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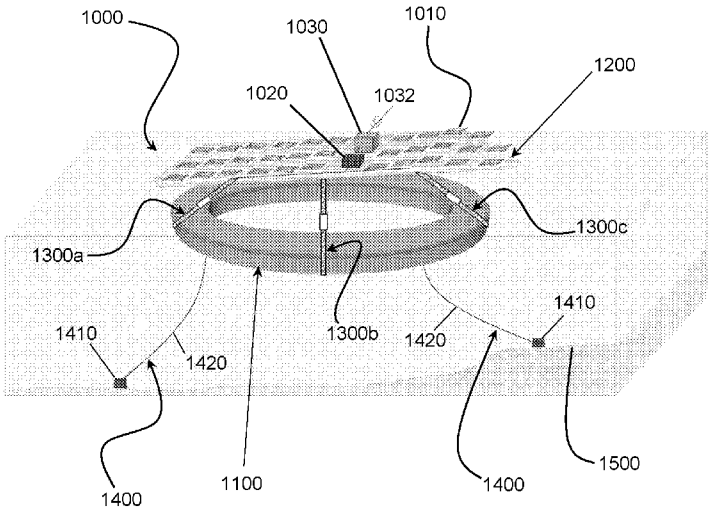

Figure 1

(57) Abstract: A floating apparatus 1000,3000 for supporting solar modules 1010 is disclosed. In a specific embodiment, the floating apparatus 1000,3000 includes a floatation device 1100,1140 operable to float in a water body, a platform 1200 for supporting the solar modules 1010, and linearly adjustable support structures 1300a,1300b,1300c arranged to space the platform 1200 from the floatation device 1100,1140. Each support structure 1300a,1300b,1300c is independently operable to adjust a respective relative distance between the platform 1200 and the floatation device 1100,1140. A method of operating the floating apparatus 1000,3000 is also disclosed.

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A FLOATING APPARATUS, AND A METHOD OF OPERATING THE FLOATING APPARATUS

TECHNICAL FIELD

The present application relates to floating apparatuses for supporting solar modules, and methods of operating the floating apparatuses.

BACKGROUND

Megacities consume large amounts of electricity daily. Renewable energy such as solar power is increasingly being used to supplement conventional power sources such as from the burning of fossil fuel. However, for solar power contribution to be significant, a solar power plant has to generate energy in the megawatt scale which requires a sizeable solar power plant. Unfortunately, megacities are already land scarce.

Existing solutions include building the solar power plant at a remote location on land and transmitting the power to the city, or building the solar power plant at sea on a floating platform which requires no land usage.

However, the solar power plants on sea are subjected to external forces such as strong wind and strong waves which can cause damage to the solar modules over time, and reduce the lifespan of the solar power plant. Moreover, due to the large size of the solar power plant that is required to generate energy in the megawatt scale, transporting and installing the solar power plant at sea becomes a difficult task.

Therefore, it is desirable to provide a floating apparatus that addresses at least one of the problems mentioned in existing prior art and/or to provide the public with a useful alternative.

SUMMARY

In a first aspect, there is provided a floating apparatus for supporting solar modules. The floating apparatus includes a floatation device operable to float in a water body, a platform for supporting the solar modules, and linearly adjustable support structures arranged to space the platform from the floatation device. Each support structure is independently operable to adjust a respective relative distance between the platform and the floatation device.

In the described embodiments, by adjusting the relative distance between the platform and the floatation device in response to external forces such as strong winds or high waves, the floating apparatus is able to protect the solar modules from being damaged by the external forces when deployed. Simultaneously, each support structure is independently operable such that the support structure is able to adjust a relative angle between the platform and the floatation device to improve solar irradiance and thus, energy yield of the solar modules when deployed.

The floatation device may include multiple floatation units. The floatation device may also include connectors for joining the floatation units together.

Preferably, the connectors may include connector plates that are disposed on an exterior surface of the floatation units. The connector plates may include grooved

fittings. Furthermore, the connector plates may be disposed on top of adjacent floatation units. The connector may also include connector strings that are partially embedded within the floatation units.

Alternatively, the connector plates may be disposed between adjacent floatation units instead.

Moreover, the floatation device may be donut shaped.

Preferably, the platform may include grooves configured to receive the solar modules within the grooves. The platform may further include support hooks disposed within the grooves.

Advantageously, the platform may be coated with a reflective material made of polytetrafluoroethylene.

Each support structure may include an adjustable column. An end of the adjustable column may be attached to the platform, and an opposing end of the adjustable column may be attached to a respective connector interface of the floatation device.

Preferably, each adjustable column may include a lifting mechanism for adjusting the respective relative distance between the platform and the floatation device. The lifting mechanism may be hydraulic powered.

Each adjustable column may further include a damping mechanism. The damping mechanism may be a mechanical shock absorber, a hydraulic shock absorber or a combination of the mechanical shock absorber and the hydraulic shock absorber.

The floating apparatus may include motion sensors for detecting wave motion, wind direction, or ship movement. The floating apparatus may also include light sensors for detecting solar irradiation.

Furthermore, the floating apparatus may include a control unit configured to receive information from the sensors, and to independently operate each support structure to adjust a respective relative distance between the platform and the floatation device based on the information received.

The floating apparatus may further include an energy storage device for storing electrical energy produced by the solar modules.

The floating apparatus may further include solar modules.

In a second aspect, there is provided a method of operating a floating apparatus for supporting solar modules. The floating apparatus includes a floatation device operable to float in a water body, a platform for supporting the solar modules, and linearly adjustable support structures arranged to space the platform from the floatation device. The method includes independently operating each support structure to adjust a respective relative distance between the platform and the floatation device.

It should be apparent that features relating to one aspect may also be applicable to features of the other aspects.

BRIEF DESCRIPTION OF DRAWINGS

Exemplary embodiments will be described with reference to the accompanying figures in which:

Figure 1 is a perspective view of a floating apparatus according to a first embodiment.

Figure 2 is a side view of the floating apparatus of Figure 1.

Figure 3A is a top view of a floatation device of the floating apparatus of Figure 1.

Figure 3B is a top view of two adjacent floatation units of the floatation device of Figure 3A.

Figure 3C is a side view of the two adjacent floatation units of Figure 3B.

Figure 3D is a top view of the two adjacent floatation units of Figure 3B according to an alternative embodiment.

Figure 3E is a side view of the two adjacent floatation units of Figure 3D.

Figure 4A is a top view of an alternative floatation device to the floatation device of Figure 3A.

Figure 4B is a top view of two adjacent floatation units of the alternative floatation device of Figure 4A.

Figure 4C is a top view of the two adjacent floatation units of Figure 4B according to an alternative embodiment.

Figure 5A is an expanded view of a region A of the floating apparatus of Figure 2.

Figure 5B is a side view of the region A of the floating apparatus of Figure 2 having a linearly adjustable support structure attached to two exemplary floatation units of the floatation device of Figure 3A.

Figure 5C is a side view of the linearly adjustable support structure attached to the two exemplary floatation units of the floatation device of Figure 3A according to an alternative embodiment.

Figure 6 is a perspective view of an alternative floating apparatus to the floating apparatus of Figure 1 having eight support structures.

Figure 7 is a top view of a platform of the floating apparatus of Figure 1.

Figure 8A is an expanded view of a region B of the platform of Figure 7 with the solar modules 1010 installed.

Figure 8B is an expanded view of the region B of the platform of Figure 7 without the solar modules 1010 installed.

Figure 8C is an expanded view of a region C within the region B, as indicated in Figure 8A.

Figure 9A is a bottom view of a portion of the platform of Figure 7.

Figure 9B a skeletal view of the region B of the platform of Figure 7.

Figure 10 is a side view of an alternative floating apparatus to the floating apparatus of Figure 1 according to an alternative embodiment.

Figure 11 is a bar graph for a cost distribution associated with an installation of the floating apparatus of Figure 1.

DETAILED DESCRIPTION

The following description includes specific examples for illustrative purposes. The person skilled in the art would appreciate that variations and alterations to the specific

examples are possible and within the scope of the present disclosure. The figures and the following description of the particular embodiments therefore should not take away from the generality of the preceding summary.

Figure 1 illustrates an exemplary floating apparatus 1000 for supporting solar modules 1010. In the embodiment, the solar modules 1010 form a solar power plant for harvesting solar energy. In this embodiment, the solar modules 1010 are bifacial solar modules. The floating apparatus 1000 is deployed out at sea where the solar modules 1010 are subjected to external forces such as the wind and waves. The floating apparatus 1000 includes a floatation device 1100. The floating apparatus 1000 also includes a platform 1200 for supporting the solar modules 1010, and other electrical equipment such as an inverter unit 1020 and a transformer unit 1030. An energy storage device is also housed within the inverter unit 1020 for storing a portion of the electrical energy harvested by the solar modules. The energy storage device acts as a back-up system for powering the floating apparatus 1000 when sunlight is low.

In this embodiment, an output 1032 of the transformer unit 1030 is connected to an electrical grid (not shown) for supplying a remaining portion of the electrical energy generated from the solar modules 1010 to the electrical grid. The floating apparatus 1000 further includes first, second and third linearly adjustable support structures 1300a,1300b,1300c that are arranged to space the platform 1200 from the floatation device 1100. Notably, the floatation device 1100 is operable to float in the sea, and is arranged to have a buoyancy force which may allow the floatation device 1100 to remain buoyant while supporting the weight of the platform 1200, and the first, second and third linearly adjustable support structures 1300a,1300b,1300c.

In this embodiment, the floating apparatus 1000 also includes a mooring mechanism 1400 to anchor the floatation apparatus 1000. The mooring mechanism 1400 includes anchors 1410 which are attached to the sea floor 1500 when the floating apparatus 1000 is deployed, and mooring lines 1420 which tether the floatation device 1100 to the anchors 1410. Prior to being moored, the floating apparatus 1000 is mobile and can be towed to a desired location before being moored.

Figure 2 illustrates a side view of the floating apparatus 1000 having the floatation device 1100, the platform 1200 including the solar modules 1010, and the transformer unit 1030 (the inverter unit 1020 is blocked from view by the transformer unit 1030), and the first, second and third linearly adjustable support structures 1300a,1300b,1300c.

The floating apparatus 1000 further includes motion sensors for detecting wave motion, wind direction and ship movements, and light sensors for detecting solar irradiation.

The floating apparatus 1000 further includes a control unit which receives information from the motion sensors and light sensors. The control unit is configured to independently operate each support structure 1300a,1300b,1300c is independently operable to adjust a respective relative distance between the platform 1200 and the floatation device 1100 based on the information received. As the floating apparatus 1000 is deployed at sea, the floating apparatus 1000 is sometimes subjected to strong winds and waves. Beneficially, by adjusting the relative distance between the platform

1200 and the floatation device 1100 based on the information received from the motion sensors, the solar modules 1010 that are supported on the platform 1200 can be placed at a distance above sea level to reduce an impact that the external forces have on the solar modules 1010. This prevents the solar modules 1010 from getting damaged by the external forces, and extends a lifespan of the solar modules 1010. Furthermore, there are less residue being deposited on the solar modules 1010 due to the distance of the solar modules 1010 above sea level.

