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(54) **Title:** SOLAR PHOTOVOLTAIC TRACKING SYSTEM AND USE THEREOF

(57) **Abstract:** The invention relates to a solar photovoltaic tracking system, comprising: - at least one photovoltaic module; - a guide track for guiding a movement of the at least one photovoltaic module, wherein said guide track has a substantially convex shape, which guide track is arranged such that in use of the solar photovoltaic tracking system the guide track is in a position facing the sun, preferably substantially perpendicular, with at least a part thereof throughout the day; - wherein said at least one photovoltaic module comprises at least one moving means for moving the photovoltaic module along the guide track, and - at least one drive means for driving the moving means. The invention further relates to the use of such a solar photovoltaic tracking system.

SOLAR PHOTOVOLTAIC TRACKING SYSTEM AND USE THEREOF

The invention relates to a solar photovoltaic tracking system.

A solar photovoltaic tracking system is known per se. An advantage of a solar photovoltaic tracking system may be that such a system allows the photovoltaic module thereof to follow a path of the sun throughout the day keeping the panel facing towards the sun, thereby increasing the energy output of the photovoltaic module and making the energy output of the photovoltaic module more even. Because of the higher output less photovoltaic modules may be required for a certain energy output thereby saving investment and space while giving the same electrical output.

A downside of said known solar photovoltaic tracking system may be that it may be mechanically complex and/or may consume a relatively large amount energy and/or may take up a relatively large space per panel and/or may be relatively expensive.

It is an object of the invention to provide a solar photovoltaic tracking system that is relatively simple and/or cheap.

This object is met by a solar photovoltaic tracking system that comprises:

- at least one photovoltaic module;

- a guide track for guiding a movement of the at least one photovoltaic module, wherein said guide track has a substantially convex shape, which guide track is arranged such that in use of the solar photovoltaic tracking system the guide track is in a position facing the sun, preferably substantially perpendicular, with at least a part thereof throughout the day;

- wherein said at least one photovoltaic module comprises at least one moving means for moving the photovoltaic module along the guide track, and

- at least one drive means for driving the moving means.

By providing the substantially convex shaped guide track and moving the photovoltaic module along the guide track during the day, the photovoltaic module may be held, i.e. tilted, in a position in which it is facing the sun in a preferably substantially perpendicular manner throughout the day. More in particular, a main plane of the photovoltaic module may be held, i.e. tilted, in a position in which it is facing the sun in a preferably substantially perpendicular manner throughout the day. The angle of incidence between the sun rays and the main plane of the photovoltaic module may therefore be preferably substantially 90° throughout the day.

It is noted that in particular a guiding surface of the guide track may be in said position, i.e. orientation, facing the sun, preferably substantially perpendicular, with at least a part thereof throughout the day.

Said guiding surface may in particular be or comprise an upper surface of the guide track, at least in use of the system.

The guide track may in particular be arranged in a substantially inclined and/or upward position, i.e. orientation, with respect to a horizontal plane, wherein the free ends of the substantially convex shaped guide track extend in a substantially inclined and/or upward direction with respect to the horizontal plane. In other words, the free ends of the substantially convex shaped guide track are positioned at a higher position than the below described middle point of the guide track.

The guide track may in particular be arranged such that a middle point of the guide track as seen in a longitudinal direction of the guide track between the free ends of the guide track is substantially perpendicular with respect to the sun when the sun is at its highest elevation point of the day, i.e. at its culmination point. Said middle point is in particular defined as the middle point of the guiding surface of the guide track as seen in the longitudinal direction of the guide track between the free ends of the guide track.

Said moving means may be arranged to move along the guide track in a first direction from a first end of the guiding surface of the guide track to the other end of the guiding surface of the guide track during the day. The position at or near the first end of the guide track from where the moving means start moving may be called a starting position. The position at or near the other, second end of the guide track where the moving means stop their movement may be called an end position. During the night the moving means may be arranged to move back along the guide track in a second, reverse direction opposite to the first direction from the end position to the starting position, such that the moving means may be in their starting position before or at least when a new day starts. Alternatively the moving means may continue to move in the first direction along a lower side of the guide track, as will be explained below with respect to an embodiment of the system according to the invention. In this embodiment the end position may be defined by the position of the moving means at sunset and the moving means will then continue to move along the lower side of the guide track to the starting position.

Said first end of the guiding surface of the guide track may be facing preferably substantially perpendicular towards the east where the sun rises.

Said second end of the guiding surface of the guide track may be facing preferably substantially perpendicular towards the west where the sun sets.

The first end of the guiding surface of the guide track may thus be facing the sun in a preferably perpendicular manner at sunrise, the middle point of the guiding surface of the guide track may thus be facing the sun in a preferably perpendicular manner when the sun is at its highest elevation point during the day, and the second end of the guiding surface of the guide track may thus be facing the sun in a preferably perpendicular manner at sunset.

The photovoltaic module may be arranged in such a manner, that the main plane thereof is substantially parallel to a local tangent line of the guiding surface of the guide track in the area of the moving means, such that the position of the moving means along the guide track defines the angle of the main plane of the photovoltaic module with respect to the sun, which is substantially equal to the angle of the guide track in said area of the moving means. As such, when the moving means are at their starting position the main plane of the photovoltaic module may be facing towards the sun at sunrise in a preferably substantially perpendicular manner, when the moving means are at the middle point the main plane of the photovoltaic module may be facing towards the sun at its highest elevation point in a preferably substantially perpendicular manner, and when the moving means are at their end position the main plane of the photovoltaic module may be facing towards the sun at sunset in a preferably substantially perpendicular manner.

It will be clear for the skilled person that at any intermediate point between said starting and end positions the main plane of the photovoltaic module may be facing towards the sun in a preferably substantially perpendicular as a result of the substantially convex shape and the position, i.e. orientation, of the guiding surface of the guiding track.

Said moving means may in particular be attached or connected to one end of the photovoltaic module, such that said one end is moved by said moving means along the guide track.

Said one end may in particular be an upper end of the photovoltaic module and/or the end that is arranged closest to the guide track.

The one end may also be defined here as a first end of the photovoltaic module. The one end may also be referred to as the one or first end zone of the photovoltaic module.

It is noted that in particular said moving means may be attached or connected to said first end (zone) only, and in particular not to said other, opposite end (zone) as described below.

Said moving means may be attached or connected to said first end (zone) itself, or to an area of the panel that is close to the first end (zone).

The other, opposite end of the photovoltaic module may be supported at a substantially fixed position in such a manner that the support allows the movement of the photovoltaic module along the guide track.

The other, opposite end may also be defined here as a second end of the photovoltaic module. The other end may also be referred to as the other or second end zone of the photovoltaic module.

The other, opposite end (zone) may in particular be a lower end of the photovoltaic module and/or the end that is arranged at the largest distance from the guide track.

It is noted that in particular only said second end (zone) may be supported by said support, and in particular not said first end (zone).

Said support may be attached or connected to said second end (zone) itself, or to an area of the panel that is close to the second end (zone).

The second end (zone) of the photovoltaic module may be directed roughly towards the South on the Northern hemisphere and roughly towards the North on the Southern hemisphere.

It will be clear for the skilled person that the first and second ends or end zones of the photovoltaic module may be supported by different elements, i.e. the first end by the guide track via the moving means and the second end by the support.

The photovoltaic module may in particular have a substantially square or rectangular shape. The lateral ends of the photovoltaic module that extend between said one end and said opposite end may be defined here as the sides of the photovoltaic module.

It is noted that in the starting position of the moving means the photovoltaic module is tilted in such a manner that a first side of the two sides extends at a higher position than the other side, thereby tilting the main plane of the photovoltaic module in a first orientation substantially towards the east and/or thereby tilting the main plane of the photovoltaic module in a substantially vertical or near vertical plane, such that the main plane is facing the sun in a substantially perpendicular manner when the sun starts to rise and is still at a low elevation point. In the end position of the moving means the photovoltaic module is tilted in such a manner that the other side of the two sides extends at a higher position than the first side, thereby tilting the main plane of the photovoltaic module in a second orientation substantially towards the west and/or thereby tilting the main plane of the photovoltaic module in a substantially vertical or near vertical plane in an opposing manner with respect to the staring position, such that the main plane is facing the sun in a substantially perpendicular manner when the sun starts to set and is again at a low elevation point. When the moving means are in the middle point the two sides extend at substantially the same height and the one end extends at a higher position than the other, opposite end, such that the main plane of the photovoltaic modules extends substantially inclined with respect to the horizontal plane only in the direction between the two ends, and is not tilted with respect to the horizontal plane in the direction between the two sides, such that the main plane is facing the sun in a substantially perpendicular manner when the sun is at its highest elevation point.

The solar photovoltaic tracking system according to the invention may thus provide a relatively complex movement and/or orientation of the photovoltaic module, while only requiring a substantially linear movement of the moving means along the guide track.

Said guide track may have any suitable substantially convex shape.

Preferably, said guide track may have a substantially elliptical shape. An elliptical shape may correspond to the azimuthal path of the sun, which is also substantially elliptical.

Alternatively, said guide track may have a substantially part-spherical shape.

Said guide track may be arranged and/or held in said position in any suitable manner. For example, said solar photovoltaic tracking system may comprise a frame for holding said guide track in said position.

In a preferred embodiment, said solar photovoltaic tracking system may comprise a frame for holding said guide track in said position, wherein said guide track is held by said frame in such a manner that an orientation and/or height thereof is, preferably manually, adjustable.

The elevation, i.e. culmination point, of the sun may vary as a result of seasonal patterns. By being able to adjust the orientation and/or height of the guide track the orientation and/or height of the guide track may be adjusted in correspondence with the seasonal elevation of the sun.

A manually adjustable guide track provides the advantage of providing a relatively simple system. Because the orientation and/or height of the guide track may be adjusted in response to seasonal patterns, it does only need to be adjusted a few times during the year. Because this is not that often, it is not a problem to adjust it manually.

Said frame may define a finite number of orientations and/or heights for holding the guide track, such as for example two, three, four, five, six, or any other suitable number of orientations and/or heights.

Said frame may for example comprise a plurality of mounting holes and/or slots for mounting the guide track to the frame, wherein screws, bolts, or any other type of fixating means may be used for fixing the guide track to the frame using the mounting holes and/or slots.

Alternatively or additionally said frame may comprise at least one telescopic frame member, for example two or four of such telescopic frame members, wherein adjusting the height and/or orientation of the guide track may be achieved by retracting or extending some or all telescopic frame members. Fixation means, such as a pin and hole fixation, may be used for fixating the telescopic frame member in a certain position.

Alternatively said frame may define an infinite number of orientations and/or heights for holding the guide track.

