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Perryman

(54) **NON-TRACKING SOLAR RADIATION COLLECTOR**

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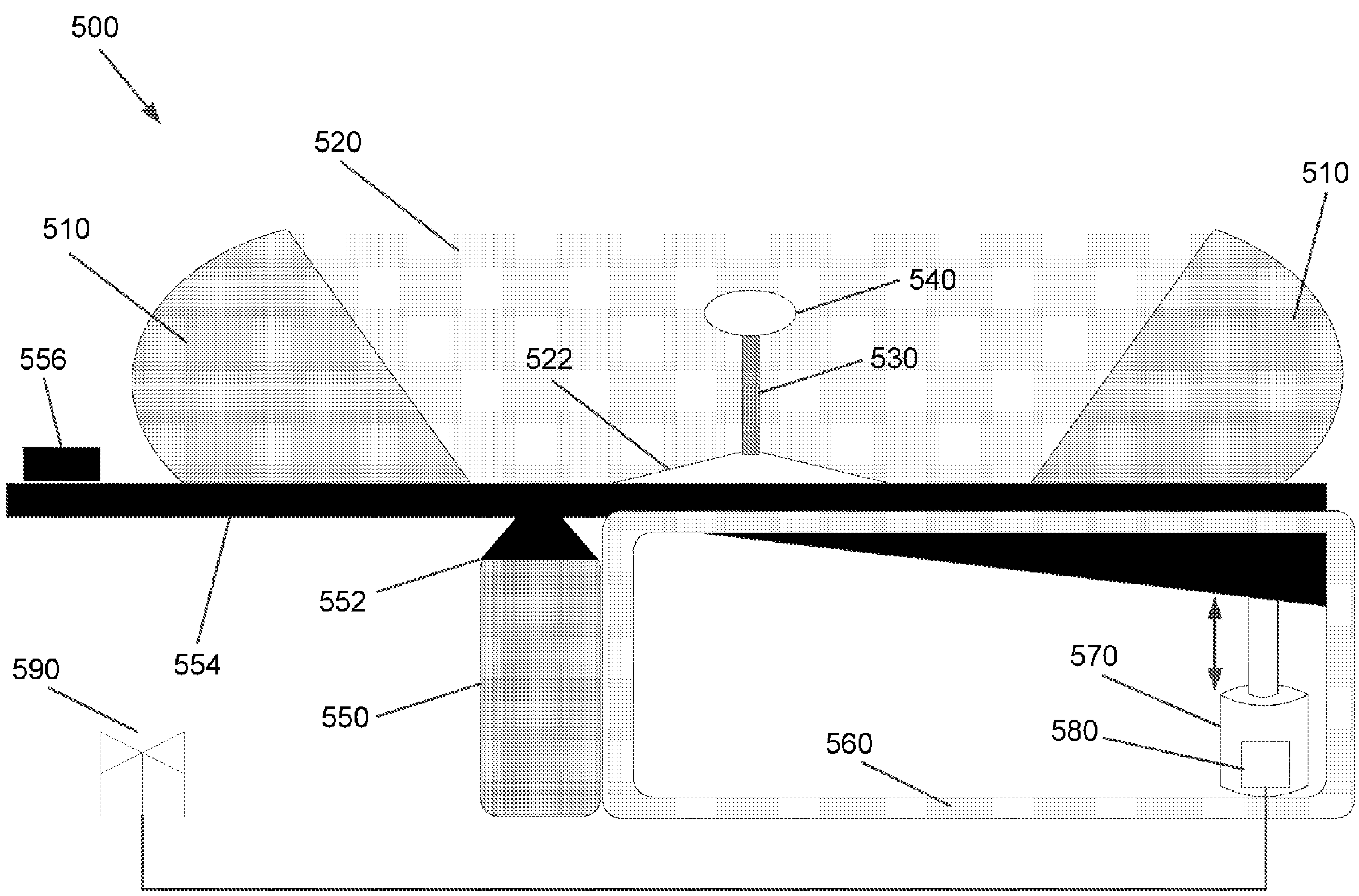
USPC **126/605**; 126/690; 126/698

(57) **ABSTRACT**

A solar collection system includes a double parabolic reflector and a light trap. The solar collection system also includes a lens configured to receive light from the double parabolic reflector and focus the reflected light into the light trap. The system may be configured to resist seismic activity and extreme weather conditions.