In addition, by independently operating each support structure 1300a,1300b,1300c to adjust a respective relative distance between the platform 1200 and the floatation device 1100 based on the information received from the light sensors, the platform 1200 can be tilted to an angle relative to the water surface (since the floatation device 1100 is operable to float in the sea). Beneficially, the platform 1200 can be tilted to an angle relative to the water surface such that respective surfaces 1012 of the solar modules 1010 are facing the sun. An optimal angle of the platform 1200 relative to the water surface occurs when incident solar rays are normal to the respective surfaces 1012 of the solar modules 1010, which maximizes an incident solar radiation gain of the solar modules 1010.

Furthermore, when the platform 1200 is tilted at an angle to the water surface, the solar modules can be cleaned efficiently by utilising gravitational flow of water that is supplied by a pump or by natural phenomena i.e., rainfall.

The floatation device 1100, the platform 1200, and the linearly adjustable support structures 1300a,1300b,1300c are described in more detail in the following sections.

Floatation Device 1100

Figure 3A is a top view of the floatation device 1100 of the floating apparatus 1000. For clarity, the rest of the floating apparatus 1000 is not depicted in Figure 3A. The floatation device 1100 includes eight floatation units 1110 that are arranged in a circle. The floatation device 1100 has a hollow centre, or in other words, the floatation device 1100 resembles the shape of a donut ("donut-shaped"). The floatation device 1100 further includes connectors (not depicted in Figure 3A) disposed at the intersection of respective adjacent floatation units 1110 for securing the respective adjacent floatation units 1110 together to form the floatation device 1100. In addition, although it is not depicted, it should be noted that connector interfaces are disposed between respective selected adjacent floatation units 1110 where the linearly adjustable support structures 1300a,1330b,1330c are attached to the floatation device 1100. This is described in more detail when describing the linearly adjustable support structures 1300a,1330b,1300c.

Turning first to the floatation device 1100, Figure 3B illustrates a top view of exemplary adjacent floatation units 1112,1114 (see also Figure 3A) having respective ends 1112b,1114a secured together via connectors 1120. An opposing end 1112a of the floatation unit 1112 is secured to another floatation unit (not depicted) that is adjacent to the floatation unit 1112 at the opposing end 1112a. Likewise, an opposing end 1114b of the floatation unit 1114 is secured to another floatation unit (also not depicted) that is adjacent to the floatation unit 1114 at the opposing end 1114b.

Figure 3C illustrates a side view of the adjacent floatation units 1112,1114 showing a top connector 1120a and a bottom connector 1120b for securing the respective ends 1112b,1114a of the floatation units 1112,1114 together. For convenience, the area where the respective ends 1112b,1114a of the floatation units 1112,1114 abut against each other is referred to as a float joint 1113.

The top connector 1120a is arranged to secure a top portion of float joint 1113 together, while the bottom connector 1120b is arranged to secure a bottom portion of the float joint 1113 together. Since the top connector 1120a and the bottom connector 1120b have similar configurations, only the top connector 1120a is described in relation to the top portion of the float joint 1113. It is understood that the description for the top connector 1120a similarly applies to the bottom connector 1120b in relation to the bottom portion of the float joint 1113.

The top connector 1120a includes a connector plate 1122 and a connector string 1124. The connector string 1124 is embedded within the top portion of the float joint 1113, and ties the top portion of the float joint 1113 to each other. The connector plate 1122 is affixed to a top surface 1125 of the floatation units 1112,1114 at the float joint 1113. The connector plate 1122 includes grooved fittings 1123 to secure the connector plate 1122 to the top surface 1125. Both ends of the connector string 1124 are attached to the connector plate 1122 to secure the top portion of the float joint 1113 together.

For a megawatt-scale solar power plant, the platform 1200 necessarily covers a large area. Correspondingly, the floatation device 1100 will be of a sizeable volume in order to have sufficient buoyancy force. Beneficially, the floatation units 1110 can be prefabricated and assembled on-site to form the floatation device 1100. This modular

concept allows the floatation device 1100 (and the floating apparatus 1000) to be deployed or installed in a remote location efficiently and effectively. Furthermore, the modular concept allows for easy scalability depending on the power generation requirements of the solar power plant.

Notably, the connector string 1124 may be a metal chain, or a thread made of plastic or natural fibres. Furthermore, other types of connectors can also be used to secure respective adjacent floatation units 1110 together. Figure 3D illustrates a top view of the two adjacent floatation units 1112,1114 secured together via an alternative connector 1130. Figure 3E illustrates a side view of the adjacent floatation units 1112,1114 with the connector 1130 disposed between the respective ends 1112b,1114a of the floatation units 1112,1114. The connector 1130 includes two connector plates 1132 which are secured to the respective ends 1112b,1114a of the floatation units 1112,1114 via a metallic screw (not depicted in Figure 3E). Alternatively, the alternative connector 1130 may be secured to the respective ends 1112b,1114a via a plastic screw, or a threaded string.

Floatation units 1100 having the alternative connectors 1130 are easier to install, while the connectors 1120 provide a more secure connection between adjacent floatation units 1110. Thus, depending on weather conditions that the floating apparatus 1000 is expected to be deployed in, either the connector 1120 or the alternative connector 1130 may be chosen. If severe wind conditions and/or waves having smaller cyclic patterns are expected, then the connector 1120 is a more suitable choice for the floatation device 1100. If moderate wind conditions and/or waves having larger cyclic

patterns are expected, then the alternative connector 1130 is a more suitable choice for the floatation device 1100.

Moreover, the floatation units 1110 may not be arranged in a circle. For example, Figure 4A illustrates an alternative floatation device 1140 having floatation units 1150 that are arranged in a generally rectangular configuration. Needless to say, it should be appreciated that the skilled person will understand that the size and shape of the floatation units 1110 may be modified accordingly to achieve a floatation device of a desired shape and/or size.

Like the floatation device 1110, the alternative floatation device 1140 also includes the connector 1120 (see Figure 4B) disposed at the intersection of respective adjacent floatation units 1150 for securing the respective adjacent floatation units 1150 together to form the floatation device 1140.

Figure 4B illustrates a top view of exemplary adjacent floatation units 1152,1154 (see also Figure 4A) having respective ends 1152b,1154a secured together via the connectors 1120. An opposing end 1152a of the floatation unit 1152 is secured to another floatation unit (not depicted) that is adjacent to the floatation unit 1152 at the opposing end 1152a. Likewise, an opposing end 1154b of the floatation unit 1154 is secured to another floatation unit (also not depicted) that is adjacent to the floatation unit 1154 at the opposing end 1154b.

Likewise, other types of connectors such as the alternative connector 1130 may be used instead. Figure 4C illustrates a top view of the two adjacent floatation units

1152,1154 secured together via the alternative connector 1130 according to an alternative embodiment.

In previous embodiments, the floatation device 1110,1140 is described as having a hollow centre i.e., donut shaped. However, this is not necessary as well. The floatation device 1110,11140 may have a solid centre instead.

Furthermore, the floatation device 1110,1140 may include any number of floatation units. For example, the floatation device 1110,1140 may include two floatation units which may be secured together on opposing ends via the connectors 1120, or the alternative connectors 1130 to form the floatation device 1110,1140. Alternatively, the floatation device 1110,1140 may include only one floatation unit, in which case, connectors are not necessary, and the floatation unit is the floatation device 1110,1140.

Linearly adjustable support structures 1300a,1300b,1300c

Figure 5A is an expanded view of a region A of the floating apparatus 1000 (see Figure 2). Specifically, Figure 5A illustrates the first linearly adjustable support structure 1300a secured to a portion 1200a of the platform 1200, and to exemplary floatation units 1116,1118 via the connector interface 1350. Figure 5B is a side view of the region A of the floating apparatus 1000. The first linearly adjustable support structure 1300a is described next with reference to Figures 5A and 5B. Notably, since the first, second and third linearly adjustable support structures 1300a,1300b,1300c have a similar configuration with respect to the platform 1200 and the floatation device 1100, the

description for the first linearly adjustable support structure 1300a similarly apply to the second and third linearly adjustable support structures 1300b,1300c.

The first linearly adjustable support structure 1300a includes an adjustable column 1330. An end 1310 of the adjustable column 1330 is secured to the portion 1200a of the platform 1200, while an opposing end 1320 of the adjustable column 1330 is secured to the connector interface 1350 via a string attachment 1356. Unlike the respective ends 1112b,1114a which are secured together via the connectors 1120, an end 1352 of the connector interface 1350 is secured to an end 1116b of the floatation unit 1116 via the connectors 1120 while an opposing end 1354 of the connector interface 1350 is secured to an end 1118a of the floatation unit 1118 via the connectors 1120.

The adjustable column 1330 includes a hydraulic powered lifting mechanism 1332 for adjusting a relative distance of the portion 1200a of the platform 1200 from the floatation units 1116,1118. This allows the solar modules 1010 supported on the portion 1200a to be placed at a distance above sea level, thus protecting the solar modules 1010 from the waves. Additionally, the distance of the solar modules 1010 can also be adjusted to increase an evaporative cooling effect on the solar modules 1010 and increase a solar energy gain of the solar modules 1010. Specifically, the efficiency of the solar modules 1010 may increase by up to 10% due to the evaporative cooling effect.

The adjustable column 1330 further includes a shock absorber 1334 which is housed within the adjustable column 1330. The shock absorber dampens the external force

generated by the waves which is transmitted to the portion 1200a of the platform 1200. In this embodiment, the shock absorber 1340 is a mechanical shock absorber. Collectively, this allows the first, second and third linearly adjustable support structures 1300a,1300b,1300c to provide better stability and less mechanical stress on the platform 1200, thus increasing reliability and lifespan of the floating apparatus 1000.

The first linearly adjustable support structure 1300a further includes an enclosure 1302 which houses the hydraulic powered lifting mechanism 1332 and a portion of the adjustable column 1330. The enclosure also houses a secondary energy storage unit, maintenance units, as well as living quarters for workers operating the floating apparatus 1000.

The first linearly adjustable support structure 1300a further includes a walkway 1304 around a circumference of the enclosure 1302. A door 1306 in the enclosure 1302 allows an operator to gain access to the adjustment unit and the shock absorber.