In another preferred embodiment, said system comprises multiple guide tracks and wherein said system further comprises a frame for holding said multiple guide tracks in their positions facing the path of the sun, wherein the different guide tracks of the multiple guide tracks are held by said frame at different heights and/or orientations.

By providing multiple guide tracks at different height and/or positions, the photovoltaic module can be arranged to move along any one of these guide tracks dependent on the season. For example, in the summer the photovoltaic module can be arranged to move along the uppermost guide track ,while in the winter the photovoltaic module can be arranged to move along the lowermost guide track. If any guide tracks are provided at intermediate heights, these guide tracks can be used for guiding the photovoltaic module during other seasons.

For example two, three, four, five, or even more guide tracks can be provided.

The photovoltaic module can be arranged to move along any one of these guide tracks manually, by manually taking up the one end of the photovoltaic module and placing the moving means on the suitable guide track.

Preferably the guide tracks are also displaced in a horizontal direction with respect to each other, wherein the uppermost guide track is arranged closest to the support and the lowermost guide track is arranged at the largest distance from the support as seen in a horizontal direction. This provides the advantage that the absolute distance between the support and the guide track remains the same for each guide track, such that the location of the support does not need to be changed while changing the guide track along which the photovoltaic module is moved.

Alternatively the location of the support may be different for each guide track and/or the length of the frame may be adjustable.

It will be clear for the skilled person that any of the guide tracks is arranged for guiding the movement of the photovoltaic module during a specific season and/or that the movement of the photovoltaic module is in particular guided by one and in particular only one guide track at a time. The movement of the photovoltaic module can thus be guided by different guide tracks, dependent on the season and in particular on the maximum inclination of the sun (zenith) in that specific season. It is noted that as will be clear for the skilled person, "a guide track" as claimed in the other claims and as referred to throughout this text can be understood as "at least one guide track".

In an embodiment of the solar photovoltaic tracking system the guide track comprises a substantially smooth guiding surface and said moving means comprise at least one wheel.

Said at least one wheel may run along said substantially smooth guiding surface, thereby moving the photovoltaic module along the guide track.

During moving the photovoltaic module along the guide track it may at the same time be tilted in said above described directions.

An advantage of providing at least one wheel as the moving means that is allowed to travel along the substantially smooth guiding surface is that the position of the moving means along the guiding surface may be chosen substantially continuously and is not limited to discrete, fixed positions.

Practically said moving means may comprise two wheels, which are arranged next to each other in the longitudinal direction of the guide track. Said two wheels may be spaced apart from each other in the longitudinal direction of the guide track by a chosen spacing distance. Providing two (spaced apart) guiding wheels may provide the or an improved tilting of the photovoltaic module.

Said at least one wheel or said two wheels may be connected to said one end of the photovoltaic module, thereby moving the one end of the photovoltaic module along the guide track.

Optionally at least one of said at least one wheel and said guide track may be made of or comprise a layer of a high friction material. This may improve holding the at least one guide wheel at the correct position along the guide track and/or may prevent slipping of the at least one guide wheel.

In an alternative embodiment of the solar photovoltaic tracking system the guide track comprises a toothed rack and said moving means comprises at least one gear.

Said at least one gear may travel along the toothed rack, thereby moving the photovoltaic module along the guide track.

The toothed rack may define the guiding surface of the guiding track.

Said at least one gear may be connected to said one end of the photovoltaic module, thereby moving the one end of the photovoltaic module along the guide track.

As described above, said other, opposite end of the photovoltaic module may be supported at a substantially fixed position in such a manner that the support allows the movement of the photovoltaic module along the guide track. Advantageously said other, opposite end of the photovoltaic module is supported by a hinge for hingedly supporting the other, opposite end of the photovoltaic module. Such a hinge allows the movement of the photovoltaic module along the guide track.

Said hinge may in particular comprise a ball joint. By supporting the other, opposite end of the photovoltaic module by means of a ball joint, the photovoltaic module is allowed to be moved along the guide track and to be tilted at the same time.

Said hinge or ball joint may be directly placed onto a base, such as the ground, a floor, a roof, or the like.

Said hinge or ball joint may be directed roughly towards the South on the Northern hemisphere and pointing roughly North on the Southern hemisphere.

Alternatively or additionally said system may comprise a said frame or a further frame for holding said photovoltaic module, wherein said frame or said photovoltaic module comprises said hinge for hingedly holding said photovoltaic module with respect to the frame. As described above, said hinge may in particular comprise a ball joint.

An advantage of providing said frame or said further frame for holding said photovoltaic module is that it may prevent the photovoltaic module to be lifted upwards, for example by the wind, or may prevent theft of the photovoltaic module.

In yet another embodiment of the solar photovoltaic tracking system said drive means are arranged to drive said moving means in accordance with a traveling speed of the sun.

As described above, said moving means may be moved in a substantially linear direction along the guiding track. The traveling speed of the moving means may be adapted to the traveling speed of the sun, such that the photovoltaic module may be held in its position, i.e. orientation, facing substantially perpendicular towards the sun throughout the day.

More in particular, the traveling speed of the moving means may be calculated by dividing the length of the guiding surface of the guide track, i.e. the length between the starting position and the end position, by the time between sunrise and sunset.

Driving the moving the means may thus be relatively simple, because it may be only require a linear movement in only a first and second, opposite direction at a substantially constant (calculated) speed. This provides a relatively simple system, while still allowing a relatively complex movement and/or tilting of the photovoltaic module.

The traveling speed of the moving means may vary throughout the year as a result of seasonal patterns.

For example, in the winter the traveling speed of the moving means may be higher than in the summer, because the days are shorter in the winter than during the summer.

It is noted that alternatively the traveling speed of the moving means may be kept the same throughout the year, wherein optionally the photovoltaic module is moved along only a part of the guide track during the winter and along the whole guide track in the summer and/or the photovoltaic module may start to move along the guide track prior to sunrise and after sunset in winter, to compensate for the shorter days in the winter. In yet another embodiment of the solar photovoltaic tracking system according to the invention said drive means are arranged to drive said moving means in a first direction along the guide track between sunrise and sunset and in a second, opposite direction between sunset and sunrise. This is in accordance with the description of the system above, wherein the moving means may be arranged to move along the guide track in a first direction from a first end of the guiding surface of the guide track to the other end of the guiding surface of the guide track during the day, and in a second, opposite direction during the night.

The traveling speed of the moving means may be the same during the day as during the night. Alternatively, the traveling speed of the moving means may be different during the day and during the night, wherein the traveling speed during the day may be lower than during the night in the winter, because of the shorter winter days.

In yet another embodiment of the solar photovoltaic tracking system according to the invention the guide track has one continuous guiding surface along both an upper side and a lower side of the guide track, wherein said drive means are arranged to drive said moving means in a first direction along the guide track.

In such an embodiment the moving means may continuously move in said first direction and return to the starting position via the lower side of the guide track.

Optionally a support track may be provided at a distance from the lower side of the guide track, for supporting the moving means while traveling along the lower side of the guide track. The distance may be substantially equal to the diameter of the traveling means.

Said drive means may be any suitable drive means, such as an (electric) motor or a hydraulic system.

Said drive means may be at least operatively coupled to the moving means.

In yet another embodiment of the solar photovoltaic tracking system according to the invention said system further comprises a control for controlling the drive means.

Said control may control the drive means to drive the moving means in either the first direction or the second direction and/or at a desired speed.

Said control may be any suitable control, such as (micro)processor.

Said control may be at least operatively coupled to the drive means.

Said solar photovoltaic tracking system may further comprise any other relevant (standard) components, such as for example a battery for storing the electrical energy generated by the photovoltaic module.

Said battery may optionally also be the power supply for the drive means, or a separate power supply may be provided for this purpose, or alternatively the drive means may be connected to the electricity grid.

Said power supply may be connected to the drive means in any suitable way, for example via wires or wirelessly.

The invention also relates to the use of a solar photovoltaic tracking system as described above in any one or more of the described embodiments and/or having any one or more of the above described features, said use comprising the steps of:

a) arranging the guide track in such a manner that the guide track is in a position facing the sun, preferably substantially perpendicular, with at least a part thereof throughout the day, and

b) moving the photovoltaic module along the guide track.

Steps a) and/or b) may be performed in accordance with the description of the photovoltaic tracking system as described above, and in particular in accordance with any one or more of the above described features, in any suitable combination.

Said use of the solar photovoltaic tracking system may involve any one or more steps that are related to the features of the solar photovoltaic tracking system as described above, in any suitable combination.

For example, step a) may be performed such that the guide track is arranged in a substantially inclined and/or upward position, i.e. orientation, with respect to a horizontal plane, wherein the free ends of the substantially convex shaped guide track extend in a substantially inclined and/or upward direction with respect to the horizontal plane.

For example, step a) may be performed such that the guide track is arranged such that a middle point of the guide track as seen in a longitudinal direction of the guide track between the free ends of the guide track is substantially perpendicular with respect to the sun when the sun is at its highest elevation point of the day, i.e. at its culmination point. Said middle point is in particular defined as the middle point of the guiding surface of the guide track as seen in the longitudinal direction of the guide track between the free ends of the guide track.

For example, step a) may be performed such that said first end of the guiding surface of the guide track may be facing preferably substantially perpendicular towards the east where the sun rises.

For example, step a) may be performed such that said second end of the guiding surface of the guide track may be facing preferably substantially perpendicular towards the west where the sun sets.

For example, it may comprise the step of (manually) adjusting an orientation and/or height of the guide track. More in particular, this step may involve mounting the guide track on the frame in accordance with a desired orientation and/or height, for example using said mounting holes and/or slots, or adjusting the height and/or orientation by extending or retracting telescopic frame frame members of the frame.

For example, it may comprise the step of (manually) placing the moving means at any of multiple guide tracks.

For example, it may comprise the step of arranging the support for the second end of the photovoltaic module such that the support is directed roughly towards the South on the Northern hemisphere and pointing roughly North on the Southern hemisphere.

For example, it may comprise the steps of calculating a desired traveling speed of the moving means and driving the moving means in accordance with the calculated traveling speed. Said calculation may be performed by a person and/or by said control.

The invention will be further elucidated with reference to figures, wherein:

Figures 1 and 2 show a first embodiment of the solar photovoltaic tracking system according to the invention in two different perspective views;

Figure 3 shows a second embodiment of the solar photovoltaic tracking system according to the invention in a perspective view;

Figure 4 shows a third embodiment of the solar photovoltaic tracking system according to the invention in a perspective view;

Figure 5 shows a fourth embodiment of the solar photovoltaic tracking system according to the invention in a perspective view;

Figure 6 shows a fifth embodiment of the solar photovoltaic tracking system according to the invention in a rear view;

Figures 7A – 7C show the positions and/or orientations of the photovoltaic module at sunrise (7A), at the highest elevation point of the sun (7B) and at sunset (7C);

Figures 8A and 8B shows the height adjustment of the guide track for adapting to seasonal patterns;

Figure 9 shows a sixth embodiment of part of the solar photovoltaic tracking system according to the invention in a perspective view, and

Figure 10 shows a seventh embodiment of part of the solar photovoltaic tracking system according to the invention in a rear view.