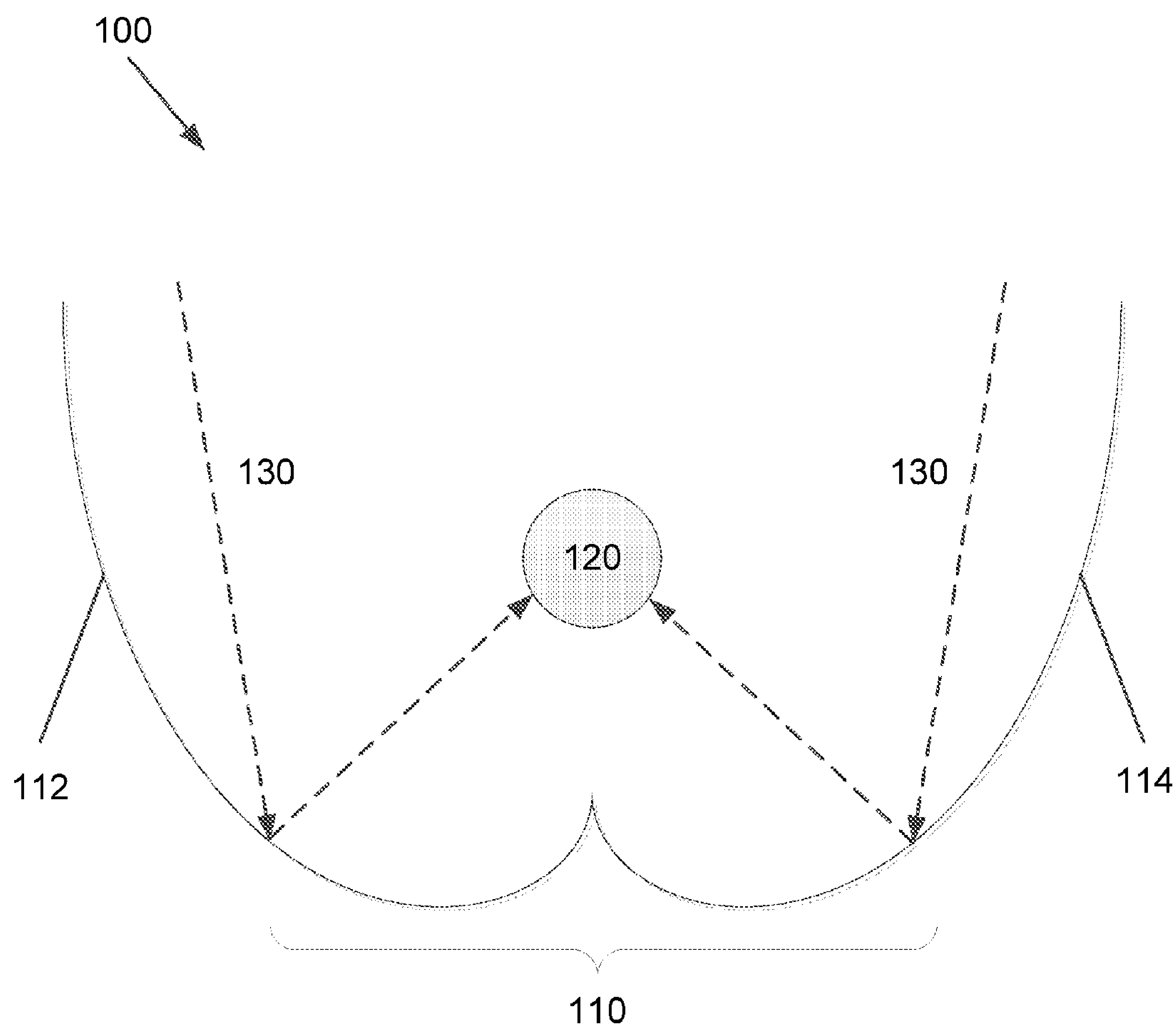

100
130
130
120
112