The connector interface 1350 may also be coupled to the exemplary floatation units 1116,1118 via the alternative connectors 1130. This is depicted in Figure 5C which illustrates a side view of the first linearly adjustable support structure 1300a having the connector interface 1350 secured to the floatation units 1116,1118 via the alternative connectors 1130. Referring to Figure 5C, respective alternative connectors 1130 are disposed between the connector interface 1350, and respective exemplary floatation units 1116,1118 to secure the connector interface 1350 to the exemplary floatation units 1116,1118. Moreover, it should also be clear that the first, second and third

support structures 1300a,1300b,1300c may also be secured to the alternative floatation device 1140, instead of the floatation device 1100.

Furthermore, the floating apparatus 1000 may include more than three support structures 1300a,1300b,1300c. For example, Figure 6 is a perspective view of an alternative floating apparatus 2000 having eight support structures 2300. The floating apparatus 2000 includes the platform 1200 which is not depicted in Figure 6 to show the relative positions of each support structure 2300. The floating apparatus 2000 further includes a floatation device 2100 which is similar in shape to the alternative floatation device 1140.

The shock absorber is also not limited to a mechanical shock absorber. For example, the shock absorber may also be a hydraulic shock absorber, or a combination of both. Furthermore, the hydraulic powered lifting mechanism may be operated by telescopic means, or by way of a spindle.

Platform 1200

Figure 7 illustrates a top view of the platform 1200 which supports the solar modules 1010, the inverter unit1020, and the transformer unit 1030. The platform 1200 includes a front surface 1202 which faces away from the floatation device 1100, and towards the sunlight when the floating apparatus 1000 is deployed at sea. The front surface 1202 of the platform 1200 is coated with a reflective material made of polytetrafluoroethylene (PTFE). The reflective material increases a reflectivity of the incident solar radiation on the solar modules 1010, which increases the solar energy gain of the solar modules 1010.

Figure 8A is an expanded view of a region B of the platform 1200 of Figure 7 with the solar modules 1010 installed. Figure 8B is an expanded view of the region B without the solar modules 1010 installed. Figure 8C is an expanded view of a region C within the region B illustrated in Figure 8A.

Referring to Figure 8B, the platform 1200 includes grooves 1210 that are configured to receive the solar modules 1010 within the grooves 1210. Once installed, the solar modules 1010 are grooved into the platform (see Figure 8A) which beneficially shelters the solar modules 1010 from strong winds.

The platform 1200 further includes support hooks 1220 disposed within the grooves 1210. The support hooks 1220 are configured to run along a width of respective grooves 1210. In particular, the support hooks 1220 include respective elongate bases 1222 which span across the width of the respective grooves 1210. The elongate bases 1222 support the solar modules 1010 along the width of the respective grooves 1210, thus providing stability to the solar modules 1010 within the grooves 1210.

The platform 1200 further includes walkways 1230 that are formed between the grooves 1210 which allows an operator to have easy access to the solar modules 1010.

Referring to Figure 8C, the support hooks 1220 further include respective latches 1224 disposed at distal ends of the respective elongate bases 1222. The respective latches

1224 are configured to latch onto the walkways 1230 to support the respective elongate bases 1222 within the grooves 1210.

Figure 9A is a bottom view of a portion of the platform 1200. The platform 1200 further includes support beams 1240 disposed on an underside of the platform 1200. The underside of the platform 1200 is the side which opposes the front surface 1202, and faces towards the floatation device 1100. The support beams 1240 provide structural support for the platform 1200.

Figure 9B illustrates a skeletal view of the region B of the platform 1200 which showcases the support beams 1240. The support beams 1240 include a first set of support beams 1242 that run along a width of the underside of the platform 1200, and a second set of support beams 1244 that run along a length of the underside of the platform 1200 such that the first set of support beams 1242 and the second set of support beams 1244 form a criss-cross pattern. The support beams 1240 further includes a third set of support beams 1246 which run parallel to the second set of support beams 1244. The third set of support beams 1246 is disposed above the second set of support beams 1244, and is spaced apart from the second set of support beams 1244 via spacers 1248. The third set of support beams 1246 is disposed under the walkways 1230 to provide structural support and stability to the walkways 1230.

It should be clear that the skilled person will understand the described embodiments of the platform 1200 are not meant to be limitative. For example, the front surface 1202 may not be coated with the reflective material. Additionally, the platform 1200 may not include the grooves 1210 and the support hooks 1220. Figure 10 is a side view of a

floating apparatus 3000 according to an alternative embodiment. The floating apparatus 3000 includes the floatation device 1140, and the support structures 1300a,1300b,1300c. However, in this embodiment, the floating apparatus 3000 includes an alternative platform 3200 having a flat surface 3210 with no grooves. The solar modules 1010 are then placed on frames 2010 that are secured on the flat surface 3210 of the platform 3200. The support structures 1300a,1300b,1300c of the floating apparatus 3000 are secured to the floatation device 1140 and the alternative platform 3200 in a similar manner as the floating apparatus 1000.

Commercial application

Megacities with high population density often face land scarcity issues. Thus, using the floating apparatus 1000 which supports the solar modules 1010 i.e., a floating solar power plant, is advantageous since the floating solar power plant does not require any land space. Furthermore, floating solar power plants may perform better than land-based solar power plants of an equivalent scale due to the evaporative cooling effect on the solar modules 1010. The floating solar power plant may be expected to have a power generation capacity of 1.2 MW, with an estimated system cost of 1.662 SGD/Wp.

Figure 11 is a bar graph for a cost distribution associated with an installation of the floating apparatus 1000. As can be seen from Figure 11, a majority of the cost comes from the installation and operation of the solar modules 1010, i.e., PV plant operation. Thus, the floating apparatus 1000 may beneficially increase the cost effectiveness of the PV plant operation by increasing the power generation capabilities of the solar modules 1010 at a fraction of the cost of the PV plant operation.

In addition, the floating solar power plant may also be used to power up sea-based industries such as desalination plants, food/fishing industries, and offshore oil and gas industries.

It should be clear that although the present disclosure has been described with reference to specific exemplary embodiments, various modifications may be made to the embodiments without departing from the scope of the invention as laid out in the claims. For example, while the floating apparatus 1000 is described as being deployed out at sea, this may not be the case, and the floating platform 1000 may be deployed on other water bodies such as lakes or reservoirs.

Furthermore, the mooring mechanism may not be a part of the floating apparatus. The mooring mechanism may be available on-site to be attached to the floating apparatus instead. Alternatively, the mooring mechanism may not be necessary at all when the floating apparatus is deployed on other water bodies.

Additionally, the output of the transformer unit may be connected to the energy storage device, instead of being connected to the power grid. The solar modules 1010 may be any type of solar modules. For example, the solar modules 1010 may be monofacial instead of bifacial solar modules. Furthermore, the material of the reflective material on the front surface 1202 of the platform 1200 may not be polytetrafluoroethylene (PTFE), but other similar types of material known to the skilled person.

Moreover, while the control unit is configured to independently operate the linearly adjustable support structures 1300a,1300b,1300c according to the information received from the motion sensors and the light sensors, the support structures 1300a,1300b,1300c may also be manually operated under abnormal conditions, such as a power failure, or when the control unit malfunctions.

CLAIMS

1. A floating apparatus for supporting solar modules, comprising

a floatation device operable to float in a water body;

a platform for supporting the solar modules; and

linearly adjustable support structures arranged to space the platform from the floatation device, each support structure being independently operable to adjust a respective relative distance between the platform and the floatation device.

2. A floating apparatus according to claim 1, wherein the floatation device includes multiple floatation units.

3. A floating apparatus according to claim 2, wherein the floatation device further includes connectors for joining the floatation units together.

4. A floating apparatus according to claim 3, wherein the connectors include connector plates that are disposed on an exterior surface of the floatation units.

5. A floating apparatus according to claim 4, wherein the connector plates include grooved fittings.

6. A floating apparatus according to claim 4 or 5, wherein the connector plates are disposed on top of adjacent floatation units.

7. A floating apparatus according to any one of claims 4 to 6, wherein the connector includes connector strings that are partially embedded within the floatation units.

8. A floating apparatus according to claim 4 or 5, wherein the connector plates are disposed between adjacent floatation units.

9. A floating apparatus according to any preceding claim, wherein the floatation device is donut shaped.

10. A floating apparatus according to any preceding claim, wherein the platform includes grooves configured to receive the solar modules within the grooves.

11. A floating apparatus according to claim 10, wherein the platform further includes support hooks disposed within the grooves.

12. A floating apparatus according to any preceding claim, wherein the platform is coated with a reflective material made of polytetrafluoroethylene.

13. A floating apparatus according to any preceding claim, wherein each support structure includes an adjustable column, and wherein an end of the adjustable column is attached to the platform, and an opposing end of the adjustable column is attached to a respective connector interface of the floatation device.

14. A floating apparatus according to claim 13, wherein each adjustable column includes a lifting mechanism for adjusting the respective relative distance between the platform and the floatation device.

15. A floating apparatus according to claim 14, wherein the lifting mechanism is hydraulic powered.

16. A floating apparatus according to any one of claims 13 to 15, wherein each adjustable column further includes a damping mechanism.

17. A floating apparatus according to claim 16, wherein the damping mechanism is a mechanical shock absorber, a hydraulic shock absorber or a combination of the mechanical shock absorber and the hydraulic shock absorber.

18. A floating apparatus according to any preceding claim, further comprising motion sensors for detecting wave motion, wind direction, or ship movement.