In the figures same or similar features are referred to using same reference numerals, increased by one hundred (100) for the second and further embodiments.

Figures 1 and 2 show a solar photovoltaic tracking system 1. In this embodiment the system 1 comprises a photovoltaic module 2 having a plurality of solar cells 3. In this embodiment the system 1 further comprises a substantially elliptically convex shaped guide track 4. Said guide track 4 is arranged such that the free ends 5, 6 thereof extend in a substantially upward direction with respect to a horizontal plane. In this embodiment a frame is provided for holding said guide track 4, said frame comprising a base 7 that extends substantially parallel to the horizontal plane, and two frame members 8 that extend substantially upward in a substantially vertical direction from said base 7 and to which said guide track 4 is mounted using mounting holes 9. Said guide track 4 is held by said frame 7, 8 in such a manner that a guiding surface 10 thereof is in a position facing the sun, preferably substantially perpendicular, with at least a part thereof throughout the day. A part of the guiding surface 10 that is located near the first free end 5 may be facing the sun in a preferably substantially perpendicular manner at sunrise. A part of the guiding surface 10 that is located near the other, opposite, i.e. second, free end 6 may be facing the sun in a preferably substantially perpendicular manner at sunset. Subsequent intermediate parts of the guiding surface 10 that are located between the free ends 5, 6 may be facing the sun in a preferably substantially perpendicular manner subsequently throughout the day. A middle point 11 is defined in the middle of the guide track 4 in the longitudinal direction thereof between the free ends 5, 6, which middle point 11 is facing the sun in a preferably substantially perpendicular manner when the sun is at its highest elevation point. Said system further comprises in this embodiment two wheels 12 which are connected to a first end 13 of the photovoltaic module 2. Said wheels 12 may be driven by a drive means to move along the smooth guiding surface of the guide track 4, thereby moving the first end 13 of the photovoltaic module 2 along the guide track 4. Said wheels 2 may start to move at sunrise from a starting position at or near the first end 5, and then move in a first direction 14 during the day until the wheels 2 stop at an end position at or near the second end 6. When the sun is at its highest elevation point, the wheels 12 may be positioned symmetrically with respect to the middle point 11, wherein the middle point 11 is located substantially in the middle of the two wheels 12. During the night the drive may drive the wheels 12 to move in a second direction that is opposite to the first direction 14, such that the wheels 12 may be at the starting position when a new day starts. The opposite end of the photovoltaic module 2, defined here as the second end 15, is supported on the ground, floor, roof, or the like by means of a ball joint 16. Said ball joint 16 allows the photovoltaic module 2 to be moved along the guide track 4, while being tilted. Two sides 17 and 18 of the photovoltaic module 2 are defined between the two ends 13, 15. At a first part of the guide track, i.e. the part that extends between the free end 5 and the middle point 11, the first side 17 extends at a higher position than the second side 18, such the photovoltaic module 2 is tilted in a first orientation facing substantially towards the east where the sun starts to rise. At a second part of the guide track, i.e. the part that extends between the middle point 11 and the free end 6, the second side 18 extends at a higher position than the first side 17, such the photovoltaic module 2 is tilted in a second, opposite orientation facing substantially towards the west where the sun will set. At the starting and end points the photovoltaic module 2 may be tilted in substantially vertical or near vertical planes, but in opposing directions, such that the angle thereof is adapted to the low elevation of the sun at sunrise and sunset and facing towards the east and west, respectively. At the middle point 11 between the first part and the second part of the guide track the two sides 17, 18 extend at substantially the same height. As a result of the guide track 4 being mounted to the frame 7, 8 at a chosen height which is at a chosen distance above the ground, floor, roof or the like on which the ball joint 16 is supported, the first end 13 extends at a higher position than the second end 15. The photovoltaic module 2 is thus always inclined by a certain inclination angle with respect to the horizontal plane, and during the first and second part of the guide track 4 also tilted by a certain tilting angle about a middle, longitudinal line that extends between the two ends 13, 15 in the middle of the two sides 17, 18. By mounting the guide track at a desired position along the frame members 8 using the mounting holes 9 and thereby at a desired height, the inclination angle of the of the photovoltaic module 2 may be chosen as desired. The traveling speed of the wheels 12 may be substantially constant and/or may be calculated in accordance with a traveling speed of the sun. A control, such as a (micro)processor may be provided for controlling the drive means to drive the wheels 12 in a desired direction and/or with a desired speed.

The solar photovoltaic tracker system 1 according to this first embodiment provides a relatively complex movement of the photovoltaic module 2 thereof in which the main plane of the photovoltaic module 2 may be facing preferably substantially perpendicular towards the sun throughout the day, while only requiring a relatively simple linear movement of the wheels 12 along the guide track 4. The system may thus be relatively simple and/or cheap, while providing a good and/or efficient energy output of the photovoltaic module 2.

Figure 3 shows a second embodiment of the system 101. Only the differences with respect to the first embodiment of figures 1 and 2 will be described here. For a further description the reader is referred to the description of figures 1 and 2.

In the system 101 according to the second embodiment the ball joint 116 that supports the second end 115 of the photovoltaic module 102 is hingedly connected to the frame 107. A further difference is that in total four frame members 108 are provided, each frame member 108 comprising mounting holes 109, thereby being able to more rigidly mount the guide track 104 thereto. The frame members 108 extend in an inclined upward manner, such that the free ends 105, 106 of the guide track 104 in this embodiment extend in an inclined upward manner.

Figure 4 shows a third embodiment of the system 201. Only the differences with respect to the first embodiment of figures 1 and 2 will be described here. For a further description the reader is referred to the description of figures 1 and 2.

In the system 201 according to the third embodiment frame member 208 comprises two parts 208A, 208B, wherein first part 208A extends around second part 208B and is allowed to move along second part 208B. Moving said first part 208A with respect to second part 208B may take place manually. First part 208A holds the guide track 204, second part 208B is connected to the frame 207. First part 208A can be fixed to second part 208B using any of the mounting holes 209 and a pin 219, thereby adjusting the height of the first part 208A with respect to second part 208B and thereby the height of the guide track 204. A battery 220 is further provided for storing electrical energy as generated by the photovoltaic module 202. Said battery 220 is connected to the photovoltaic module 202 via an electrical conducting wire 221. Said battery 220 may also be used for powering the drive means (not shown).

Figure 5 shows a fourth embodiment of the system 301. Only the differences with respect to the second embodiment of figure 3 will be described here. For a further description the reader is referred to the description of figures 1 - 3.

In the system 301 according to the fourth embodiment frame members 308 are telescopic frame members. By providing in total four telescopic frame members both the height and orientation of the guide track 304 may easily be adjusted, in particular manually. A pin (not shown) can be used for fixating the frame members 308 at a certain position using the mounting holes 109.

Figure 6 shows a fifth embodiment of the system 401. Only the differences with respect to the third embodiment of figure 4 will be described here. For a further description the reader is referred to the description of figures 1 – 4.

Figure 6 shows that in the system according to the fifth embodiment, instead of wheels 12, 112 and a smooth guiding surface 10, 110, a gear 412 and toothed rack 410 may be provided, wherein the gear 412 is connected to the first end 413 of the photovoltaic module 402, 102, and the toothed rack 410 defines the guiding surface 410 of the guide track 404. In particular two gears 412 are provided in this fifth embodiment.

Figures 7A – 7C show three different positions and orientations of the photovoltaic module 504, namely at sunrise (the “M” in the sun denotes morning), i.e. figure 7A, at the highest elevation point of the sun (the “N” in the sun denotes noon), i.e. figure 7B, and at sunset (the “E” in the sun denotes evening), i.e. figure 7C. These figures show that the photovoltaic module 504 is facing the sun substantially perpendicular throughout the day.

Figures 8A and 8B show two different height positions of the guide track 604, by changing the position of the first frame member 608A with respect to the second frame member 608B. In figure 8A the guide track 604 is shown at its uppermost position, which is suitable for the winter (the “W” in the sun denotes winter) when the sun is relatively low. In figure 8B the guide track 604 is shown at its second lowest position, which is suitable for the summer (the “S” in the sun denotes summer) when the sun is relatively high. It is noted that in the summer the guide track 604 could alternatively be positioned at the lowest position using the lowest mounting hole 209. The intermediate mounting holes 209 and thereby heights of the guide track 604 can be used between summer and winter, for example during spring or autumn. As described above, the height adjustment can be performed manually.

Figure 9 shows a sixth embodiment of the system 701. This figure shows that instead of one guide track 704 multiple guide tracks 704 can be provided, in this example three guide tracks 704. The guide tracks 704 are provided at different heights along the frame members 708 and at different horizontal positions. The photovoltaic module (not shown in figure 9 for simplicity) can be arranged to move along any of the three guide tracks 704, by positioning the moving means thereof, for example manually, on the suitable guide track 704 for that season. For example, the uppermost guide track 704 may be used in the winter, the intermediate guide track 704 during spring and autumn, and the lowermost guide track 704 during summer. In accordance with these seasons the uppermost guide track 704 may have the shortest length and largest radius of the three guide tracks and the lowermost guide track 704 may have the longest length and smallest radius of the three guide tracks, to adjust to relatively short winter days and relatively low winter sun, and relatively long summer days and relatively high summer sun, respectively.

Figure 10 shows a guide track 804 having one continuous guiding surface 810 along both the upper side and the lower side thereof. In such an embodiment the photovoltaic module 802 is moved in one and the same first direction throughout the day and night. During the day the photovoltaic module 802 moves along the upper side of the guide track 804 and during the night the photovoltaic module 802 moves along the lower side of the guide track 804. Such a guide track 804 may advantageously be provided for the winter season, when the nights are longer than the days, because as a result of the convex shape of the guide track the length of the lower side of the guide track 804 is longer than the upper side, such that, at a constant traveling speed of the moving means, the photovoltaic module 802 has a longer trajectory during the night than during the day. A support track 830 may be provided at a distance from the lower side of the guide track 804 for supporting the moving means when traveling along this lower side, thereby preventing the moving means from detaching from the guide track 804. The distance is substantially equal to the diameter of the gears 812.

It is noted that the invention is not limited to the shown embodiments but also extends to variants within the scope of the appended claims.