114
110

FIG. 2

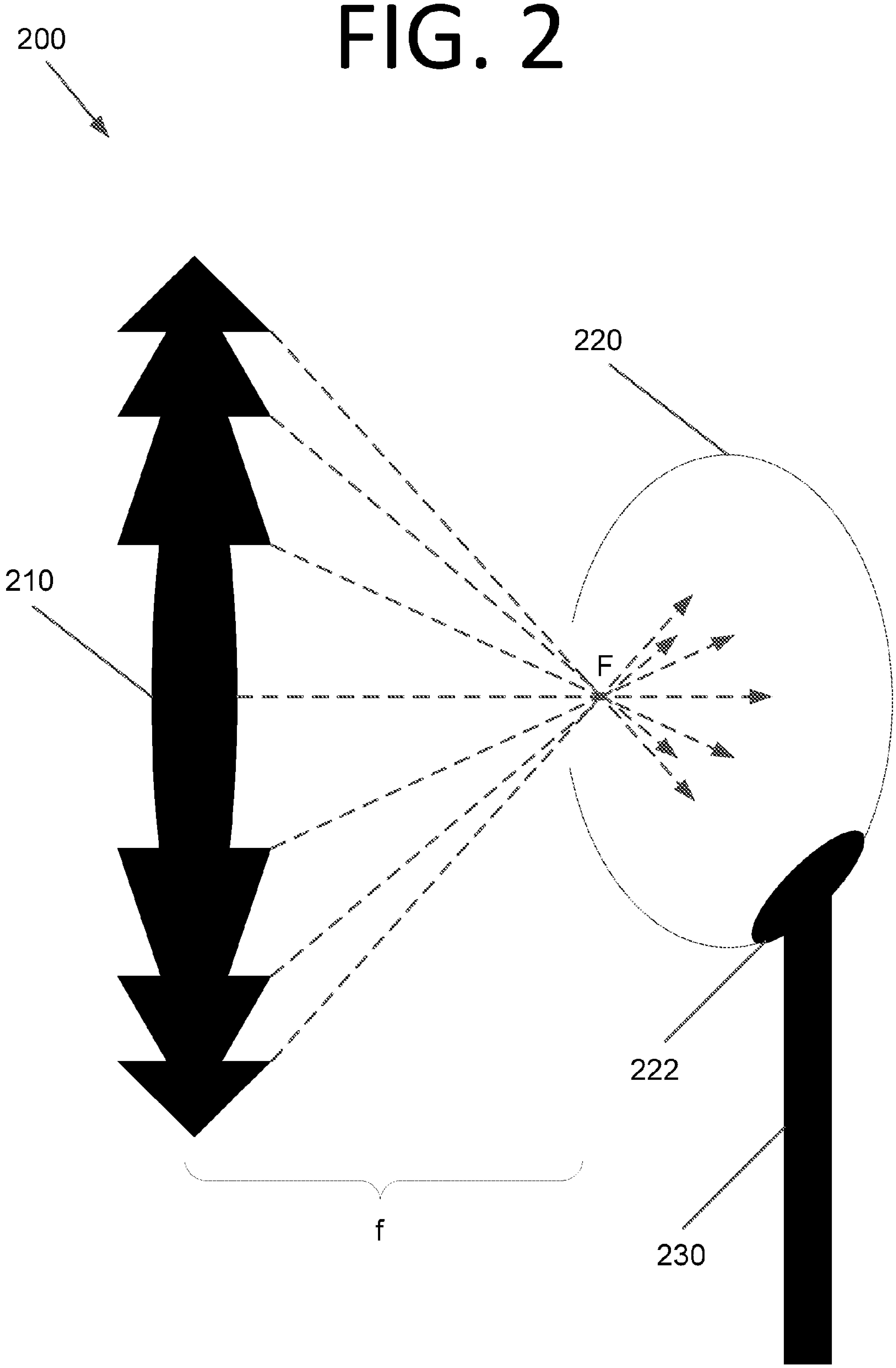


