areas covered by a plurality of solar panel assemblies 10 it is possible to include a battery in every solar panel assembly creating a distributed system. On the other side it is possible to provide electrical lines 81 connecting the array of solar panel assemblies in between and with an external connection 82 with the external world. These lines 81 and 82 usually comprise an electric connection for battery management and for data exchange between different array elements. Since usually agricultural use is executed in lines as shown by the two parallel lines 85, the electric lines 81 and 82 can be positioned parallel to the agricultural plough lines 85. Water distribution lines extend from the stands 30 to distribute gathered water over the entire surface.

An array of isolated solar panel assemblies 10 can comprise wireless communication means. Then each solar panel assembly 10 can be an access point of a distributed computer network, not needing further infrastructure.

Fig. 6A shows a solar cluster comprising numerous solar arrays 10 organized in a staggered pattern from the front as well as three consecutive rows from the side. In this orientation they are oriented for ultra-low horizon plane at dawn, dusk and or maintenance, harvesting, etc. when they are producing the lowest energy yield. Between two solar panels 10 of Fig. 6A, shown as "adjacent " in a front view, there is an empty row with a solar panel in the row behind. This is shown with different length of supports 30. In the side view the agricultural line 85 between two solar panels is clearly visible.

Fig. 6B shows the solar cluster of Fig. 6A in operation when the solar panels 10 change their angle to follow the sun as it rises and/or sets over the horizon. Fig. 6C shows the same cluster being positioned an alternate angle. Fig. 6D shows a typical midday sun angle as well as operational standby mode. The main reason for this angle for standby mode is to optimize light detection as stated.

Fig. 7A shows a frontal diagram of a gutter arrangement with three flexy drain pipes as upper lines 64 which are connected at junction piece 65 to continue as line 62. It is noted that it is possible to only provide one of these pipes 64. There is a possibility if longer runs are involved to put two, three, four or even more conduit pipes 62 that lead water away from the gutter 60 to ensure smooth flow without overflow (wastage) and/or redundancies in case of blockage.

Fig. 7B shows a schematic side profile of a gutter similar to the arrangement of Fig. 7A. The attachment of the solar panel 20 to the support is not shown. In this embodiment the flexible pipe 62 is leading down the central tower column 30. A marginal kink in the pipe is shown in the drawing to demonstrate the slack in order to facilitate the varying angles of tilt that the solar panel 20 may have during operational periods as shown in Fig. 6A to 6D.

Fig. 8 shows a schematic perspective view of a solar panel platform 120 according to a further embodiment; A solar panel 121 is mounted on a substructure 122 having a central functional ridge 123. The functional ridge 123 as a central node attached to a stand 30 as shown in Fig. 2.

A gutter and reflective profile 160 is provided on two opposite sides, especially sides which can be tilted towards the ground. The gutter and reflective profile 160 comprises a lower plan profile section 161, which can be reflective on the inner side, and an upper curved section 162. The upper curved section 162 is complementary to the adjacent substructure 122 in order to provide almost no cavity and slot between the upper curved section 162 and the substructure 122. The lower edge 163 of the lower plan profile section 161 is raised over the plan surface and can retain water from directly falling down to the ground. It is noted that the gutter and reflective profile 160 is attached to the substructure 122 with two rods 164 fixedly connected at the outer end of the gutter and reflective profile 160. Both surfaces 161 as well as 162 can be provided with the structure as shown in Fig. 4C, a plurality of prismatic grated surfaces 156 as reflecting surfaces.

The curved surface can cover an angle of 60 to 90 degrees, wherein the plan profile 161 can have an angle between 30 and 60 degrees compared to the plan of the platform surface.

The rods 164 are slidably integrated into the substructure 120. One or more drives (not shown) are connected to the rods, e.g. being a worm at the inner end, to push them out of the substructure 120 to extend the gutter and reflective profile 160 to provide a space between the upper curved section 162 and the substructure 122. The function will be described in connection with the further drawings. When strong winds are blowing, then the drives are activated and bring the gutter and reflective profile 160 near the substructure 122 not allowing the wind forces to attack the solar panel platform.

Fig. 9 shows a schematic perspective view of the solar panel platform 120 of Fig. 8 in an extended position. The main difference is the passage 124 between the gutter and reflective profile 160 and the substructure provided by the extended position of the rods 164.

Fig. 10 shows a schematic perspective view from below on the solar panel platform 120 of Fig. 9 within its extended position. Reference numeral 130 designates the stand attachment for mounting the solar panel platform 120 on a stand, mast or pole. The substructure 122 comprises in parallel to the gutter and reflective profile 160 a functional ridge 123 extending beyond the lower surface 125 of the substructure 123. It comprises on the lower side two stripes 170 of LED lights going from one edge 126 to the stand attachment 130 in the middle and is then prolongated to the opposite edge. Of course, there can be a number of single LED lights or there can be more than two lines of LED stripes 170. The stripes are provided on a flat lower surface, which can also be convexly curved. The border surface 256 is curved – in cross section - in a quarter spherical shape and is reflective. Therefore the surface 256 takes the same function as the reflecting surface 56 of Fig. 4. The lower plan profile 160 has the function of the reflecting surface 51.

Fig. 11 shows a perspective view from above on the substructure 122 of Fig. 10 without the solar panel 121 mounted on it. Drives for rods 164 and electrical connections etc. are omitted. The substructure has the shape of a tray with an essentially flat bottom surface 127. There are provided four reinforcing webs 128 reaching from the corners of the substructure 122 towards the center, where the attachment 130 for a stand is provided. It is possible to provide a plurality of photovoltaic cell modules on the substructure with spaces between them to gather rain water on the surface 127 of the tray.

The inner upper section 262 of the substructure 122 on the sides with the gutter and reflective profile 160 is shown as a hollow complementary section to the upper curved profile 162.

Fig. 12 shows an enlarged view of a corner of the solar panel platform 120 of Fig. 8 in the extended position. It is a schematical view in the sense that the rod 164 is provided at the level of the photovoltaic panel, wherein the connection to the drive has to be effected within the tray of the substructure 122, here shown with the single line of the curved section 262. It can be seen that the passage 124 allows light and water to pass from the upper side to the underside. The curvature of the curved section can be chosen to direct the incoming light to the ground or onto the also reflecting curved section 262 of the substructure 122 to be reflected again towards the ground or on the plan reflecting profile 161. Direct incoming light from above is reflected from the plan reflecting profile 161 towards the reflecting border surface 256 of the central ridge 123.

Fig. 13 shows an enlarged view of the underside of the solar panel platform 120 of Fig. 8. Reference numeral 165 designates an outlet of the lower edge 163. Liquid collected on the upper lip of the edge 163 is guided to the central connection where a flexible line 62 can be connected.

LIST OF REFERENCE SIGNS

10	solar panel assembly	31	ground
11	oleophilic layer	40	universal joint
12	clear polymer or glass	50	optical elements at the edge
20	platform	51	reflecting surface
21	upper surface	52	light gathering lens
22	lower surface	53	arcuate upper entry surface
23	attachment point	54	lower perpendicular outgoing surface
24	edge of the platform		
30	stand	55	optical element at the centre

56	reflecting surface
57	triangular reflecting profile
58	trapezoid profile
60	gutter wall
61	conduit line / borehole
62	flexible line
63	funnel attachment
64	upper line
65	line junction
70	LED
71	light diffracting lens
81	electric line
82	external connection
85	agricultural line
101	incoming light beam
102	reflected beam
103	ground impending light beam
104	main reflecting surface
105	adjacent acute angled surface
106	intermediate reflected beam
109	detail view
120	solar panel platform
121	solar panel
122	substructure
123	central functional ridge
124	passage
125	lower surface
126	edge
127	bottom surface
128	reinforcing web
130	stand attachment
156	grated reflecting surface
160	gutter and reflective profile
161	lower plan profile
162	upper curved section
163	lower edge
164	side rod connection
165	outlet
170	LED stripe
256	reflecting border surface
262	substructure curved section
403	arm
404	first mechanism
406	first motor
410	horizontal axis
414	second mechanism
416	second motor
420	vertical axis

CLAIMS

1. A solar panel assembly (10) comprises a stand (30) to be anchored on or in the ground (31), a solar panel platform (20, 120) oriented to the skies and one or more directional mechanisms (40; 404, 414) connecting the upper free end of the stand (30) with the solar panel platform (20, 120), allowing the solar panel on the platform (20, 120) to be directed in at least one favorable orientation towards the sun, characterized in that one or more optical elements (50; 55, 161, 162) are provided at all or at a majority of portions of the edges (24) of the platform around the solar panel directing the gathered light under (22) the platform (20) and then to the ground (31) under or near the solar panel assembly (10).

2. The solar panel assembly (10) according to the preamble of claim 1 or according to claim 1, characterized in that a plurality of light sources (70) are provided at the underside (22) of the solar panel platform (24) directed towards the ground (31).