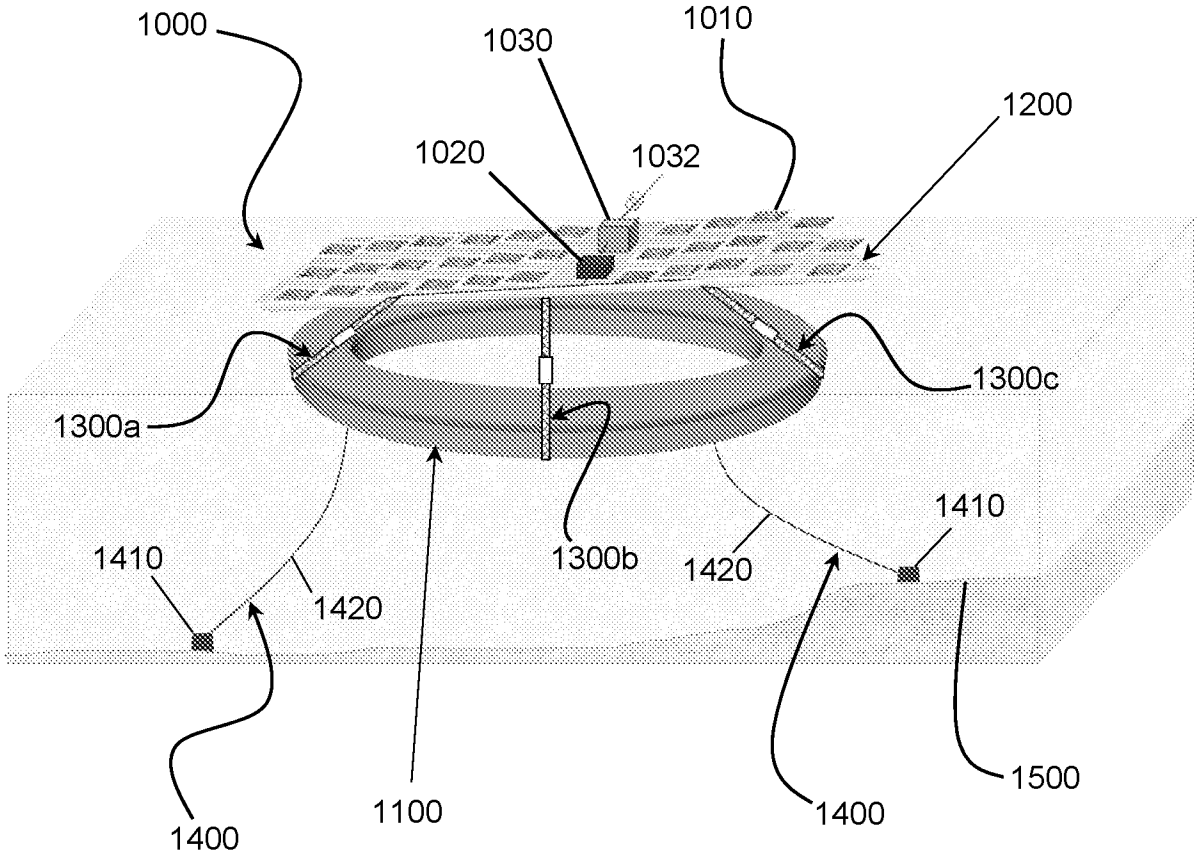
19. A floating apparatus according to any preceding claim, further comprising light sensors for detecting solar irradiation.

20. A floating apparatus according to claim 18 or 19, further comprising a control unit configured to receive information from the sensors, and to independently operate each support structure to adjust a respective relative distance between the platform and the floatation device based on the information received.

21. A floating apparatus according to any preceding claim, further comprising an energy storage device for storing electrical energy produced by the solar modules.

22. A floating apparatus according to any preceding claim, further comprising solar modules.

23. A method of operating a floating apparatus for supporting solar modules, the floating apparatus including a floatation device operable to float in a water body, a platform for supporting the solar modules, and linearly adjustable support structures arranged to space the platform from the floatation device, the method comprising independently operating each support structure to adjust a respective relative distance between the platform and the floatation device.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1300c
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1420
1300b
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1100
1400