Claims

1. Solar photovoltaic tracking system, comprising:

- at least one photovoltaic module;
- a guide track for guiding a movement of the at least one photovoltaic module, wherein said guide track has a substantially convex shape, which guide track is arranged such that in use of the solar photovoltaic tracking system the guide track is in a position facing the sun, preferably substantially perpendicular, with at least a part thereof throughout the day;
- wherein said at least one photovoltaic module comprises at least one moving means for moving the photovoltaic module along the guide track, and
- at least one drive means for driving the moving means.

2. Solar photovoltaic tracking system according to claim 1, wherein said guide track has a substantially elliptical shape.

3. Solar photovoltaic tracking system according to claim 1 or 2, comprising a frame for holding said guide track in said position facing the sun, wherein said guide track is held by said frame in such a manner that an orientation and/or height thereof is, preferably manually, adjustable.

4. Solar photovoltaic tracking system according to claim 1 or 2, wherein said system comprises multiple guide tracks and wherein said system further comprises a frame for holding said multiple guide tracks in their positions facing the sun, wherein the different guide tracks of the multiple guide tracks are held by said frame at different heights and/or orientations.

5. Solar photovoltaic tracking system according to any of the preceding claims, wherein the moving means connect to one end of the photovoltaic module.

6. Solar photovoltaic tracking system according to any of the preceding claims, wherein the guide track comprises a substantially smooth guiding surface and said moving means comprise at least one wheel.

7. Solar photovoltaic tracking system according to any of the claims 1 - 5, wherein the guide track comprises a toothed rack and said moving means comprises at least one gear.

8. Solar photovoltaic tracking system according to any of the preceding claims, wherein a second end of the photovoltaic module is supported at a substantially fixed position in such a manner that the support allows the movement of the photovoltaic module along the guide track.

9. Solar photovoltaic tracking system according to any of the preceding claims, wherein a or said second end of the photovoltaic module is supported by a hinge for hingedly supporting the second end of the photovoltaic module.

10. Solar photovoltaic tracking system according to claim 9, wherein said hinge comprises a ball joint.

11. Solar photovoltaic tracking system according to claim 9 or 10, wherein said system comprises said frame or a further frame for holding said photovoltaic module, wherein said frame or said photovoltaic module comprises said at least one hinge for hingedly holding said photovoltaic module with respect to the frame.

12. Solar photovoltaic tracking system according to any of the preceding claims, wherein said drive means are arranged to drive said moving means in accordance with a traveling speed of the sun.

13. Solar photovoltaic tracking system according to any of the preceding claims, wherein said drive means are arranged to drive said moving means in a first direction along the guide track between sunrise and sunset and in a second, opposite direction between sunset and sunrise.

14. Solar photovoltaic tracking system according to any of the preceding claims 1 - 12, wherein the guide track has one continuous guiding surface along both an upper side and a lower side of the guide track, wherein said drive means are arranged to drive said moving means in a first direction along the guide track.

15. Solar photovoltaic tracking system according to any of the preceding claims, wherein said drive means are arranged to drive said moving means with a substantially constant speed.

16. Solar photovoltaic tracking system according to any of the preceding claims, further comprising a control for controlling the drive means.

17. Use of a solar photovoltaic tracking system according to any of the preceding claims, said use comprising the steps of:

a) arranging the guide track in such a manner that the guide track is in a position facing the sun, preferably substantially perpendicular, with at least a part thereof throughout the day, and

b) moving the photovoltaic module along the guide track.

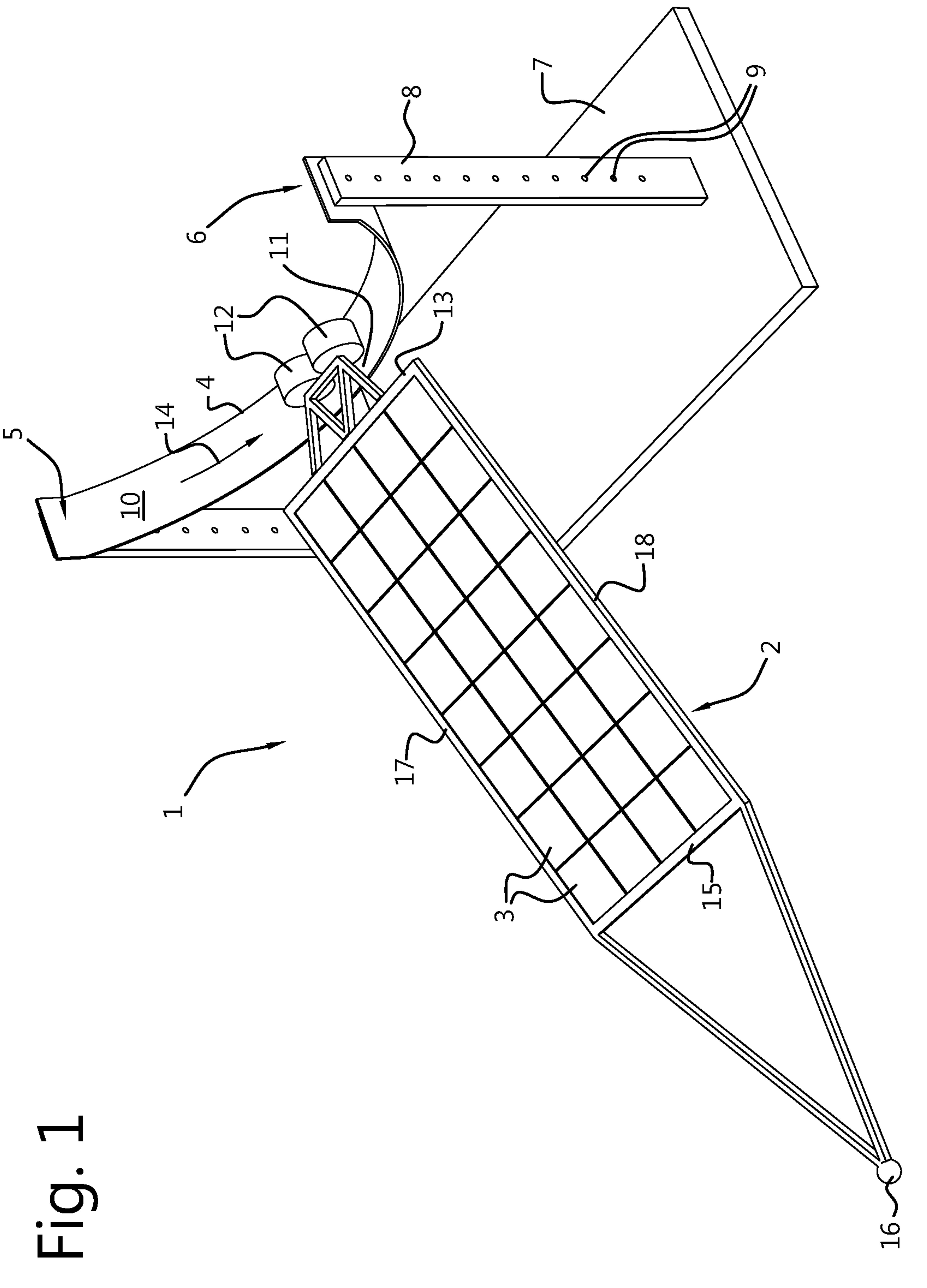
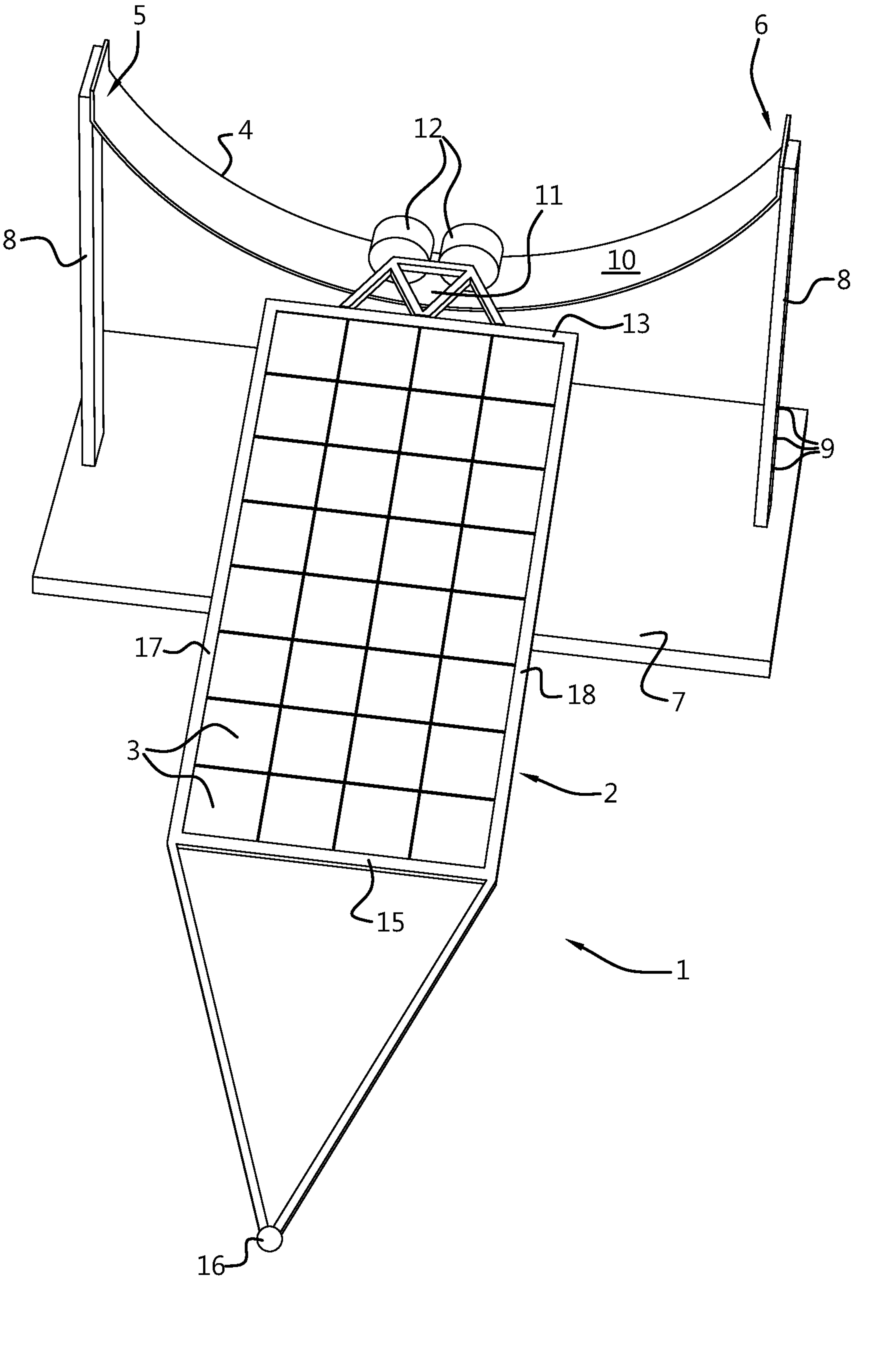