3. The solar panel assembly (10) according to claim 2, wherein the light sources (70, 170) are positioned along the surrounding edges (24) of the solar panel platform (24) or are positioned in a predetermined pattern on the underside (22, 122) of the solar panel platform (20), especially in the centre of the underside (22, 122).

4. The solar panel assembly (10) according to claim 2 or 3, wherein the light sources are LEDs (70, 170), especially tuneable LED's to a predetermined grow light wavelength adjusted by a control unit.

5. The solar panel assembly (10) according to any one of claims 1 to 4, wherein the solar panel platform (20, 120) has at least one exterior edge (24) comprising at least one rainwater gutter (60, 160) at the at least one edge of the solar panel platform (20, 120) and at least one distribution element (62, 64), wherein the distribution element (62, 64) comprises one end (63) being connected with the at least one rainwater gutter (60, 160) and the other end being adapted to deliver rainwater collected in the gutter (60, 160) to a receiver inside the stand (30) or to the ground (31) below.

6. The solar panel assembly (10) according to claim 5, wherein the rainwater gutter

(60, 160) is connected to a conduit (61) passing the thickness of the solar panel platform (20) connected to a flexible conduit (62) as distribution element.

7. The solar panel assembly (10) according to any one of claims 1 to 6, further comprising a battery which can be charged by the solar panel and driving the directional mechanisms (40; 404, 414).

8. Array of solar panel assemblies (10) comprising a plurality of solar panel assemblies (10) according to any one of claims 1 to 7, positioned in rows, wherein opposing edges (24) of solar panel assemblies (10) of adjacent rows are provided in a minimum distance less than 80% of the width of the adjacent solar panel assemblies (10) creating agricultural pathways (85) in between the rows of stands (30) under the solar panel platforms (24).

9. Array of solar panel assemblies (10) according to claim 8, wherein the minimum distance between opposing edges (24) of solar panel assemblies (10) of adjacent rows is less than a percentage of the width of the adjacent solar panel assemblies (10) taken from the group 60%, 40%, 20%, 10% and 5%.

10. Array of solar panel assemblies (10) according to claim 8 or 9, wherein the minimum distance as predetermined between rows also applies to the distance between adjacent columns of the array.

11. Array of solar panel assemblies (10) according to any one of claims 8 to 10, wherein electrical and/or communication lines (81) are interconnecting all solar panel assemblies (10) and/or electrical and/or communication lines (82) are connecting the array with an external system.

12. Array of solar panel assemblies (10) according to any one of claims 8 to 11, wherein each solar panel assembly comprises a wireless communication means, especially wherein each communication means is configured to be an access point of a distributed computer network.

13. The solar panel assembly (10) according to any one of the preceding claims, characterized in that the one or more optical elements (161, 162) are mounted on the inner side of a profile (160), wherein the profile (160) is connected via at least one web (164) to the solar platform (120), wherein the at least one web (164) is connected with a drive within the solar platform (120), wherein the connection of the at least one web (164) is adapted to extend the profile (160) from the solar platform (120) creating a passage (124) between the profile (160) and the platform (120).

14. The solar panel assembly (10) according to claim 13, wherein the outer surface (262) of the body of the substructure (122) facing the inner surface of the profile (160) is complementary to this inner surface so that the inner surface of the profile (160) is mainly in direct two-dimensional contact with this outer surface (262) when the profile (160) is fully retracted.

15. The solar panel assembly (10) according to claim 13 or claim 14, wherein the upper section of the profile (160) is curved, especially covering an angle of 60 to 90 degrees, wherein the lower section of the profile (160) is a plan profile (161) having an angle between 30 and 60 degrees to the plan of the platform surface, optionally having a raised gutter edge (163) at the lower free edge.