Figure 1

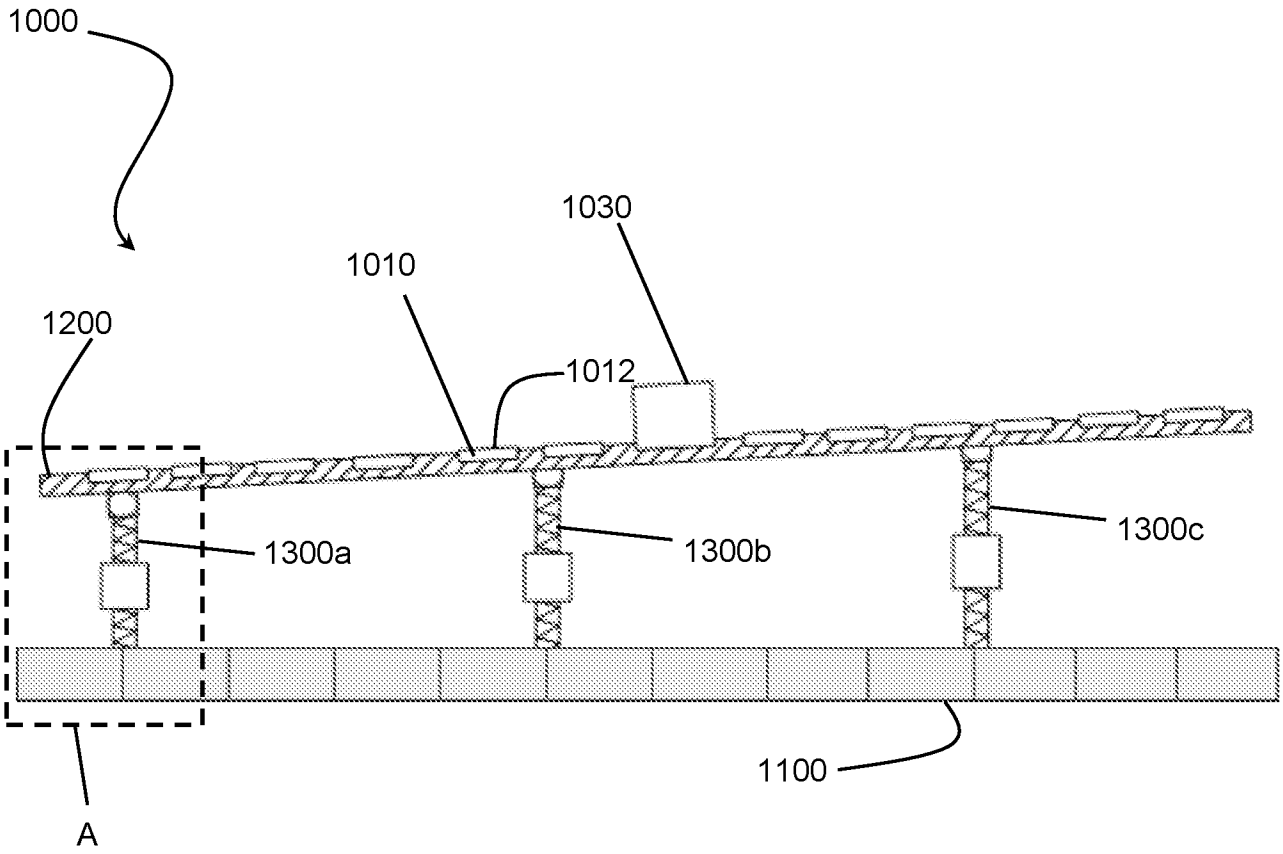


Figure 2

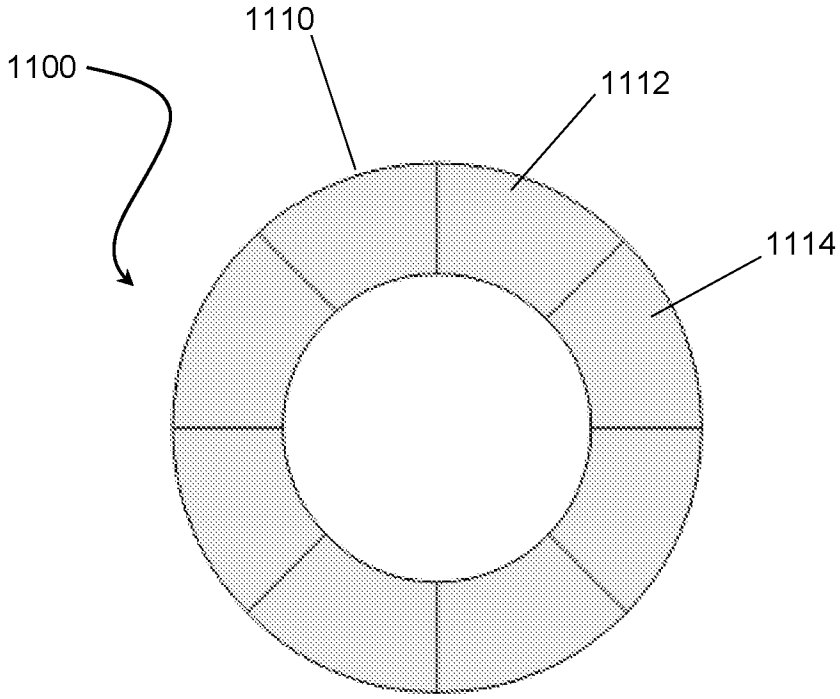


Figure 3A

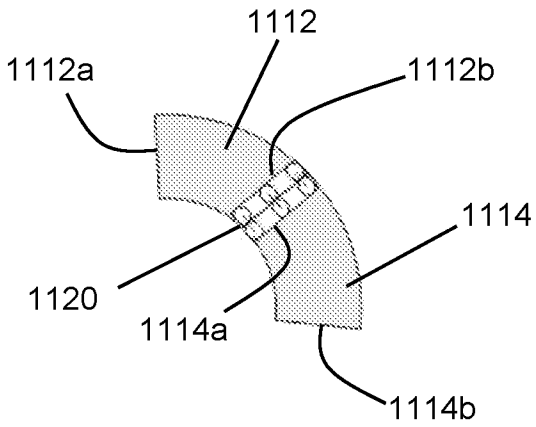


Figure 3B

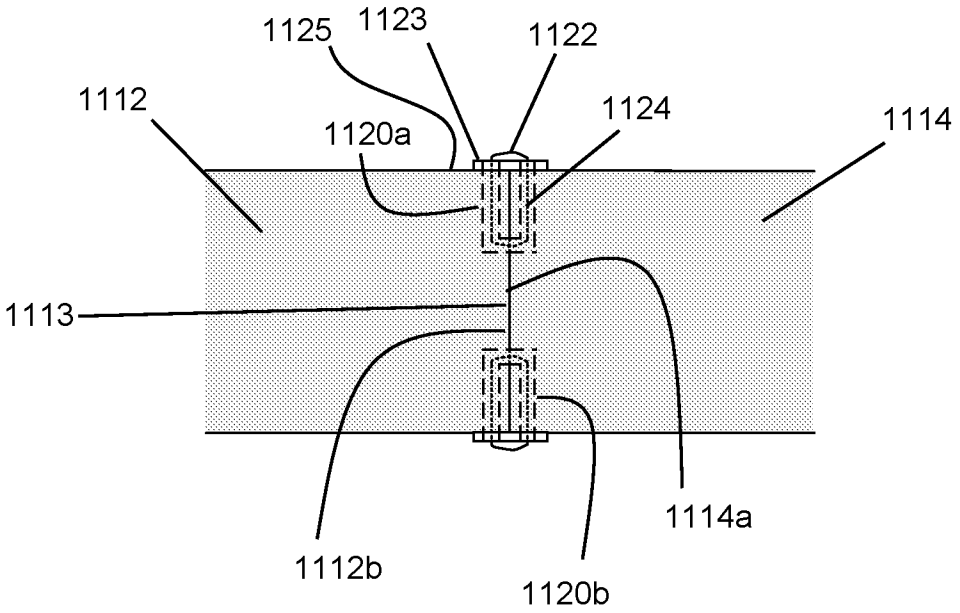


Figure 3C

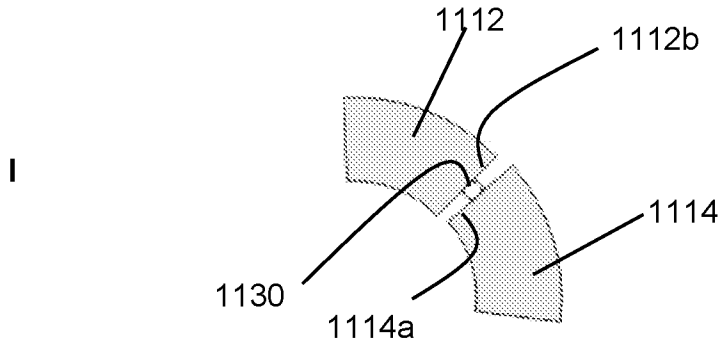


Figure 3D

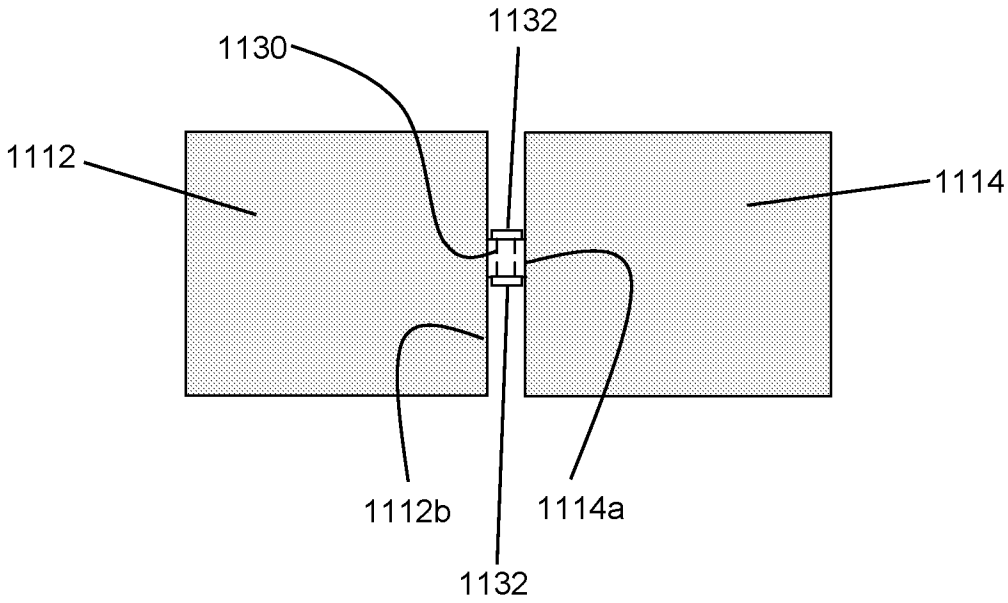


Figure 3E

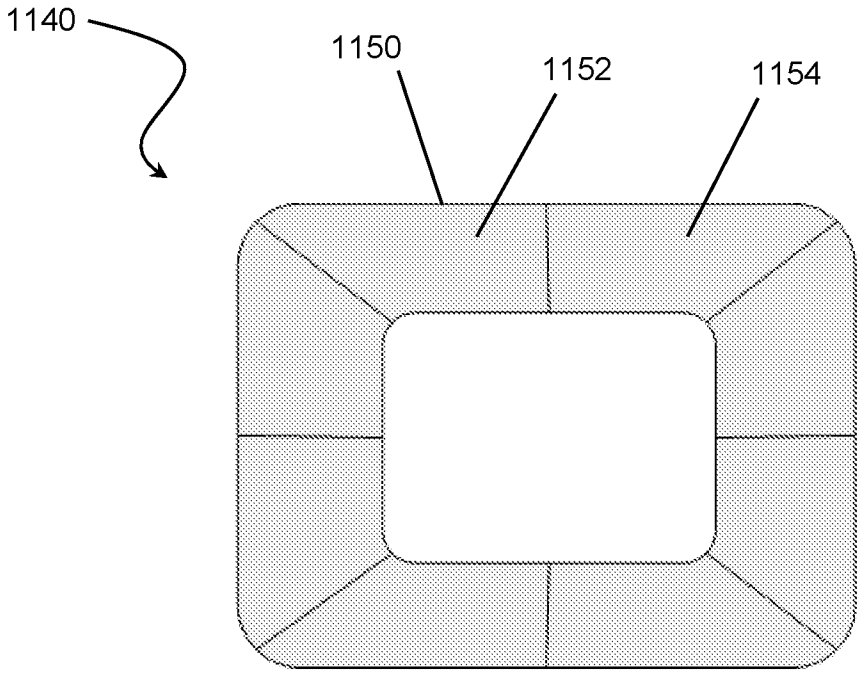


Figure 4A

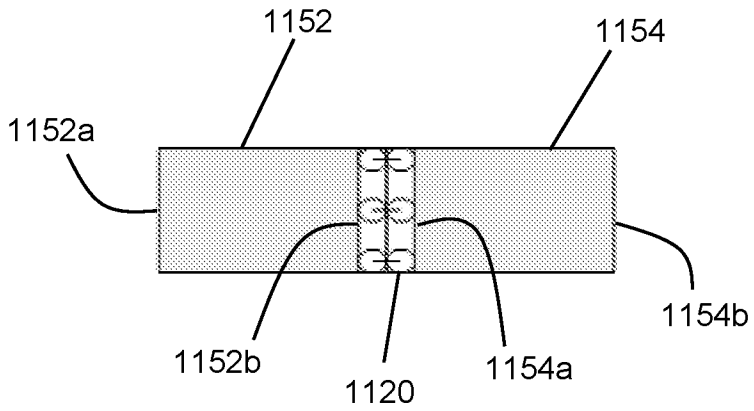


Figure 4B

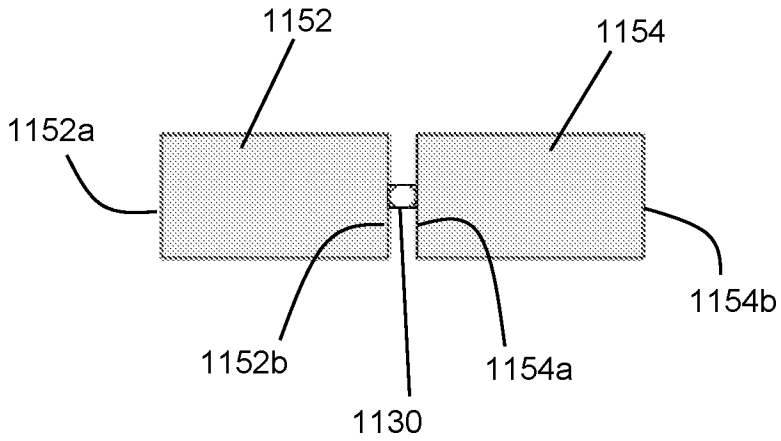
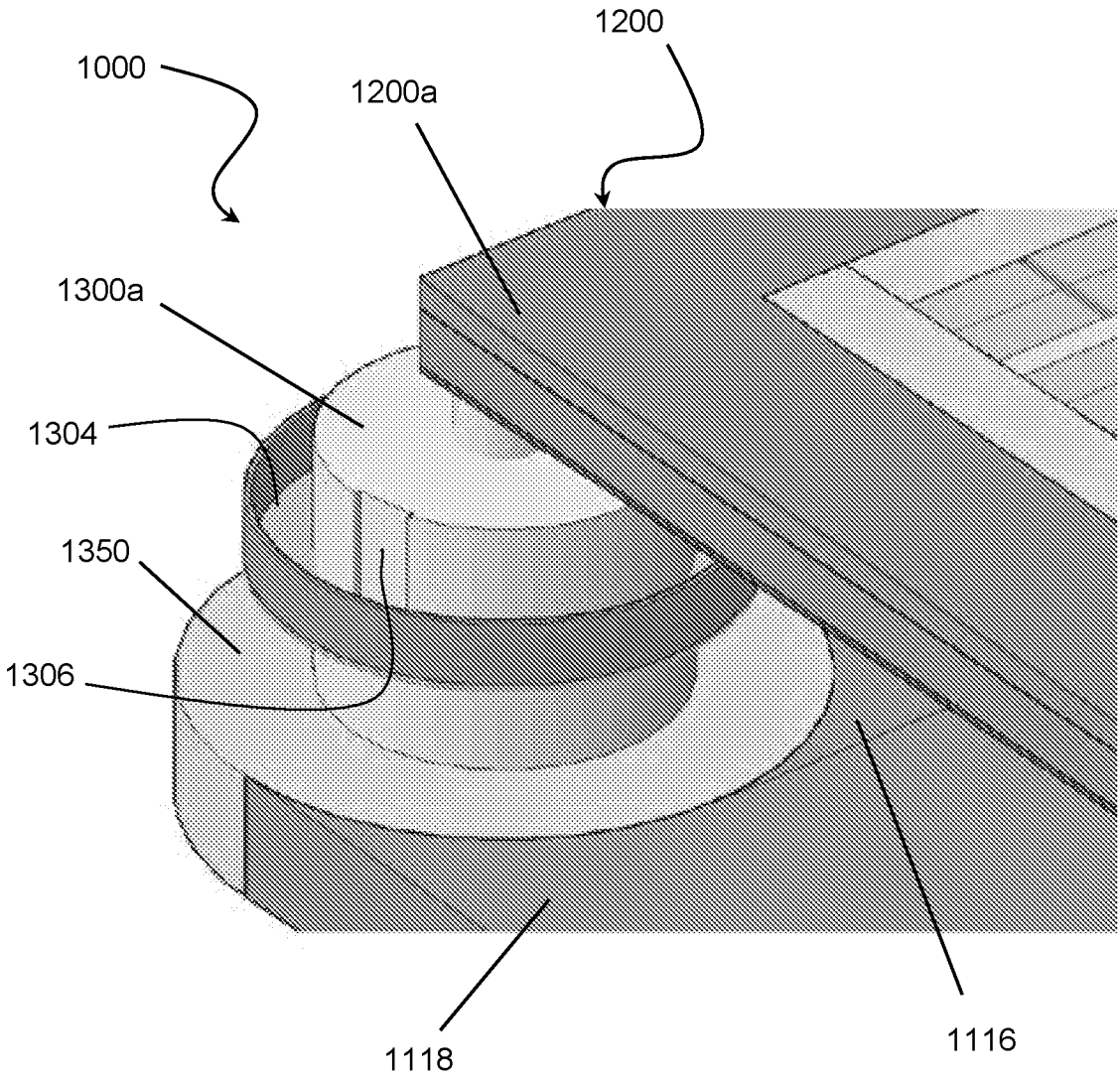