Fig. 1

Fig. 2



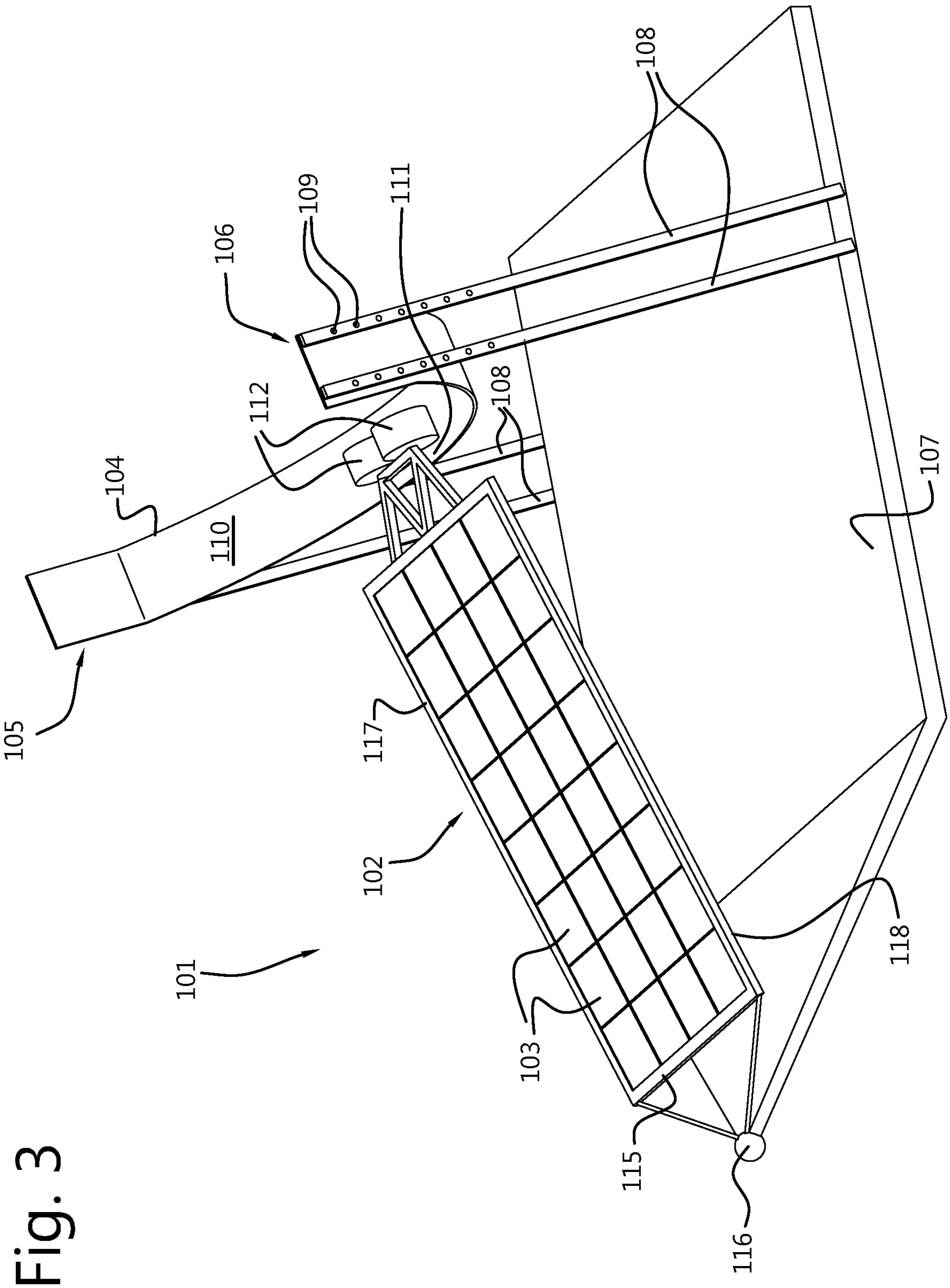

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Fig. 3

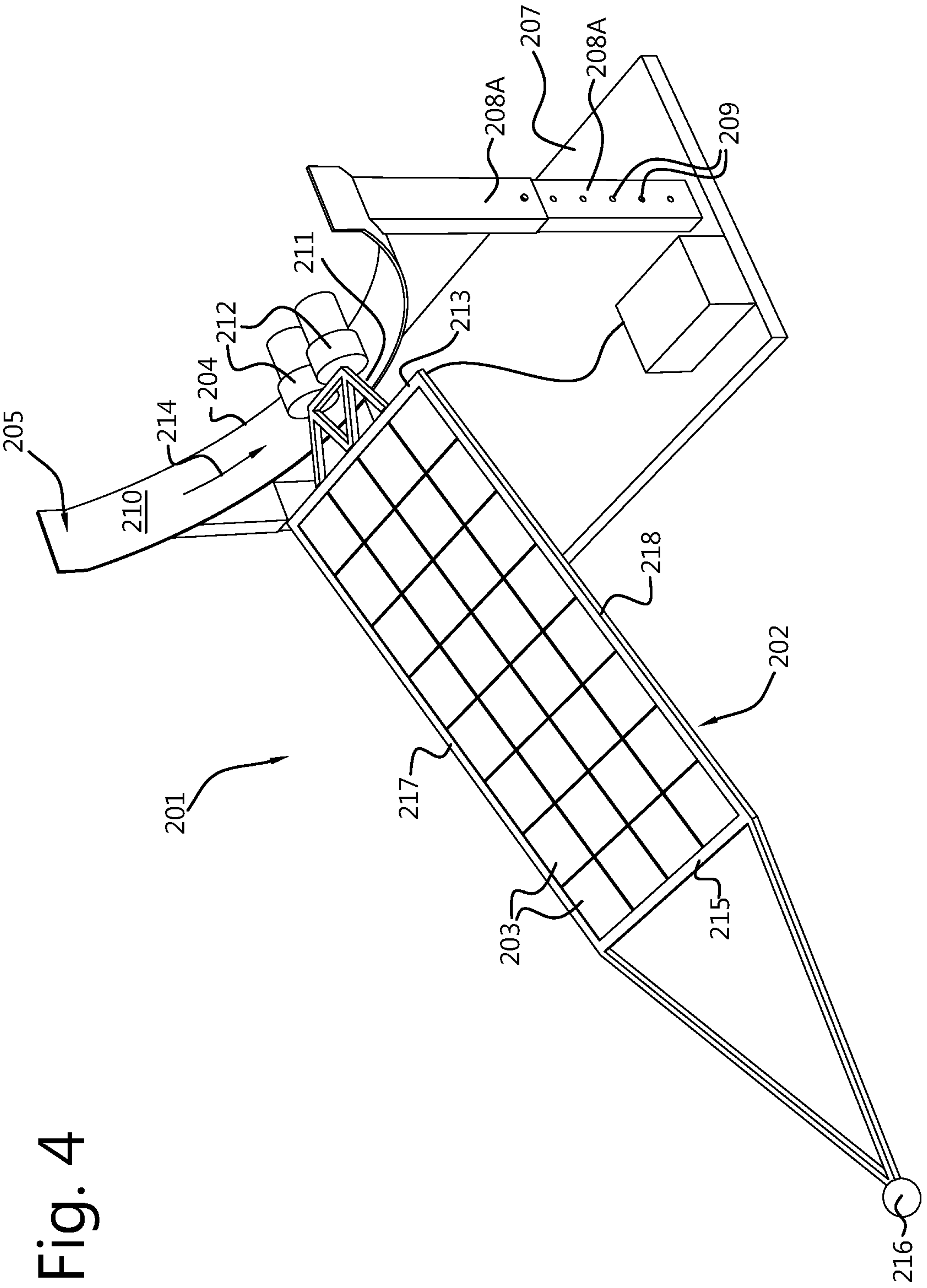
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Fig. 4

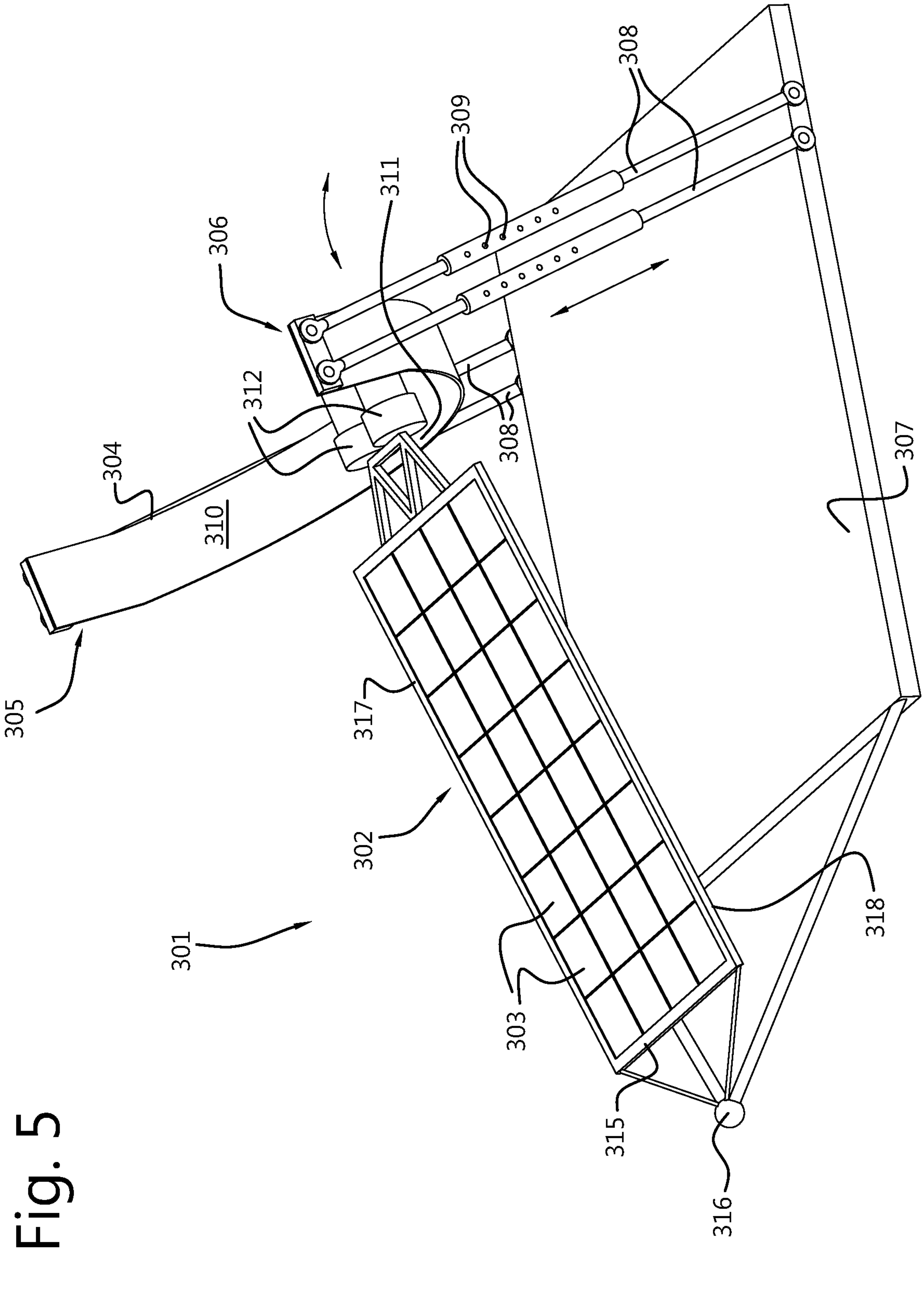
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Fig. 5