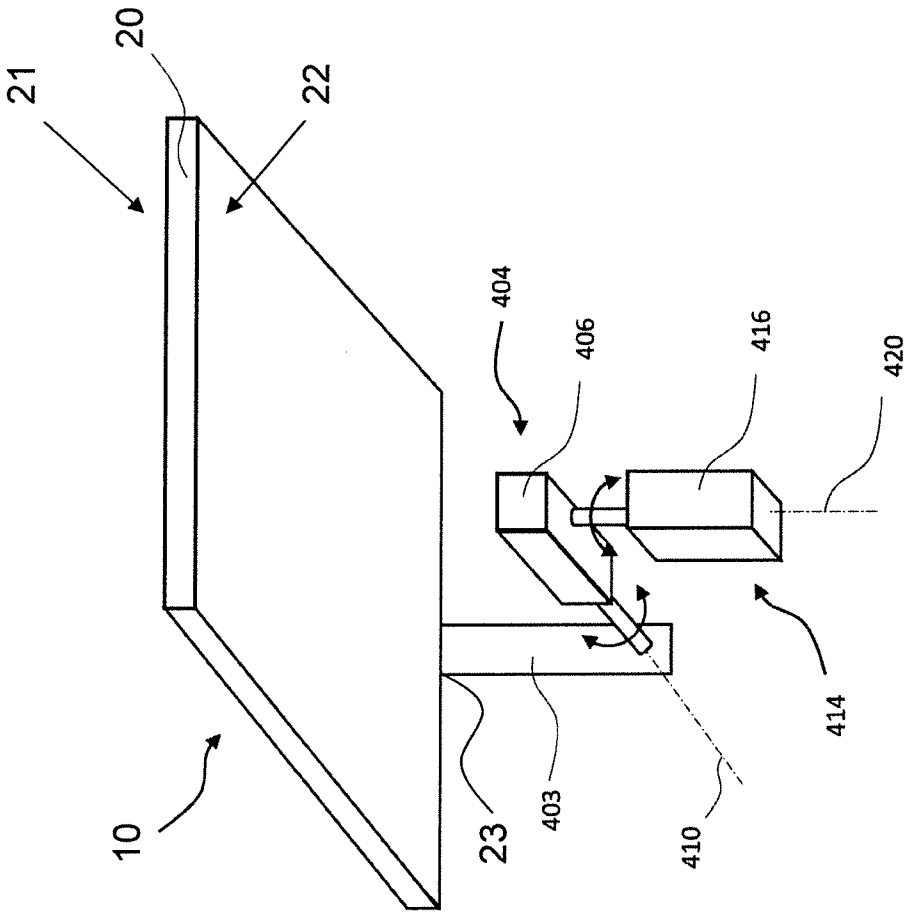


Fig. 1

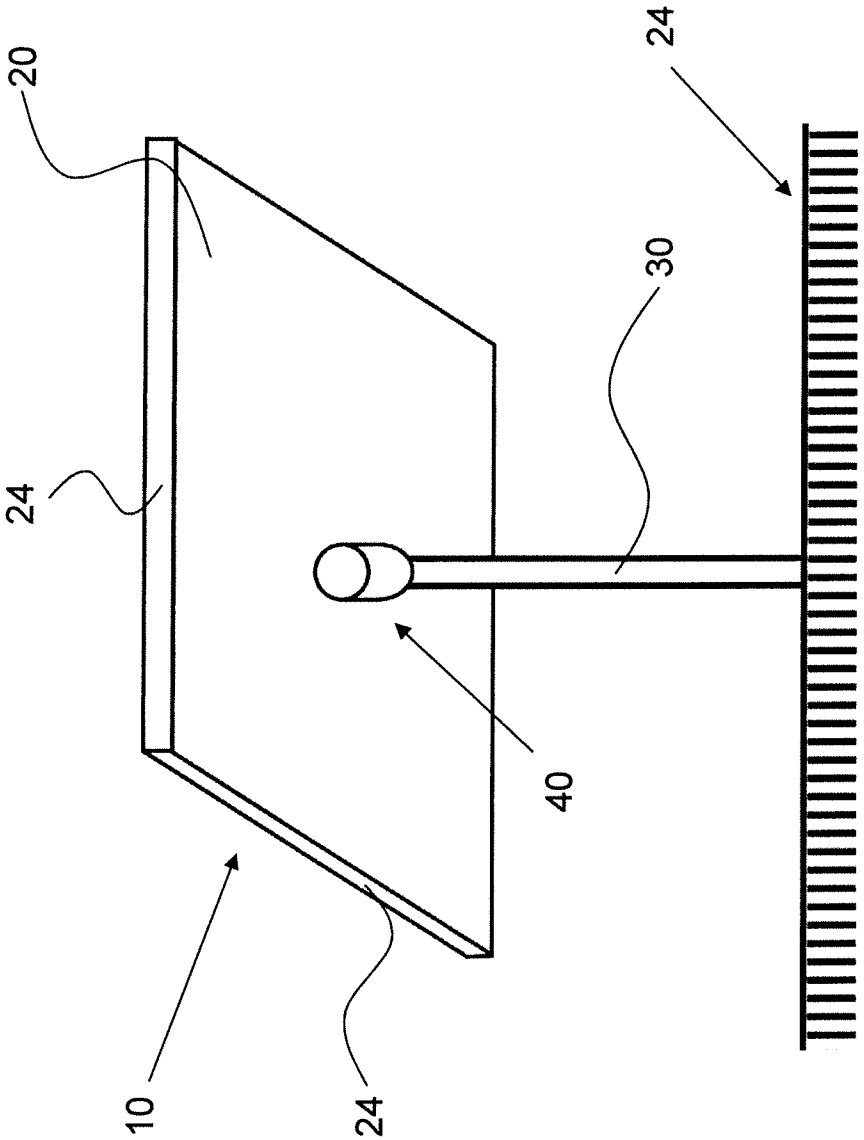


Fig. 2

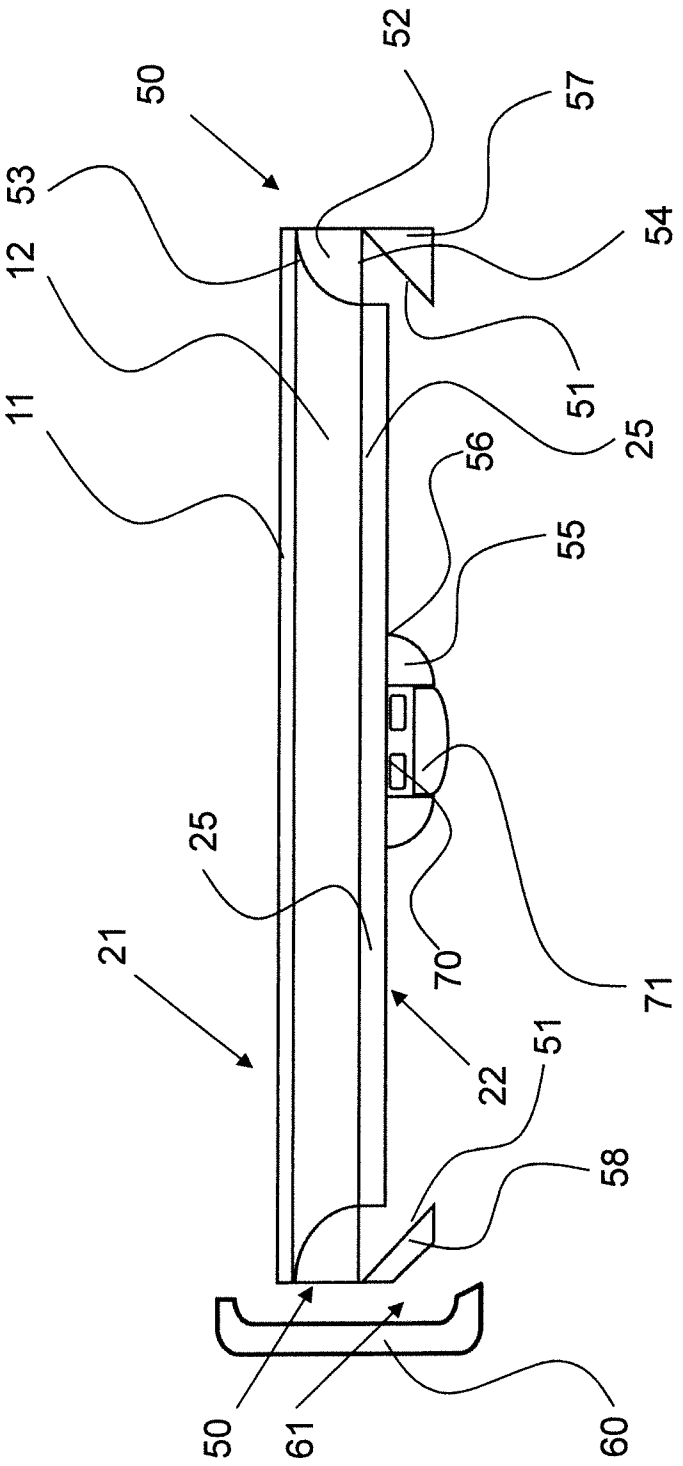