Figure 4C



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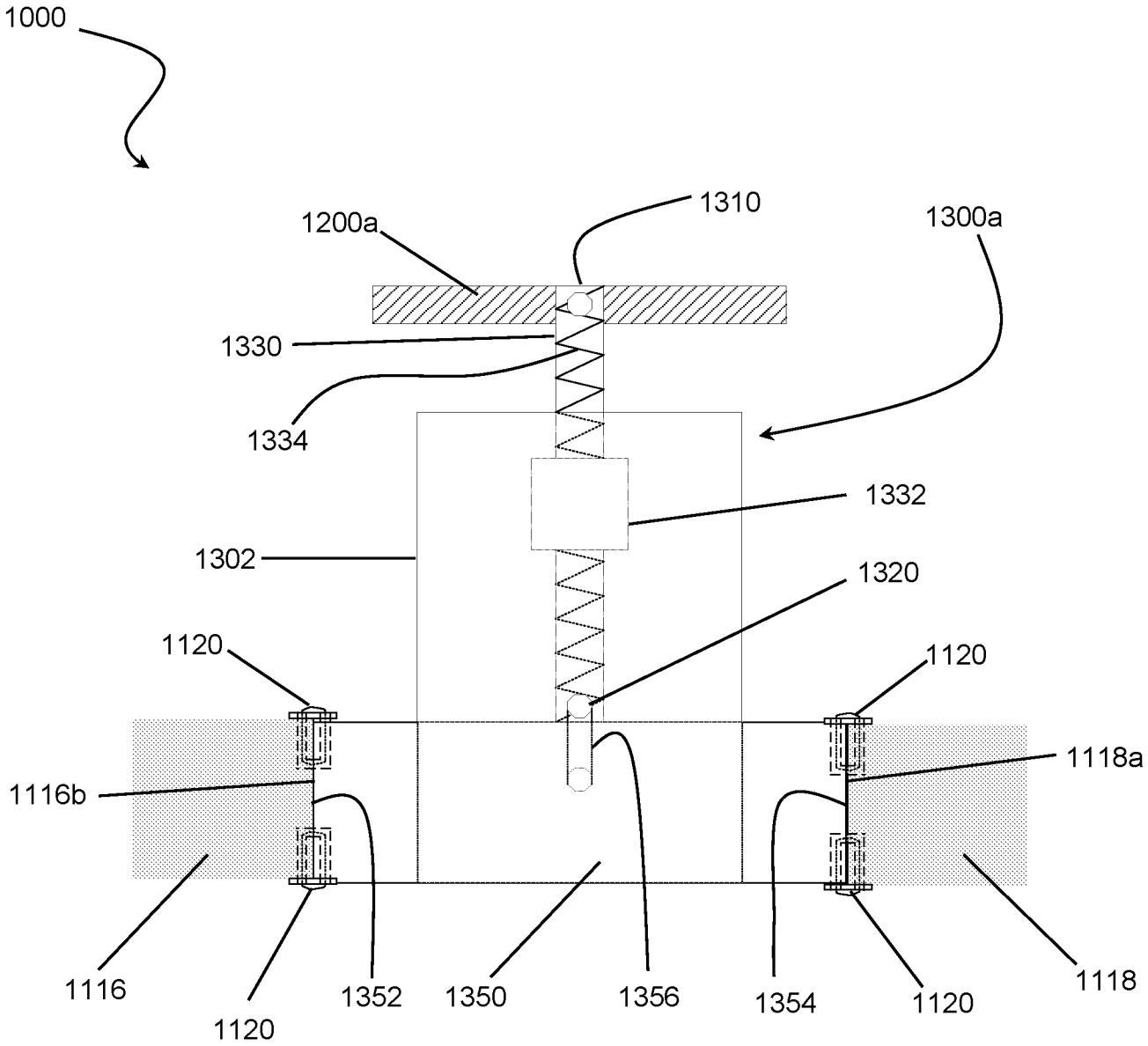
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1118

Figure 5B

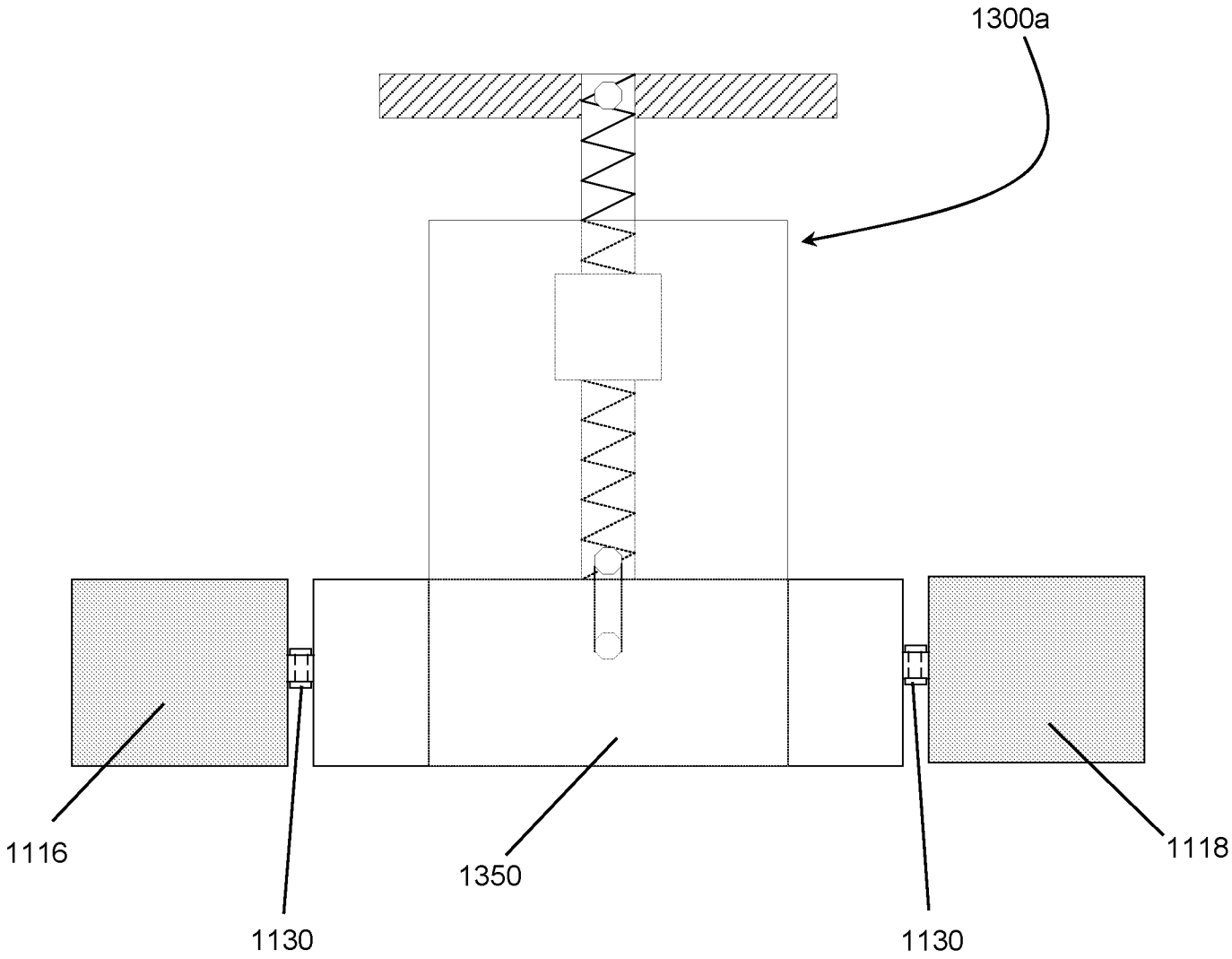
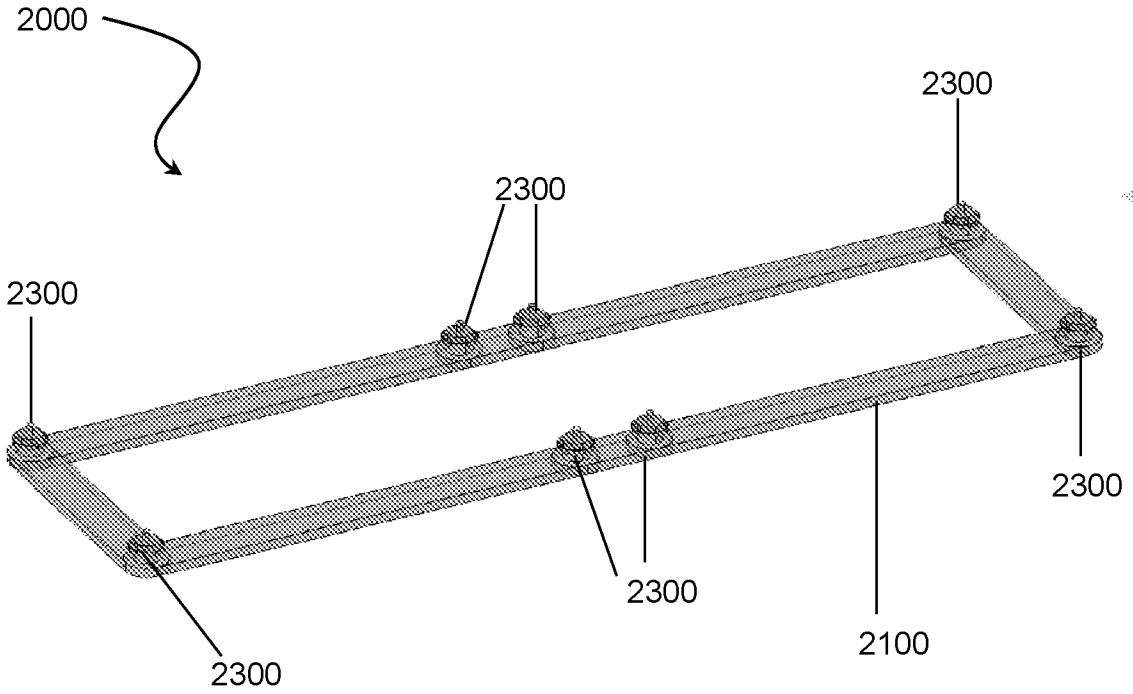