Fig. 6

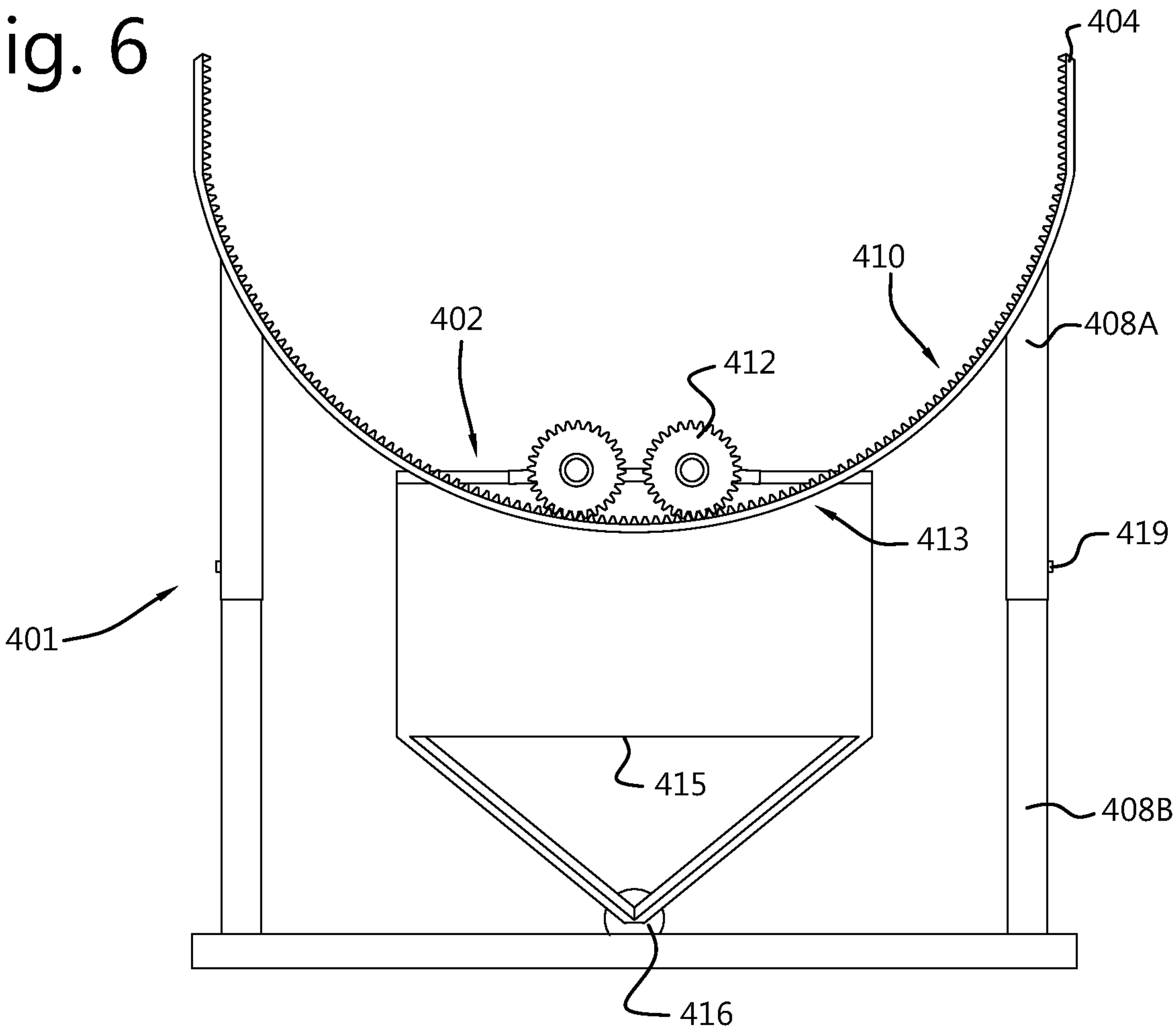


Fig. 7A

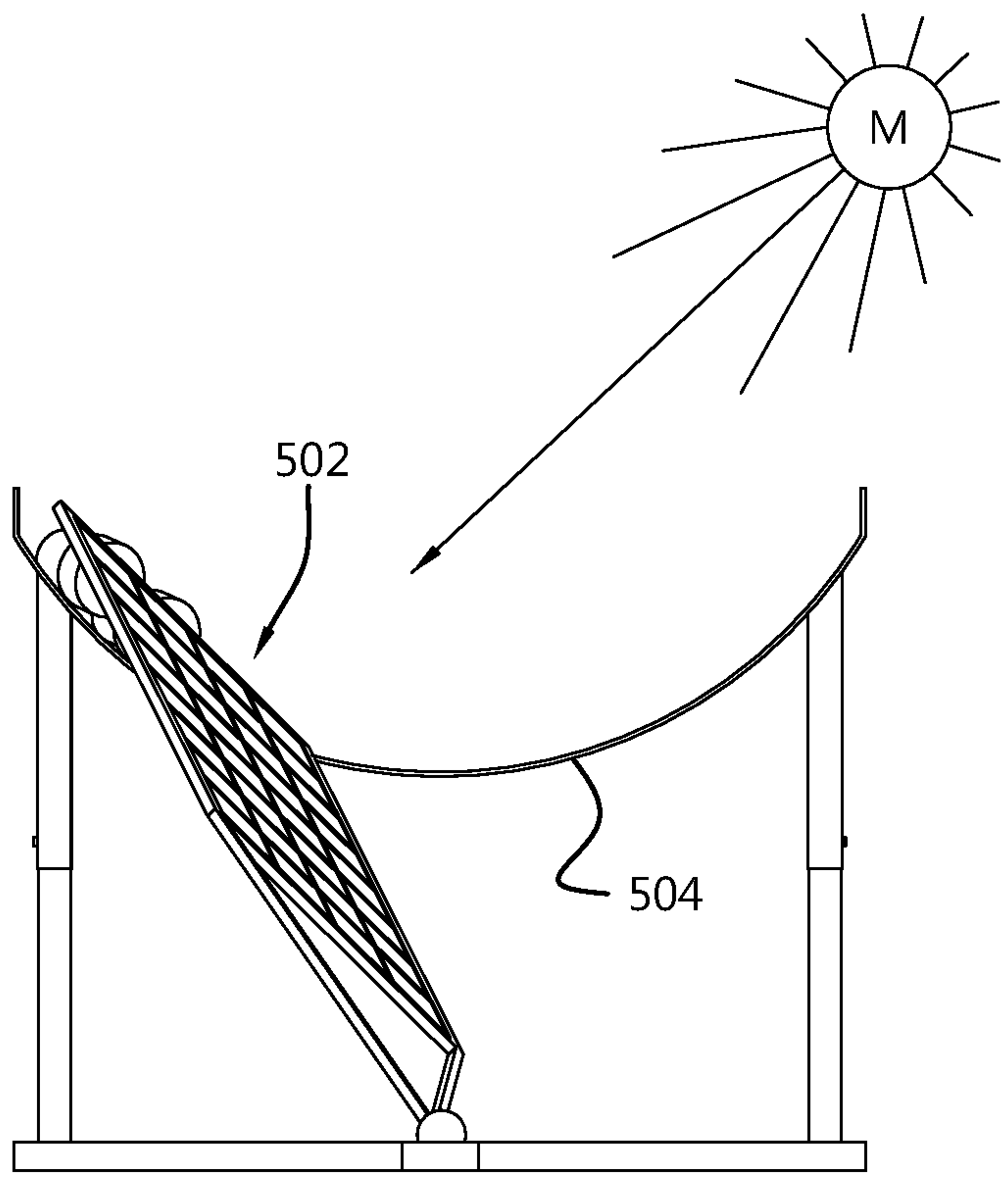


Fig. 7B

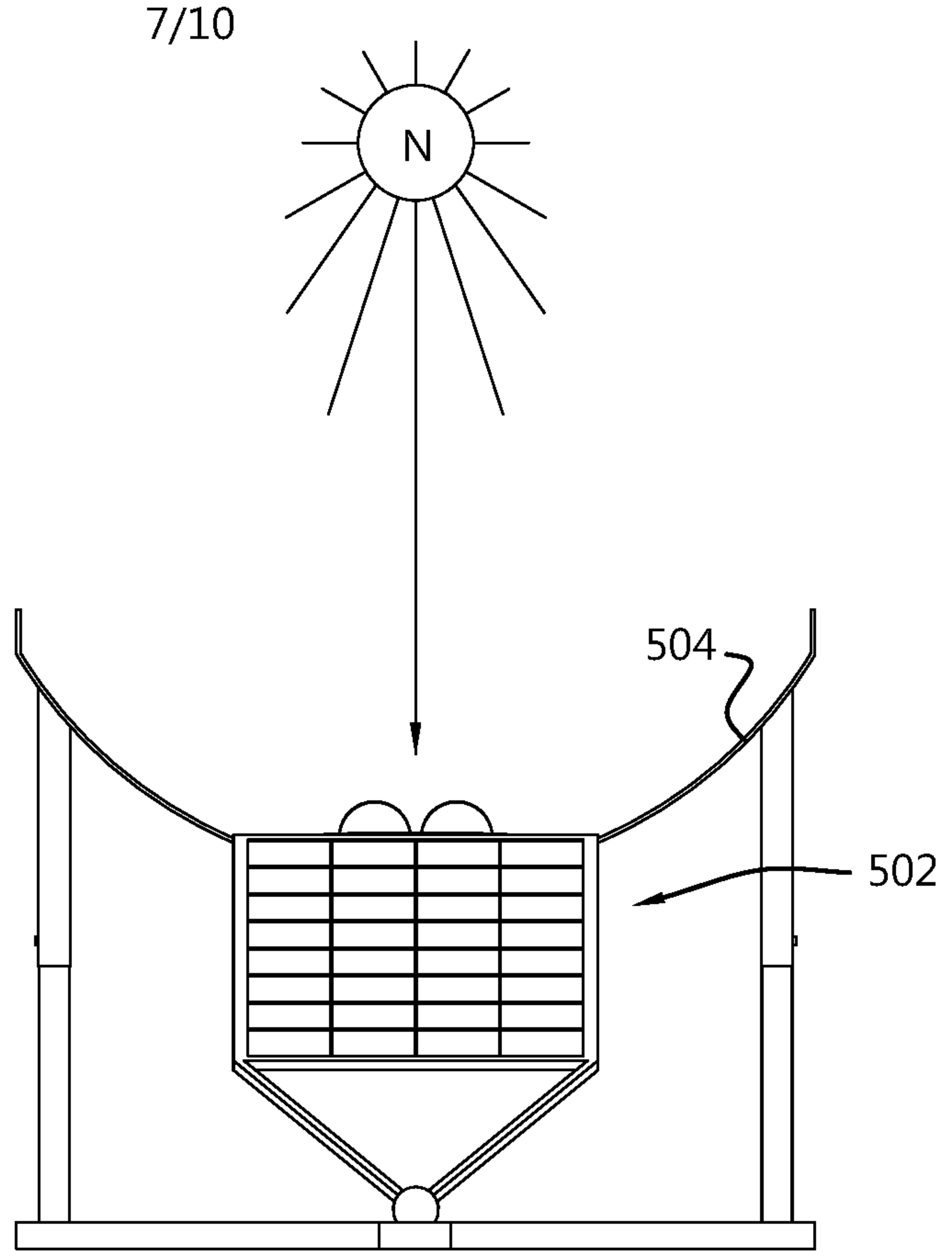