Fig. 3

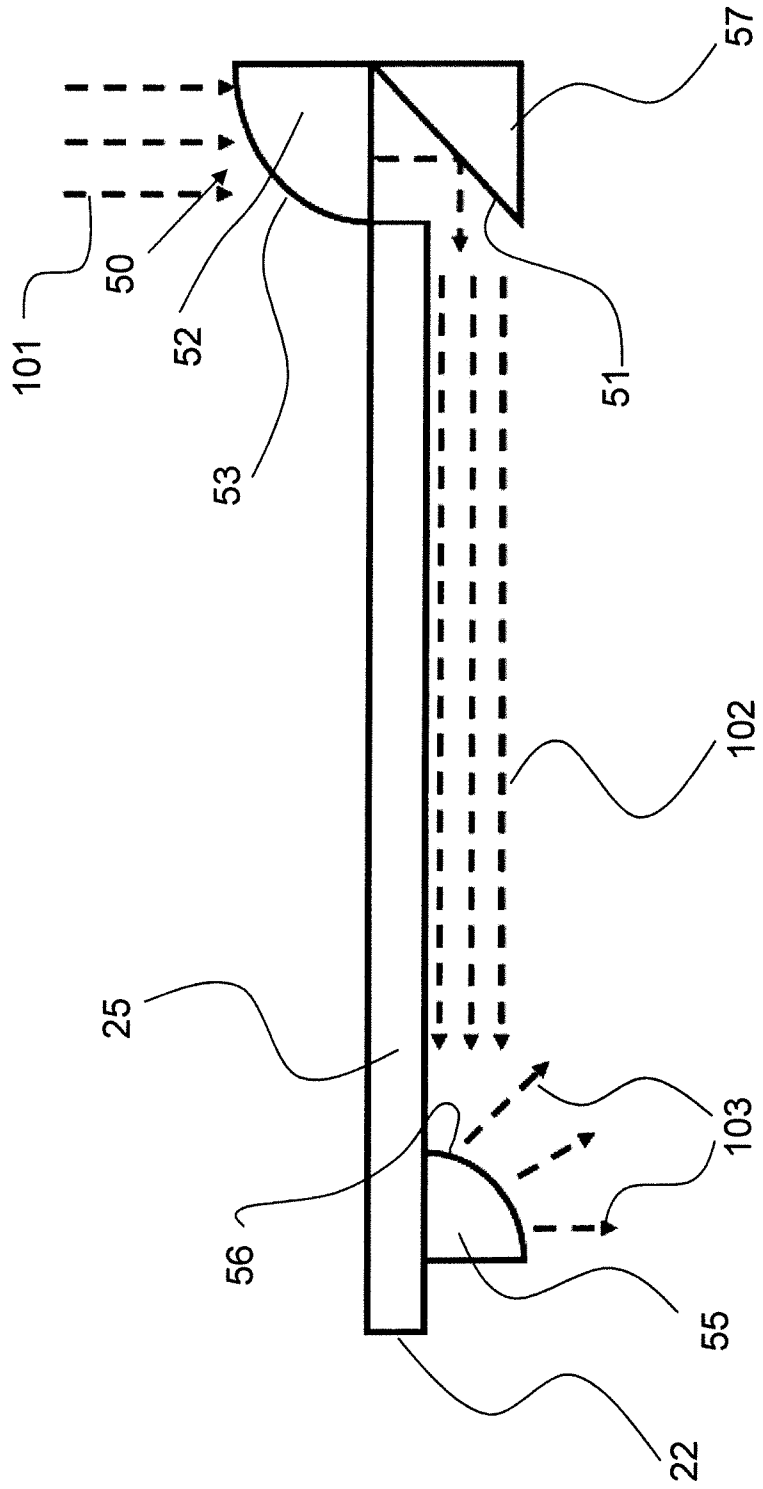


Fig. 4A

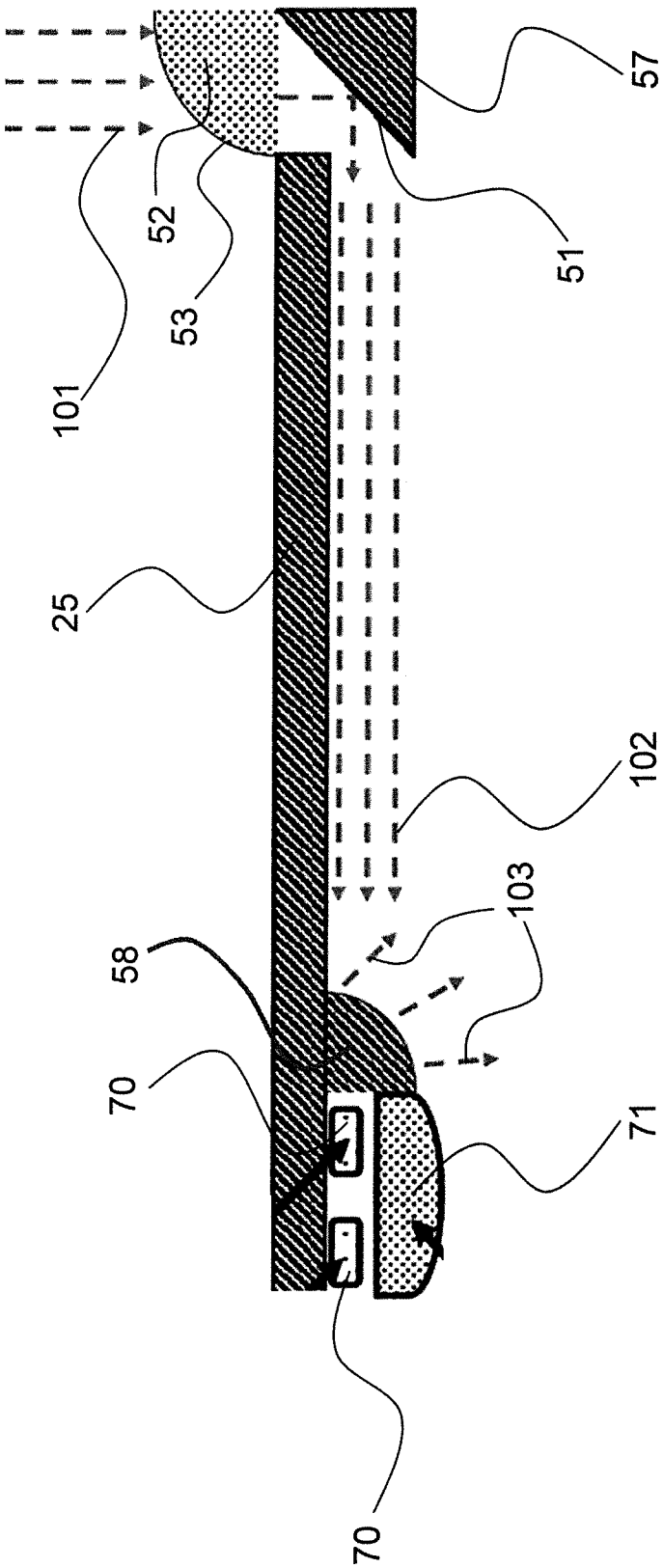


Fig. 4B

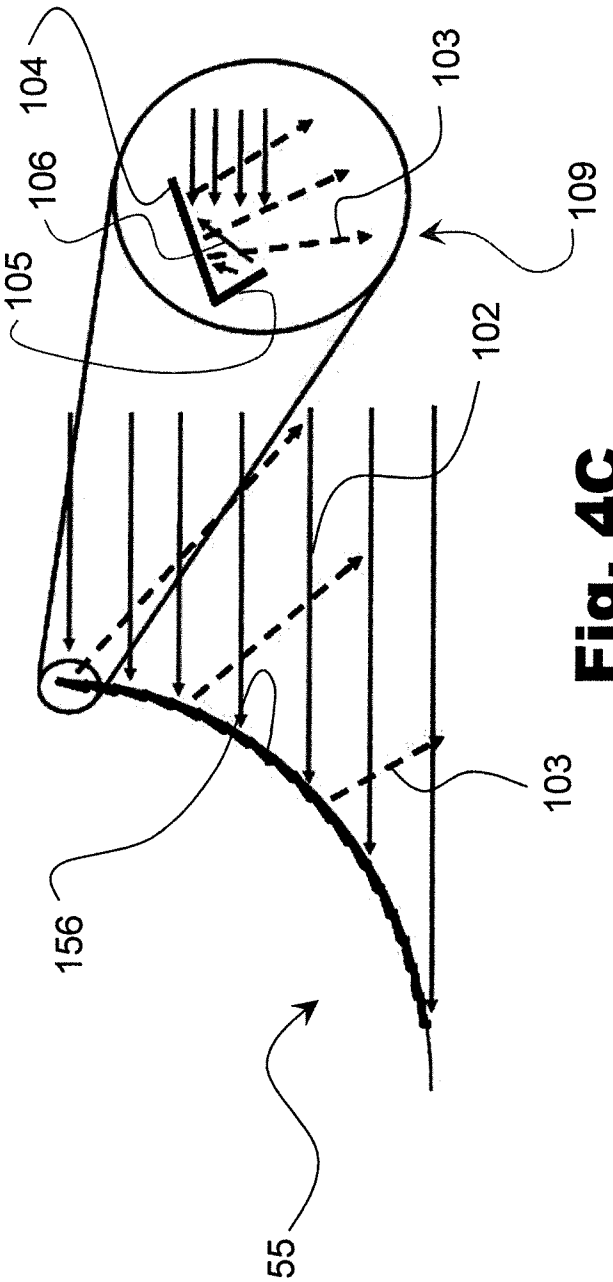