Figure 5C



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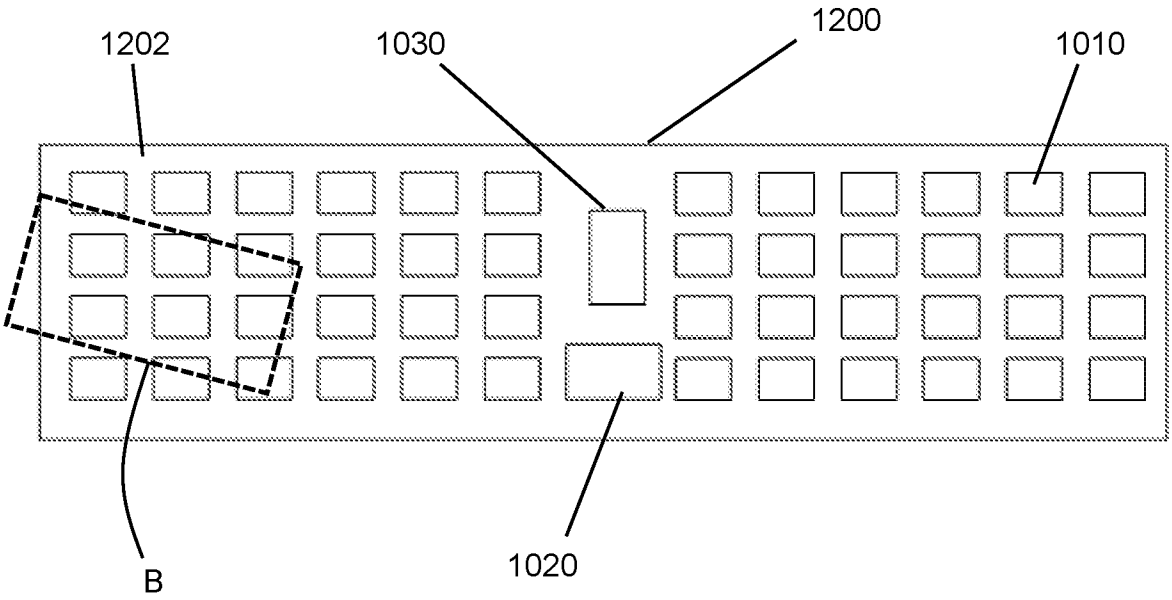