Fig. 7C

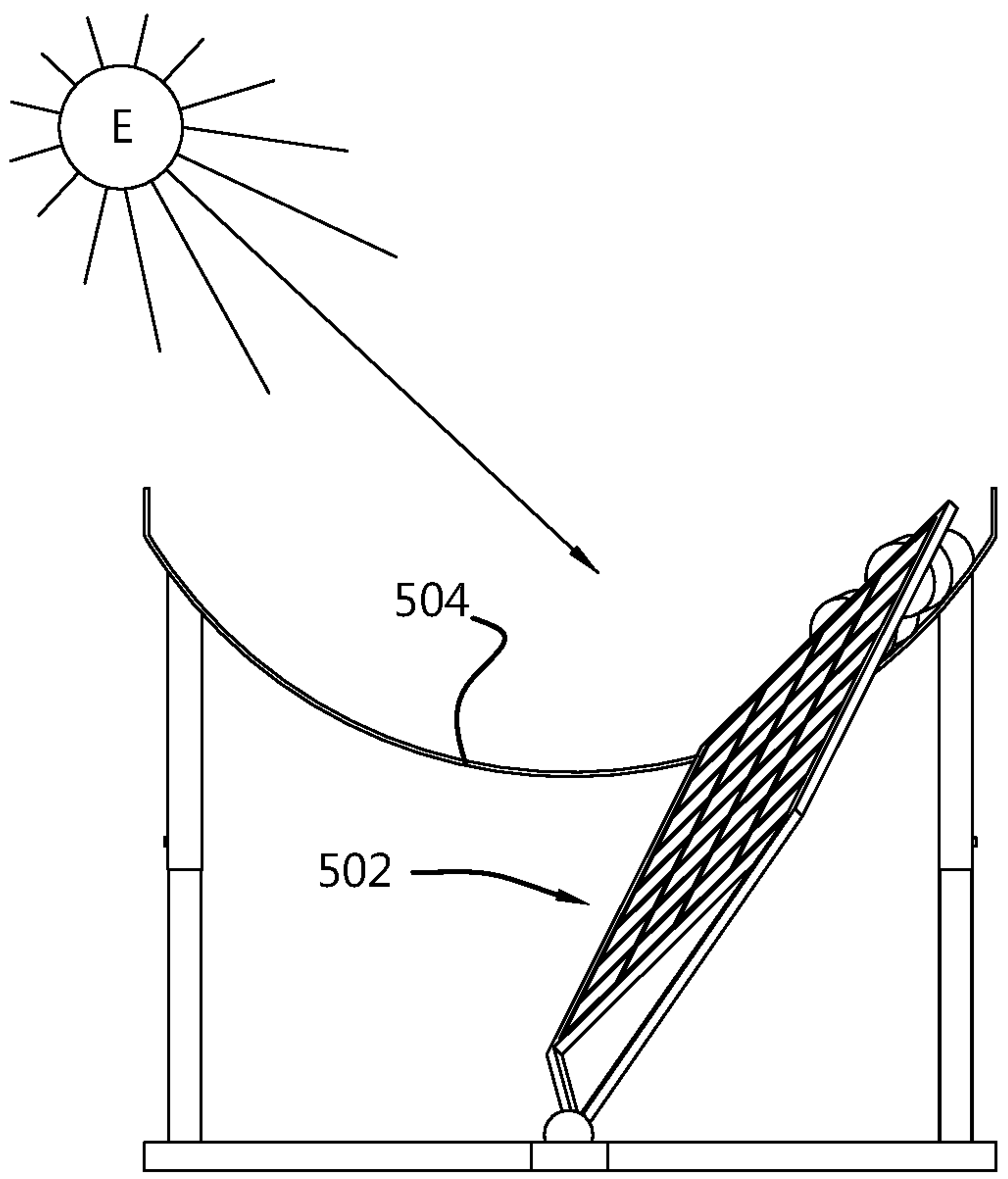


Fig. 8A

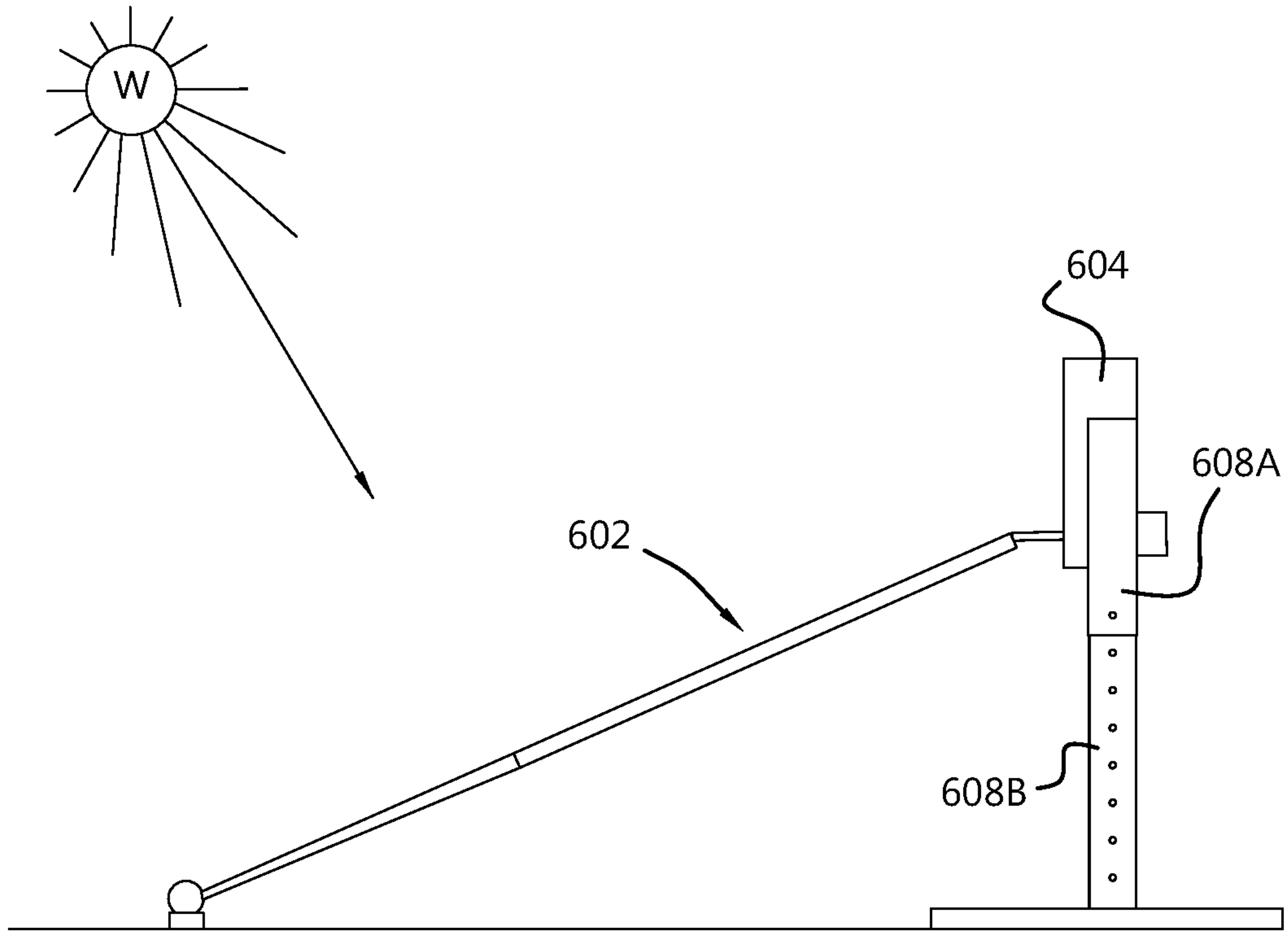


Fig. 8B