Fig. 4C

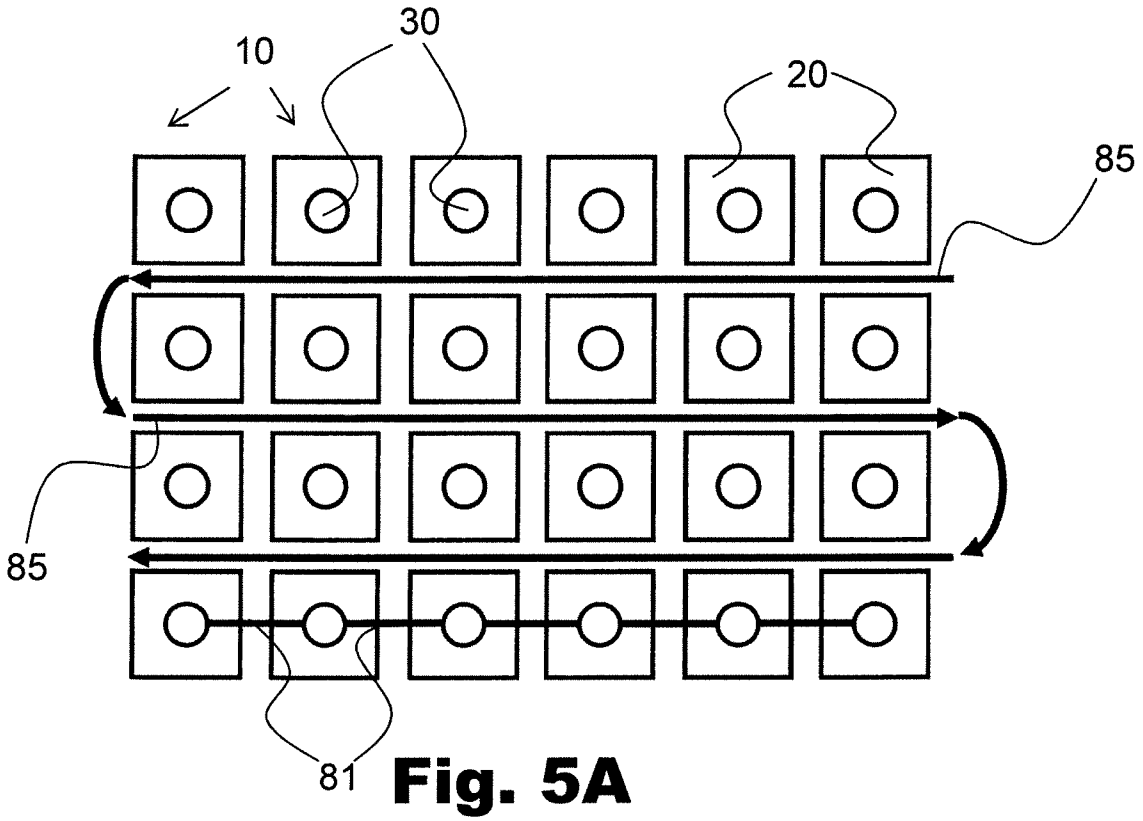


Fig. 5A

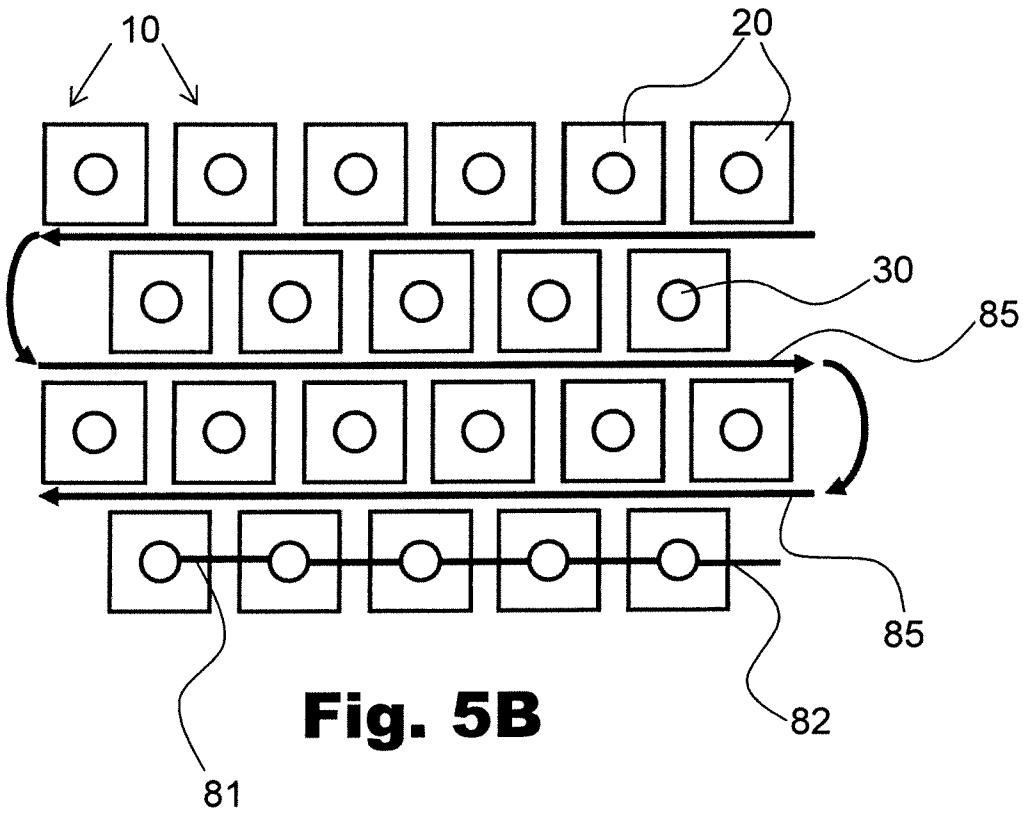
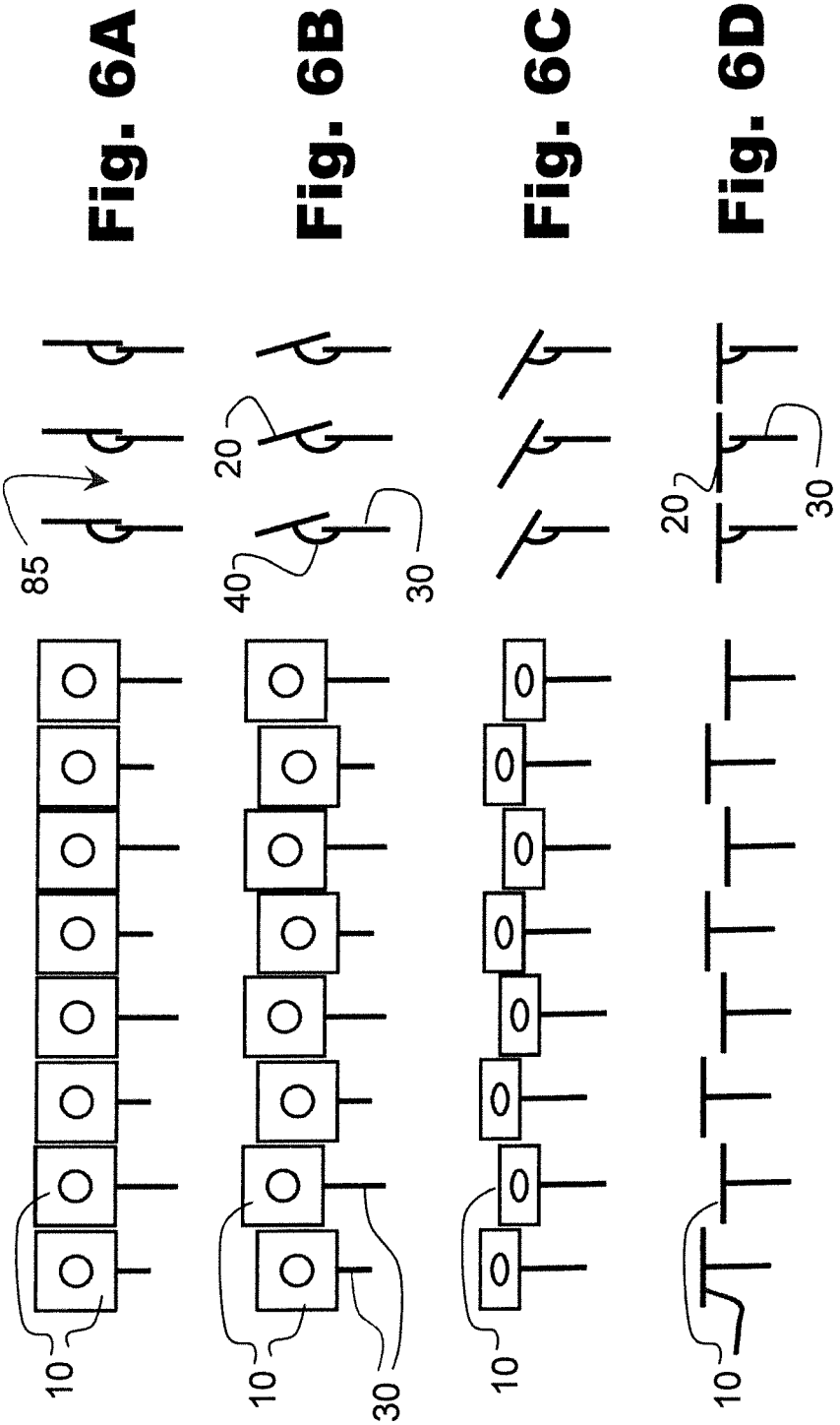