Figure 7

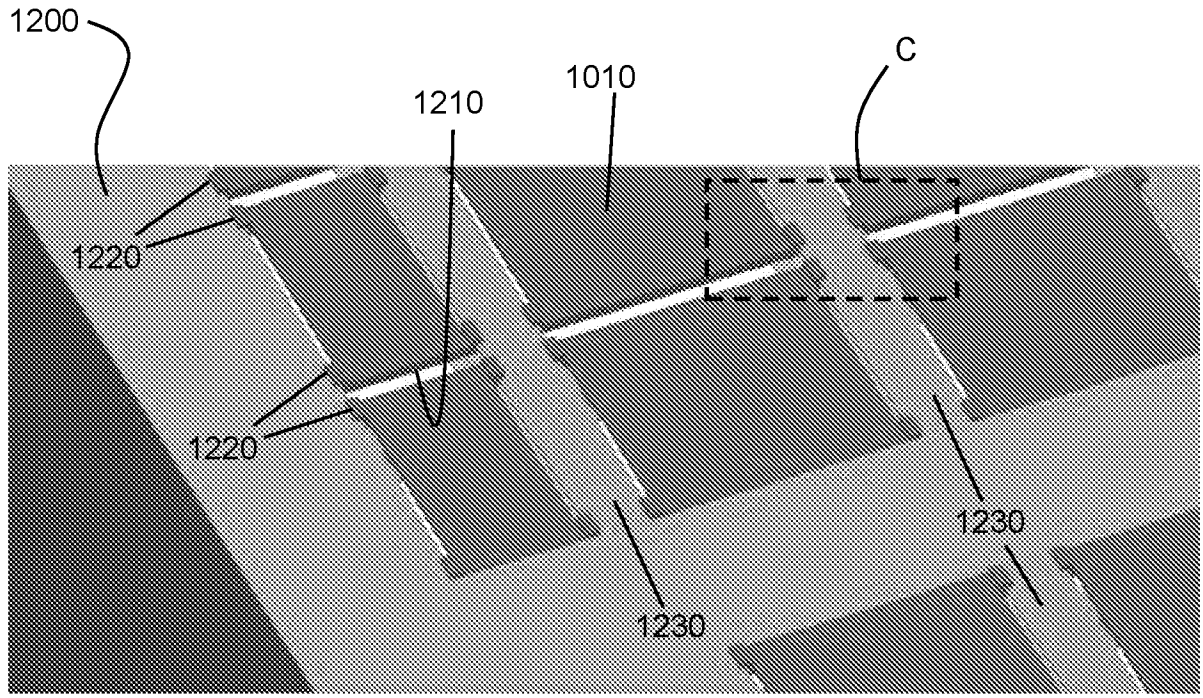


Figure 8A

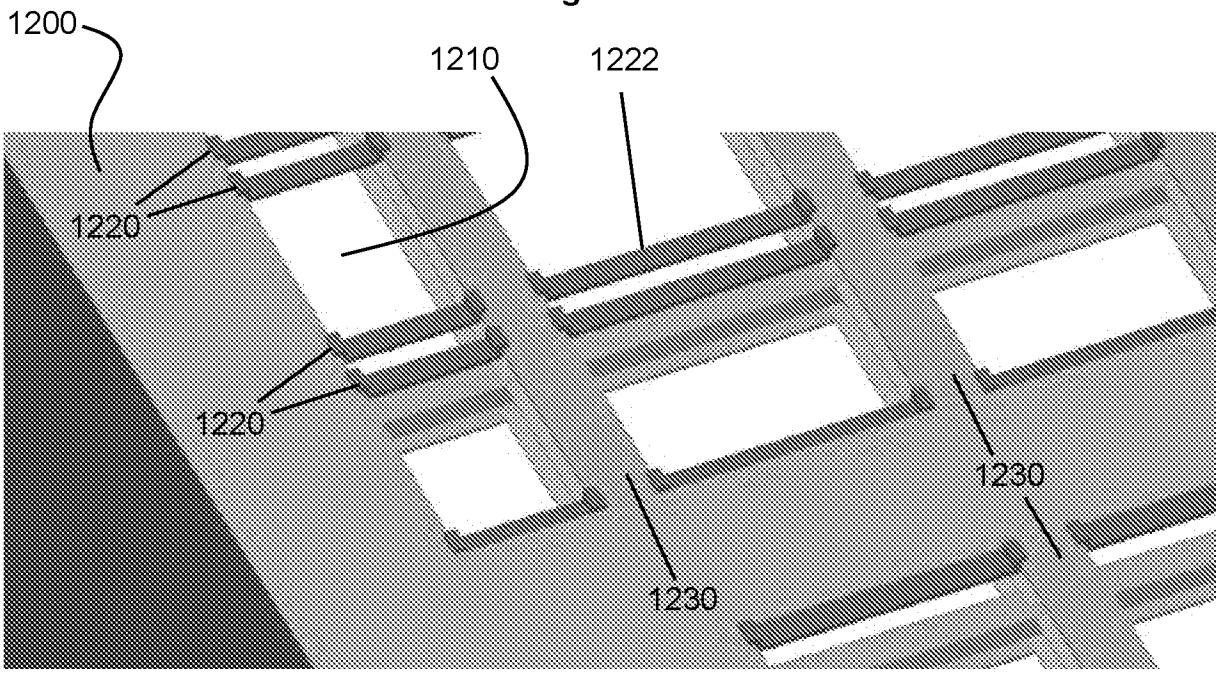


Figure 8B

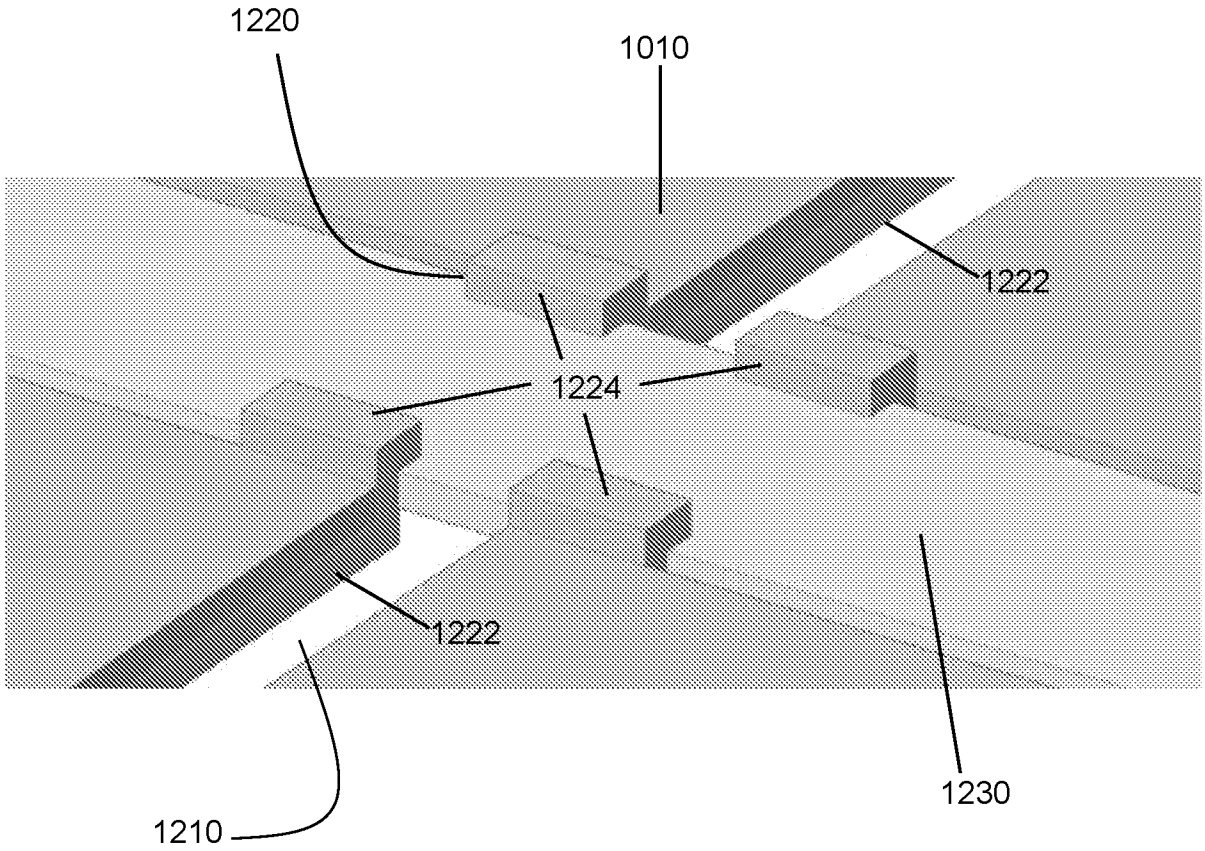


Figure 8C

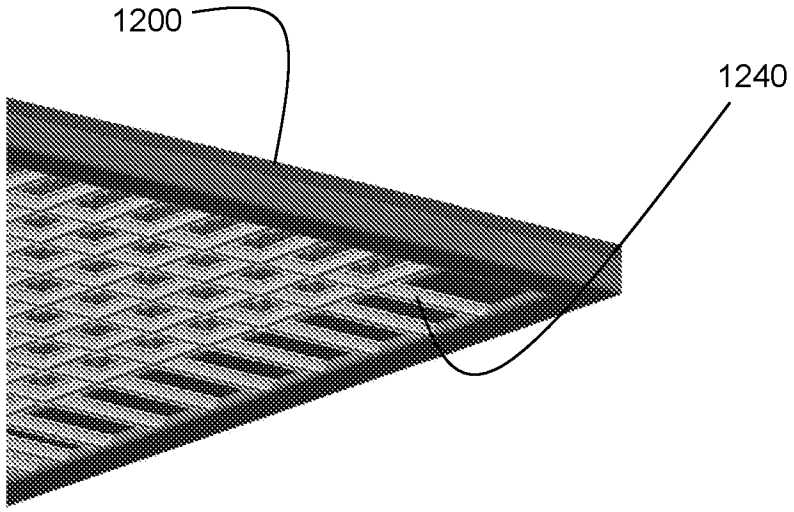


Figure 9A

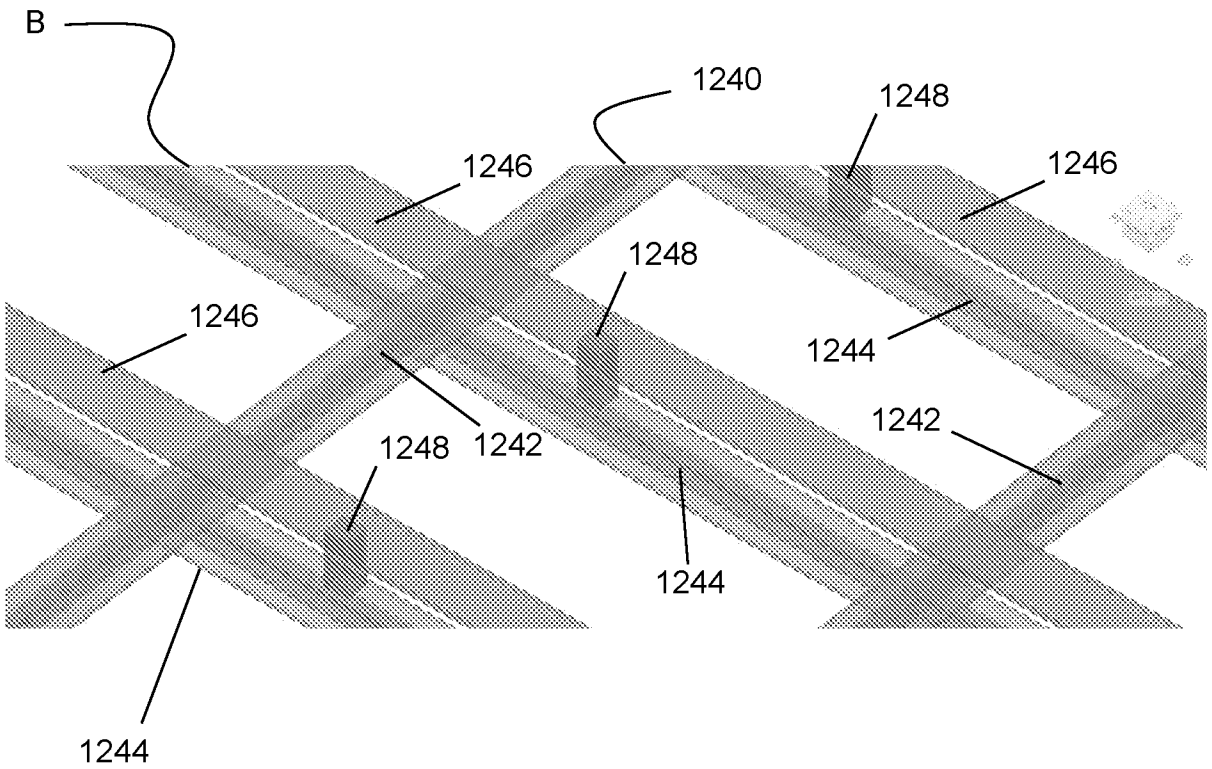
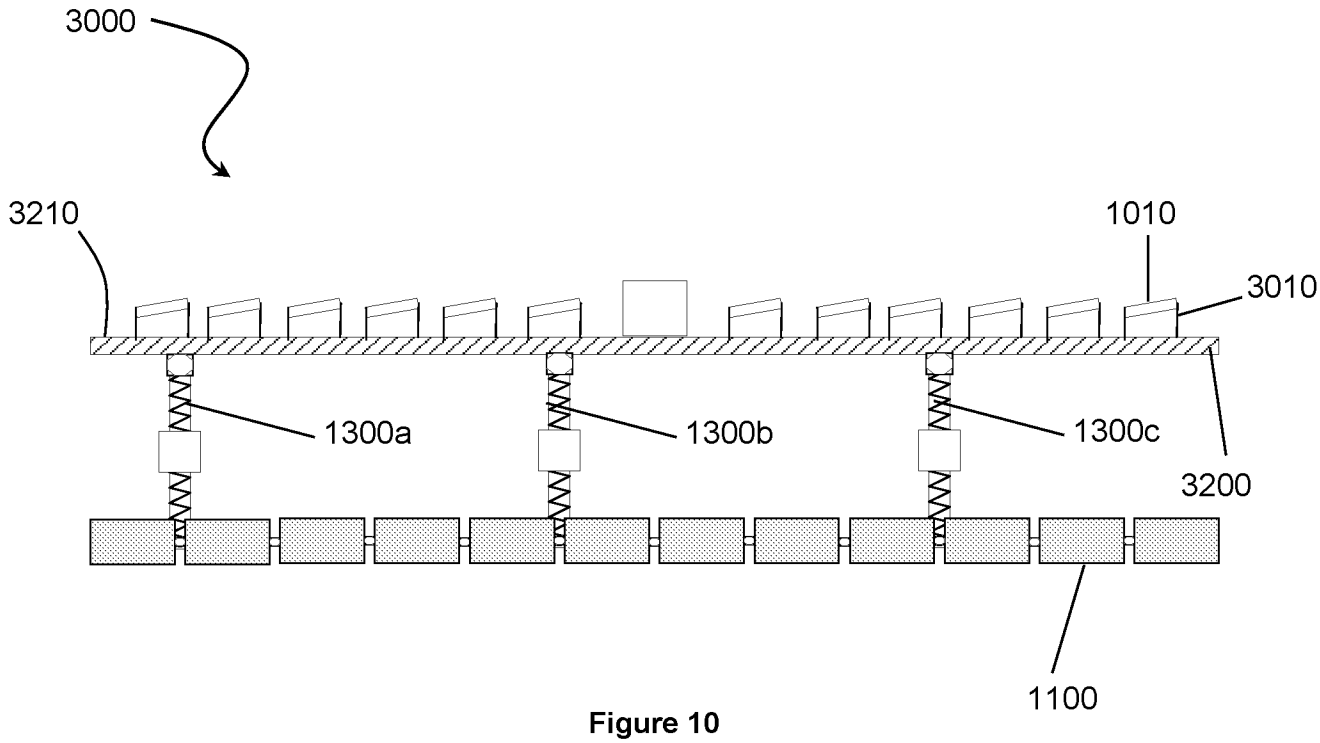


Figure 9B



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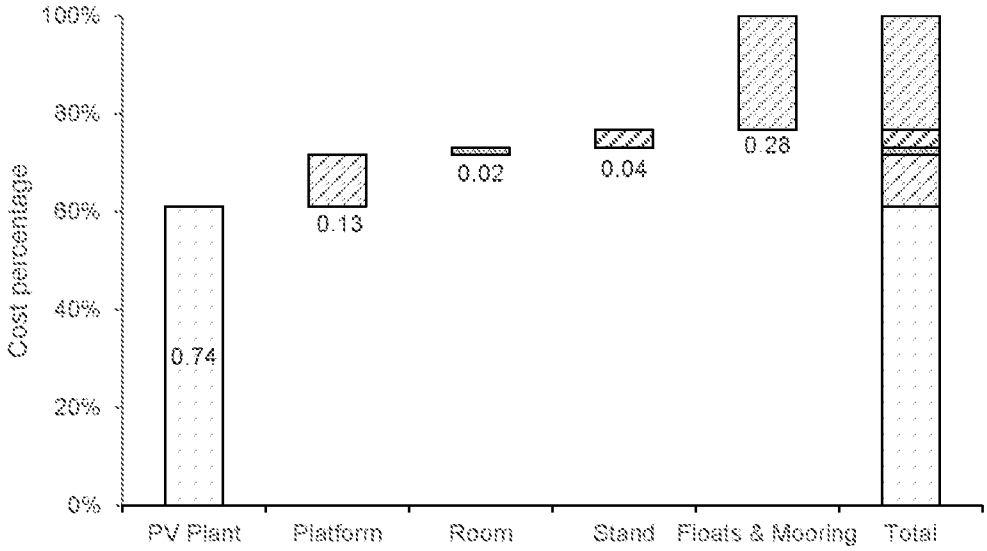
100%
80%
60%
40%
20%
0%
Cost percentage
0.74
0.13
0.02
0.04
0.28
PV Plant
Platform
Room
Stand
Floats & Mooring
Total

Figure 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SG2021/050334

A. CLASSIFICATION OF SUBJECT MATTER

H02S 20/30 (2014.01) *F24S 20/70 (2018.01)* *B63B 35/44 (2006.01)*

According to International Patent Classification (IPC)

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H02S; F24S; B63B

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)

FAMPAT: floating apparatus, waterborne, buoyant, solar power plant, photovoltaic panel, support, column, adjustable, shiftable, slidable, independently, self-driven, 浮体, 太阳能电池板, 支架, 可伸缩, 独立 and related terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 209459246 U (UNIV HEBEI TECHNOLOGY) 1 October 2019 Figs. 1-2; pars. [0009]-[0024] of the original non-English language document (a machine translation is enclosed **only** for your reference)	1-23
A	CN 109525179 A (SHAANXI SHENGGAO POWER CONSTRUCTION ENG CO LTD) 26 March 2019 Whole document of the original non-English language document (a machine translation is enclosed **only** for your reference)	
A	KR 101817228 B2 (WP CO LTD) 10 January 2018 Whole document of the machine translation	
A	CN 107054577 A (CHANGZHOU TRINA SOLAR ENERGY) 18 August 2017 Whole document of the original non-English language document (a machine translation is enclosed **only** for your reference)	

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

*Special categories of cited documents:

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"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
10/08/2021 *(day/month/year)*	*11/08/2021* *(day/month/year)*

Name and mailing address of the ISA/SG

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/SG2021/050334

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

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 209459246 U	01/10/2019	NONE	
CN 109525179 A	26/03/2019	NONE	
KR 101817228 B2	10/01/2018	WO 2019/088350 A1	09/05/2019
CN 107054577 A	18/08/2017	NONE	