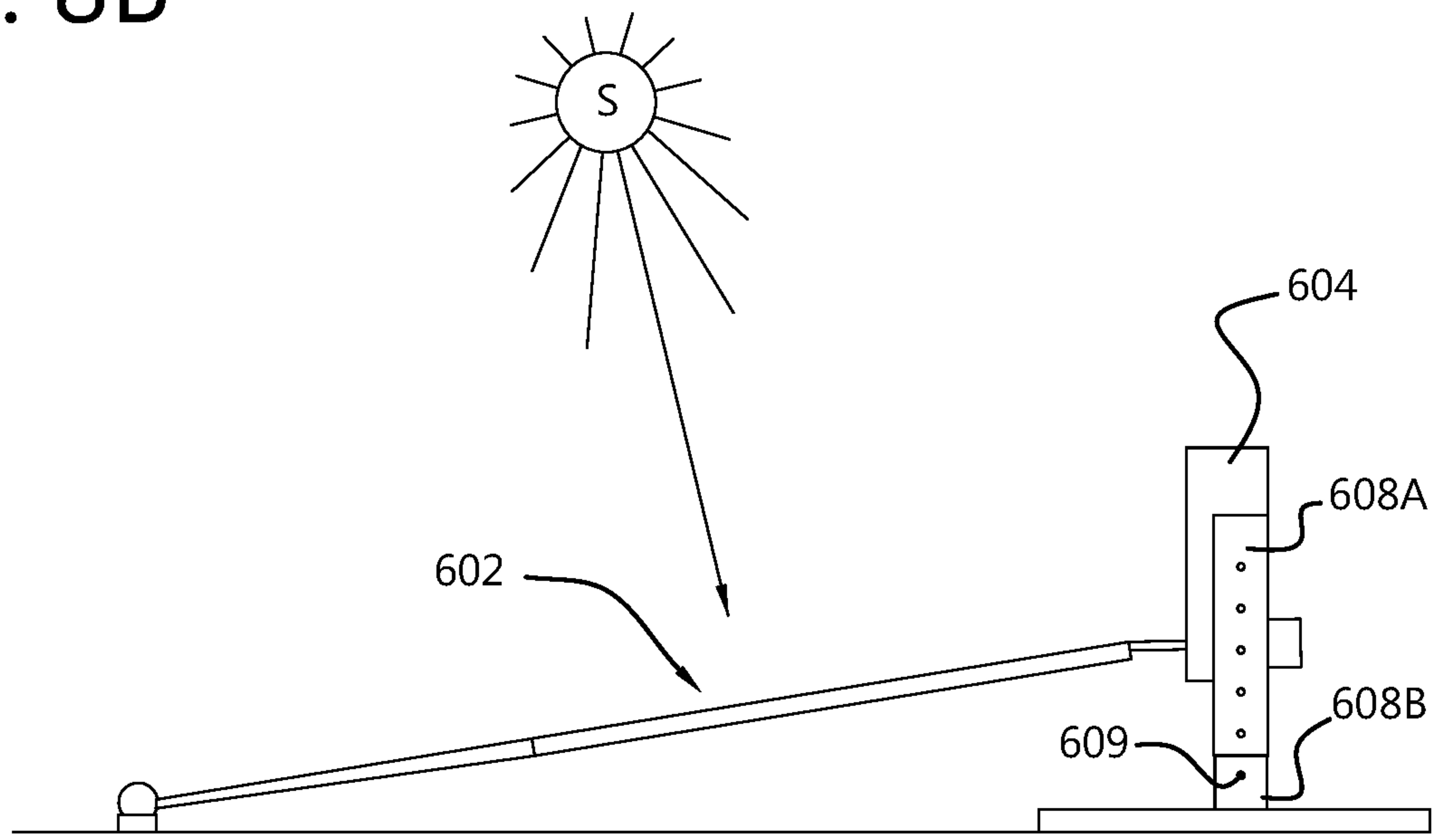
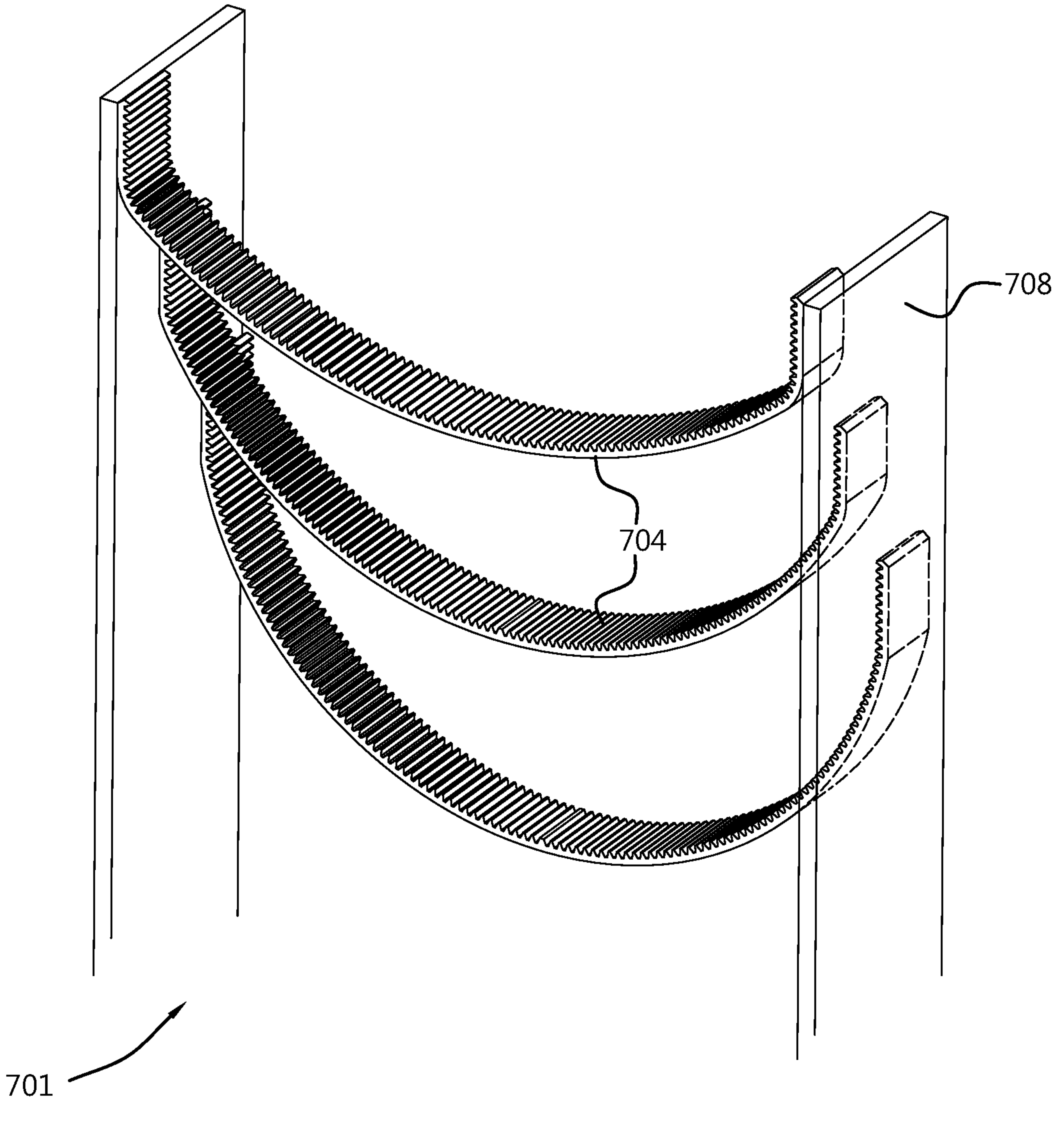


Fig. 9



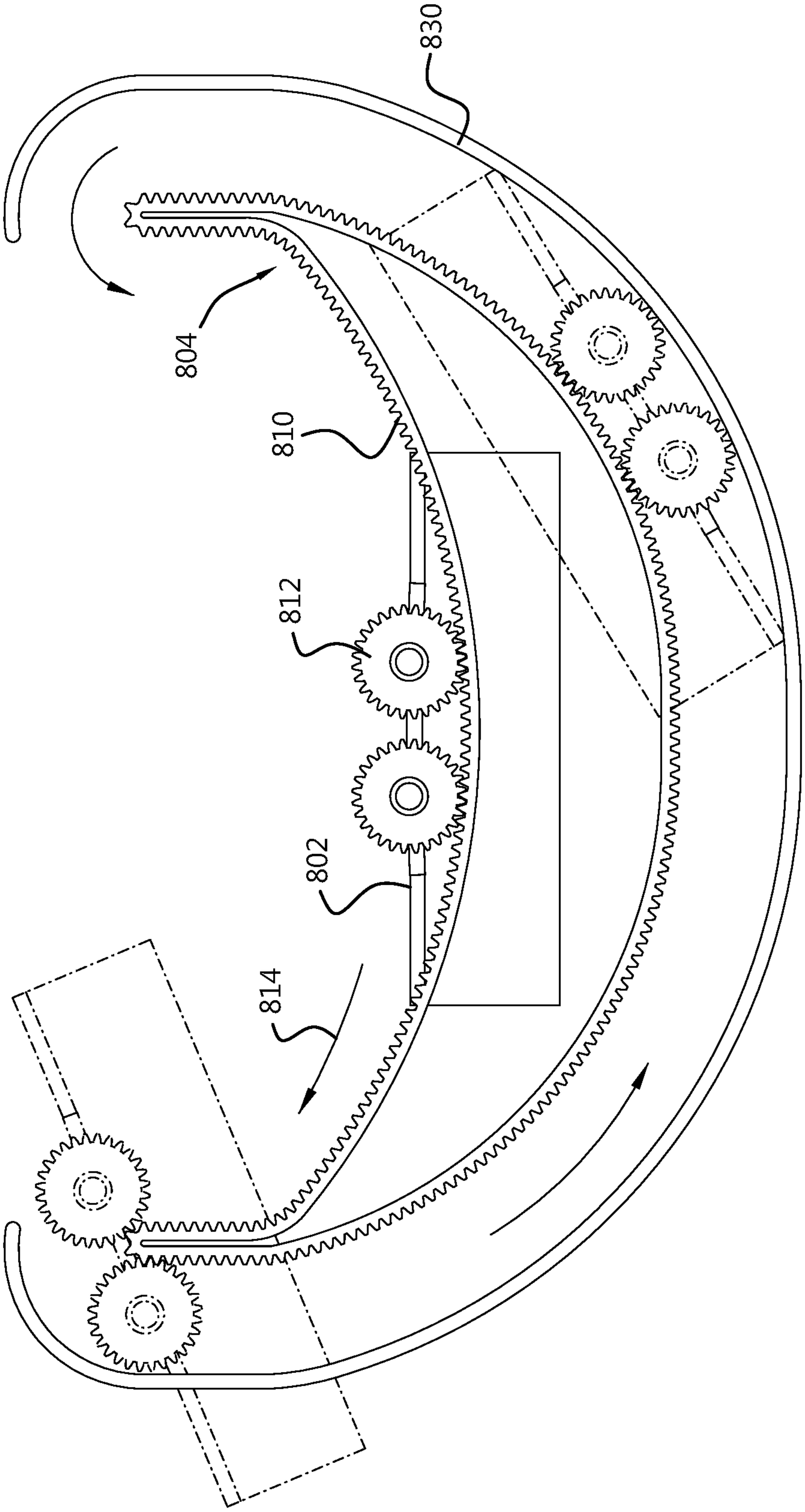


Fig. 10