Fig. 5B


Fig. 6A
Fig. 6B
Fig. 6C
Fig. 6D
85
10
20
30
40

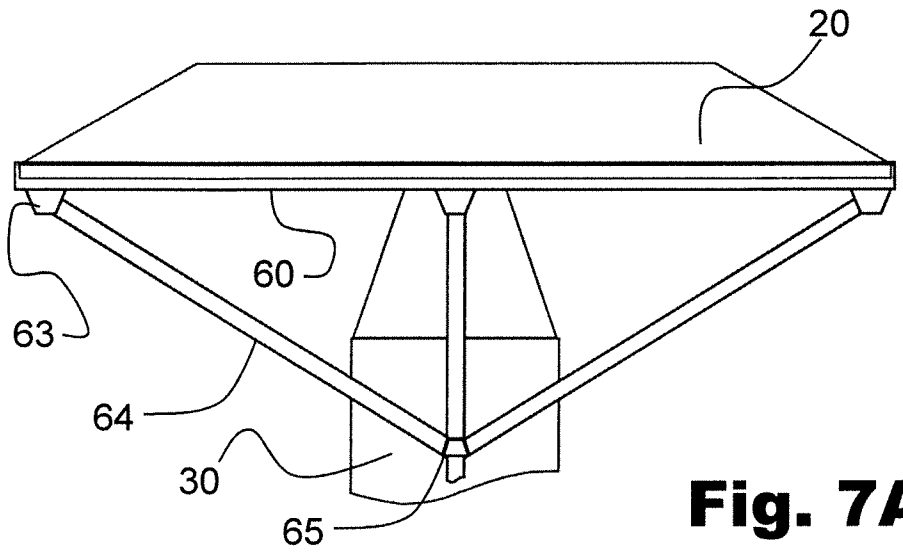


Fig. 7A

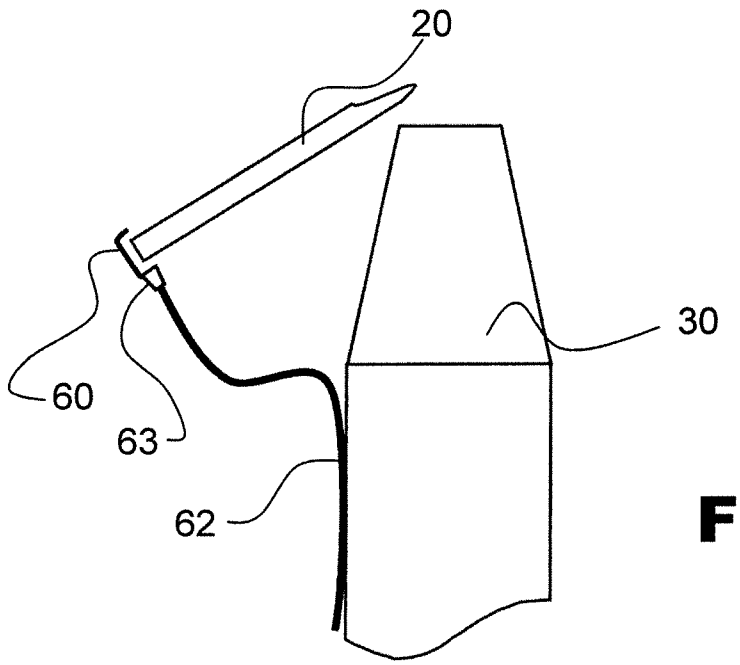


Fig. 7B

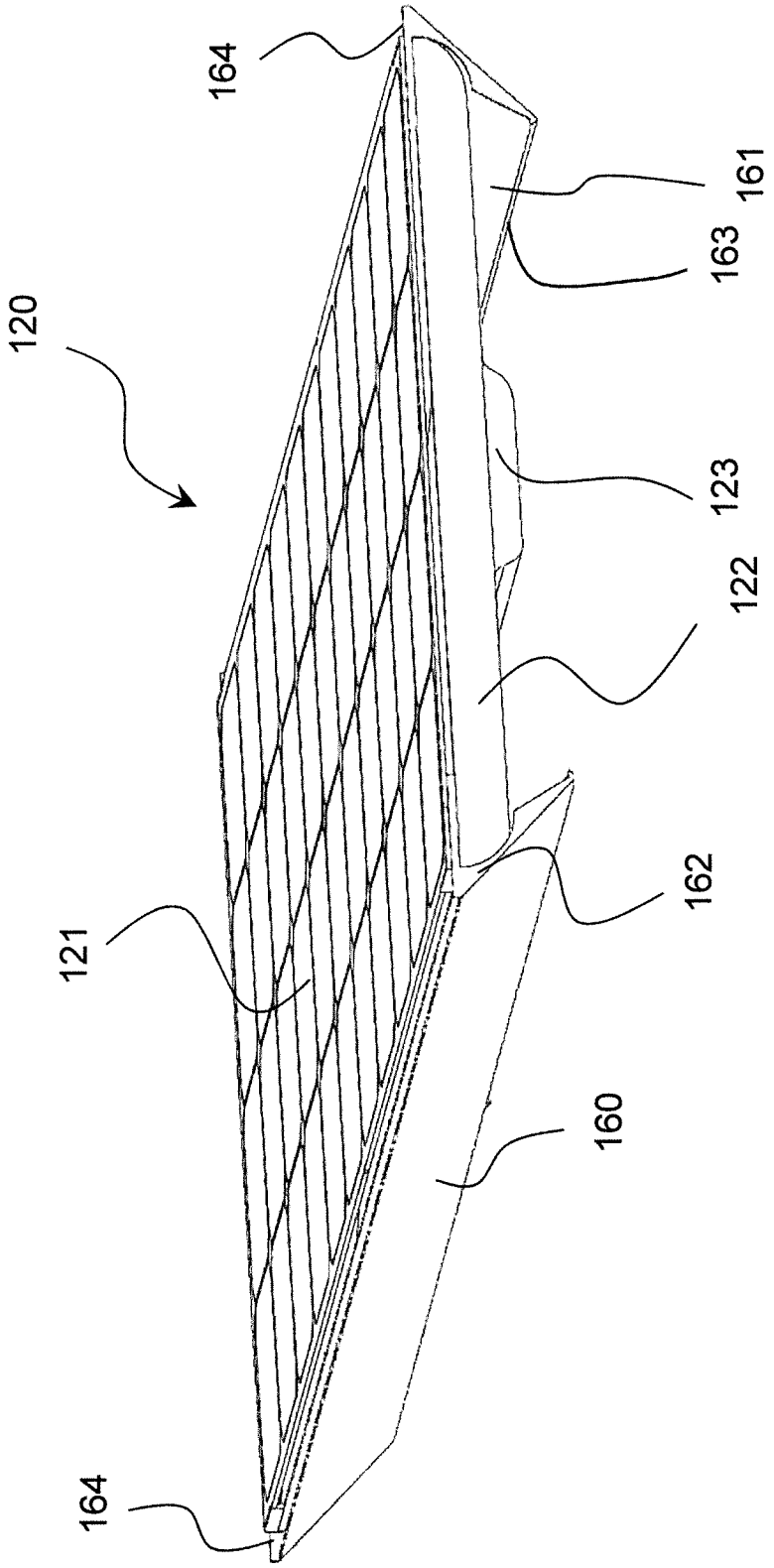


Fig. 8

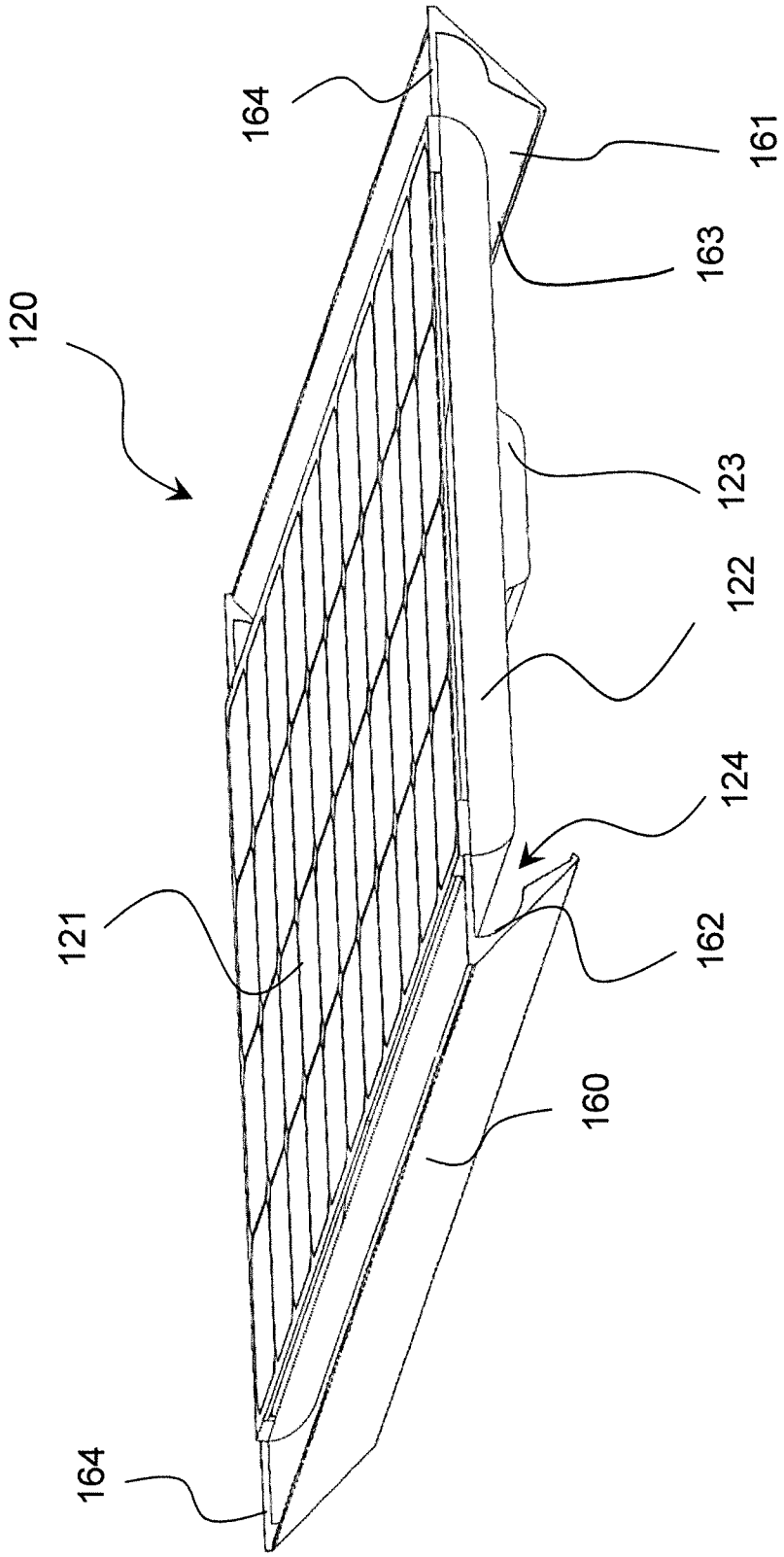


Fig. 9

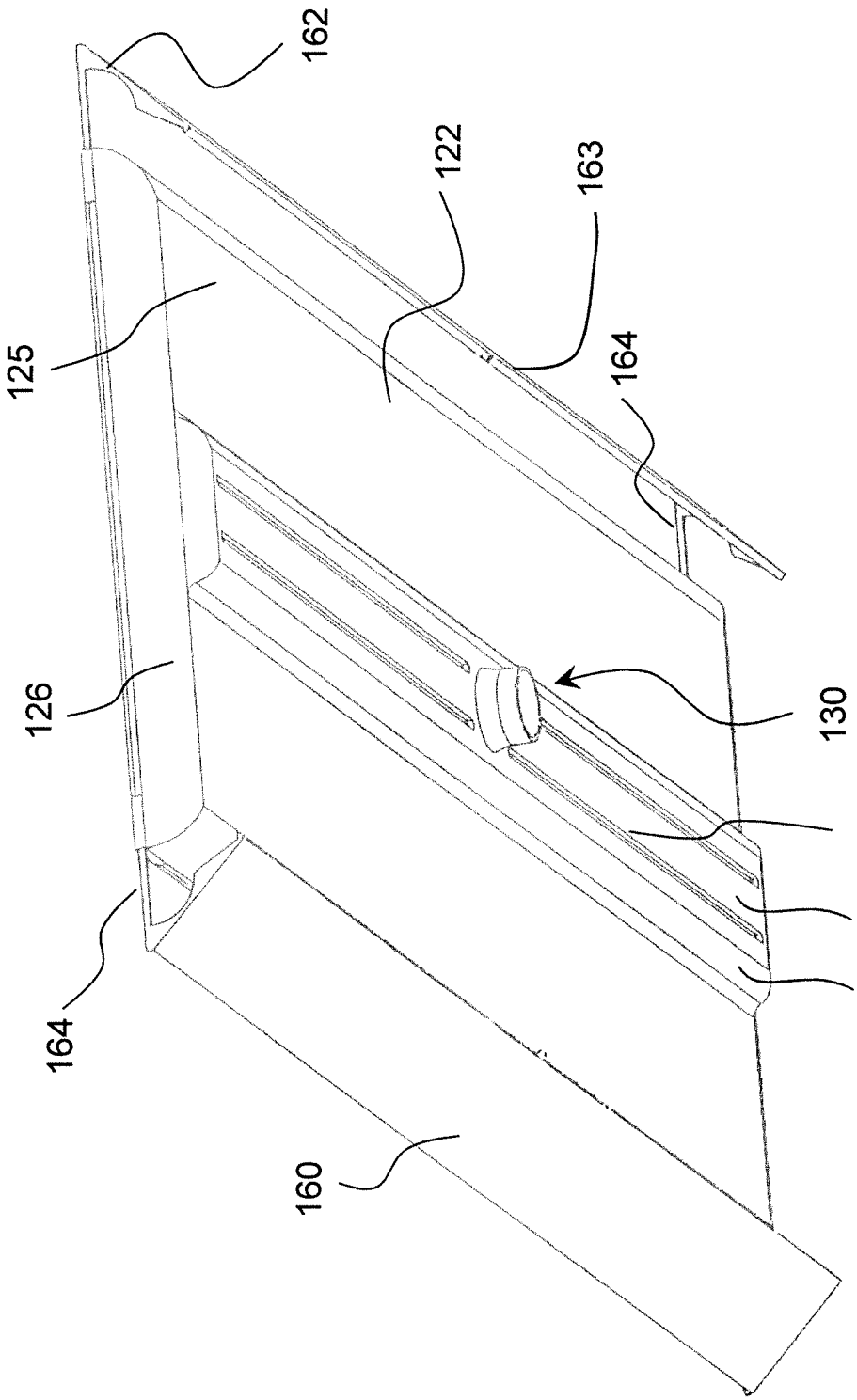


Fig. 10

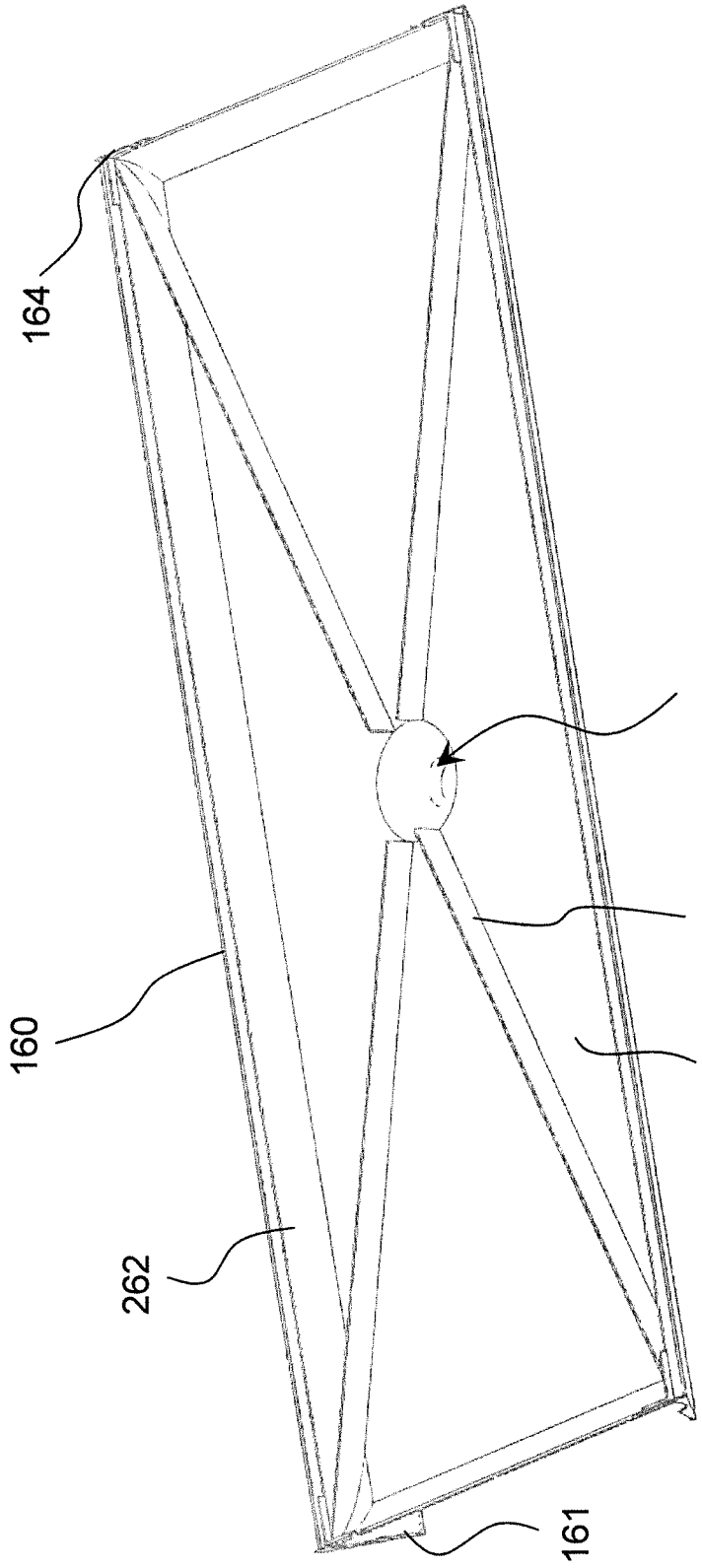


Fig. 11

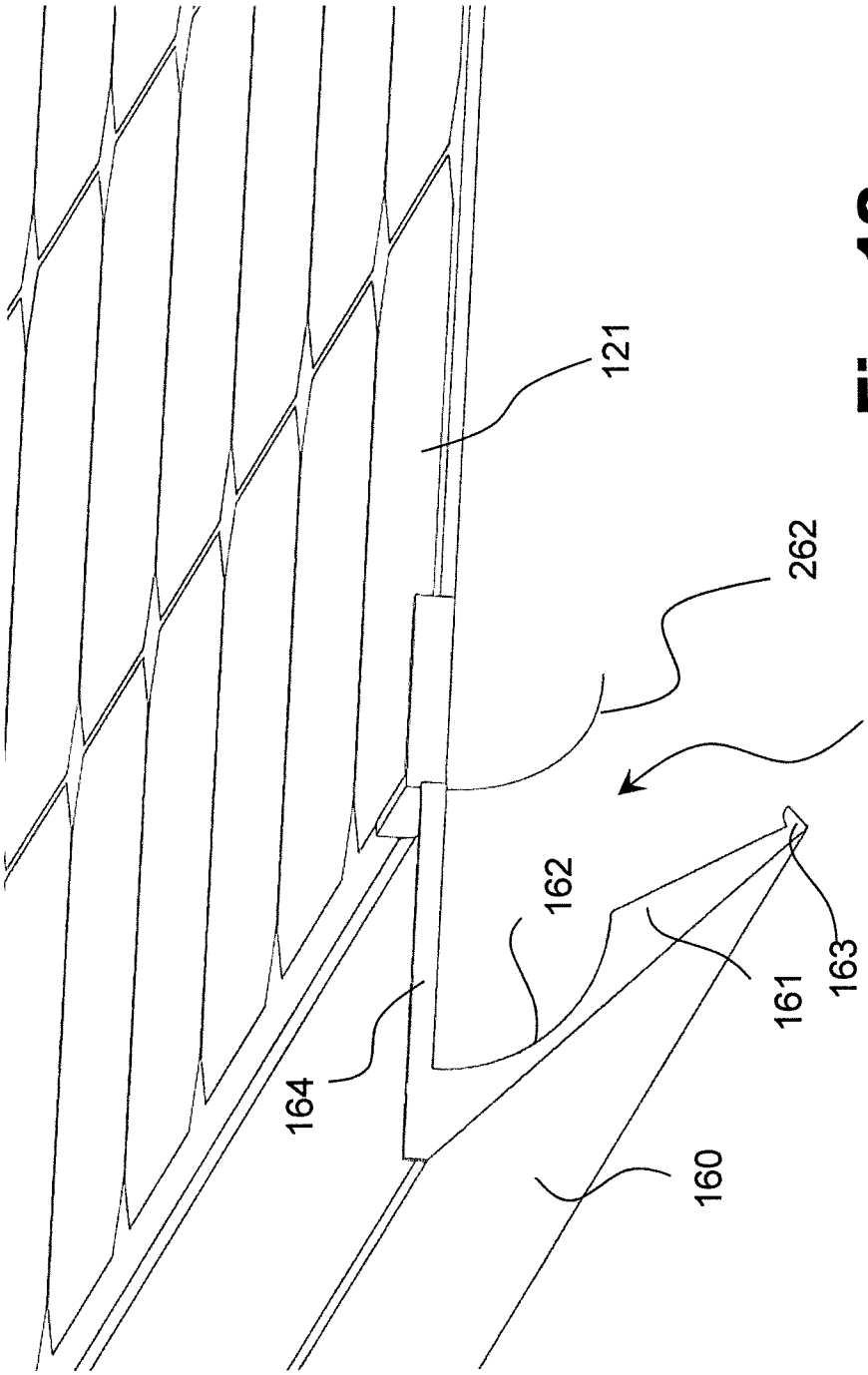


Fig. 12

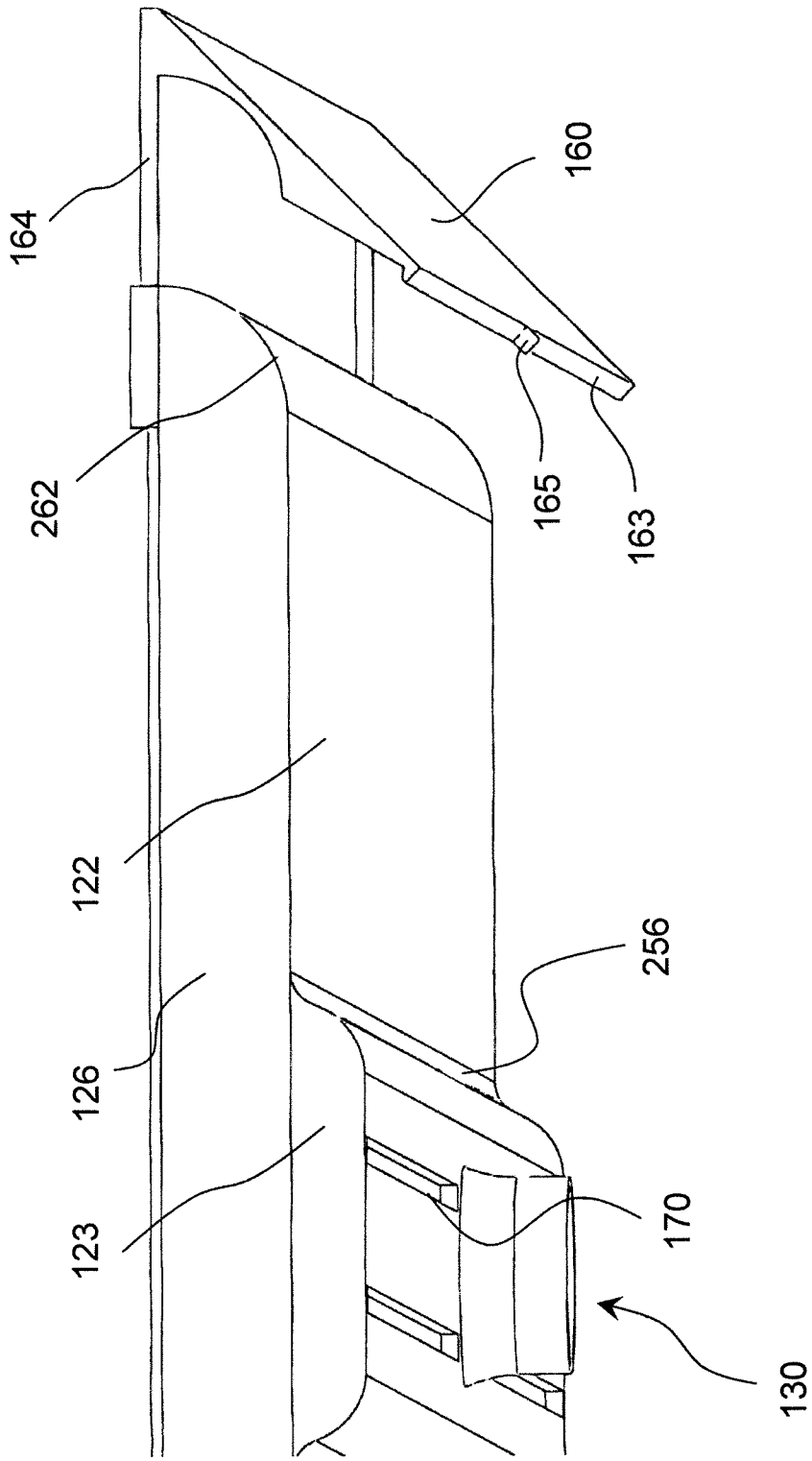


Fig. 13

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/053366

A. CLASSIFICATION OF SUBJECT MATTER
INV. F24S23/70 F24S30/40
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F24S A01G H02S

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)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2005/034611 A1 (REVEO INC [US]; SADEG FARIS M [US]) 21 April 2005 (2005-04-21)	1-12
A	page 10, line 1 - page 14, line 4; figures	13-15

Y	DE 10 2013 002825 A1 (GRIMM FRIEDRICH [DE]) 21 August 2014 (2014-08-21)	1,5,6, 8-11
A	abstract; figures paragraph [0005]	13-15

Y	KR 2010 0130115 A (INTMOA CO LTD [KR]) 10 December 2010 (2010-12-10)	1-12
A	abstract; figure 3 paragraphs [0043] - [0076]	13-15

A	US 2014/130843 A1 (KOSTUK RAYMOND K [US] ET AL) 15 May 2014 (2014-05-15) paragraphs [0025] - [0027], [0048]; figures	1-15

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 April 2018	04/05/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Oliveira, Casimiro

1

Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2015 204755 A (RIKEN TECHNOS CORP) 19 November 2015 (2015-11-19) abstract; figures paragraphs [0001], [0002], [0041] - [0054]	1-15
A	WO 2005/034610 A1 (REVEO INC [US]; FARIS SADEG M [US]) 21 April 2005 (2005-04-21) page 3, line 21 - page 9, last line; figures	1,2,4-7
A	US 2012/047824 A1 (CHANG YEE SHYI [TW] ET AL) 1 March 2012 (2012-03-01) paragraphs [0026] - [0034]; figures	1,2,4
A	EP 2 476 305 A2 (BODE PROJECT EN INGENIEURSBUREAU B V [NL]) 18 July 2012 (2012-07-18) paragraphs [0086] - [0088]; figures	1
A	US 2016/262323 A1 (IWAI MASAYUKI [JP]) 15 September 2016 (2016-09-15) paragraphs [0018], [0019], [0026]; figures	1
A	CN 104 663 266 A (INST ADVANCED TECHNOLOGY UNIV SCIENCE & TECHNOLOGY CHINA) 3 June 2015 (2015-06-03) abstract; claims; figures	1

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2018/053366

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2005034611 A1	21-04-2005	TW 200526112 A	16-08-2005
		US 2005105970 A1	19-05-2005
		WO 2005034611 A1	21-04-2005
DE 102013002825 A1	21-08-2014	NONE	
KR 20100130115 A	10-12-2010	NONE	
US 2014130843 A1	15-05-2014	NONE	
JP 2015204755 A	19-11-2015	NONE	
WO 2005034610 A1	21-04-2005	CN 1889824 A	03-01-2007
		EP 1684571 A1	02-08-2006
		KR 20060132580 A	21-12-2006
		US 2005076563 A1	14-04-2005
		WO 2005034610 A1	21-04-2005
US 2012047824 A1	01-03-2012	TW 201209255 A	01-03-2012
		US 2012047824 A1	01-03-2012
EP 2476305 A2	18-07-2012	EP 2476305 A2	18-07-2012
		NL 2006020 C	19-07-2012
		NL 2007897 C	19-07-2012
		NL 2007898 C	19-07-2012
		NL 2007899 C	19-07-2012
		NL 2007900 C	19-07-2012
		NL 2007901 C	19-07-2012
US 2016262323 A1	15-09-2016	CN 106488701 A	08-03-2017
		JP 5791215 B1	07-10-2015
		JP 2016059280 A	25-04-2016
		TW 201611720 A	01-04-2016
		US 2016262323 A1	15-09-2016
		WO 2016042796 A1	24-03-2016
CN 104663266 A	03-06-2015	NONE	