FIG. 3

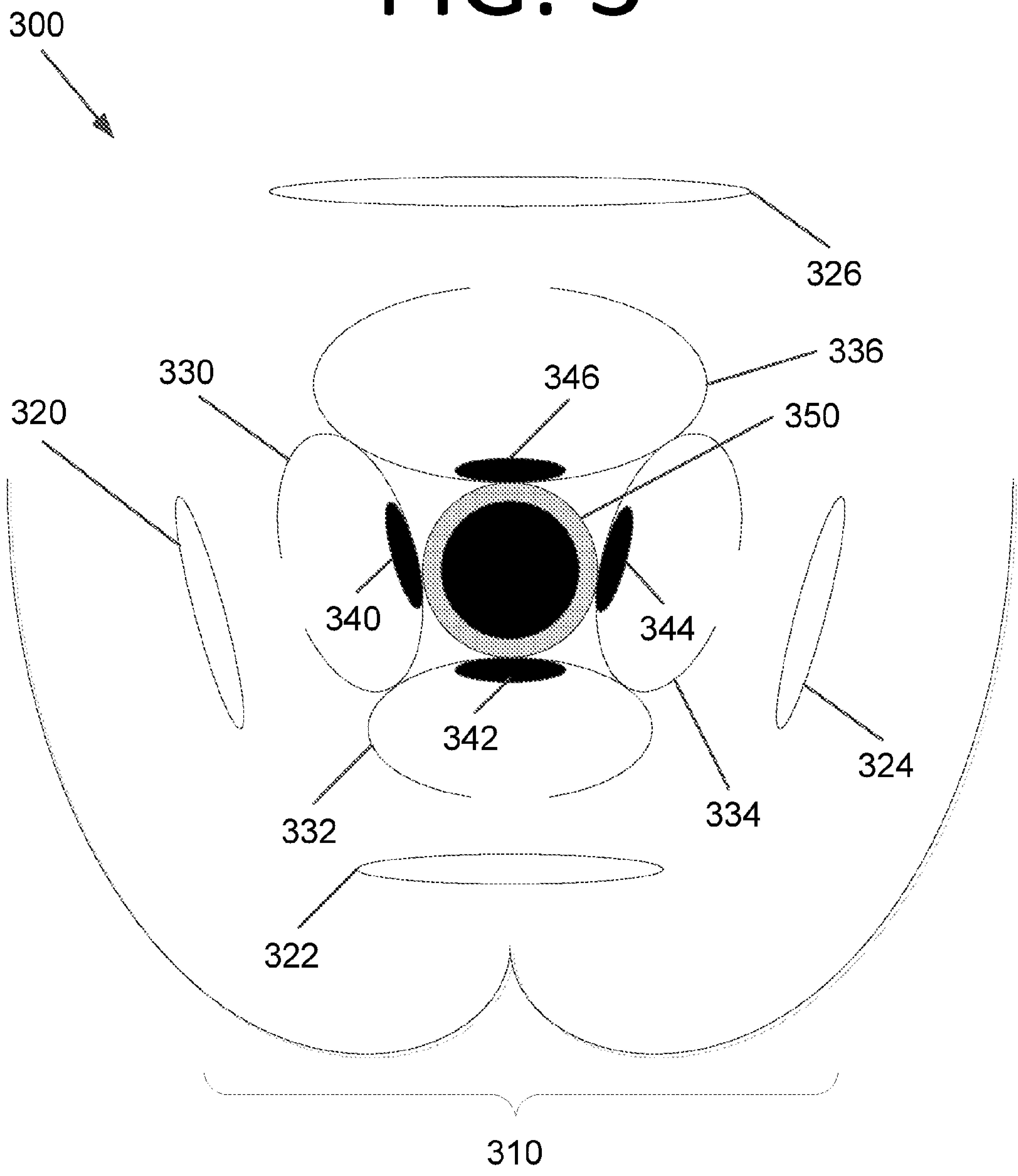


FIG. 4

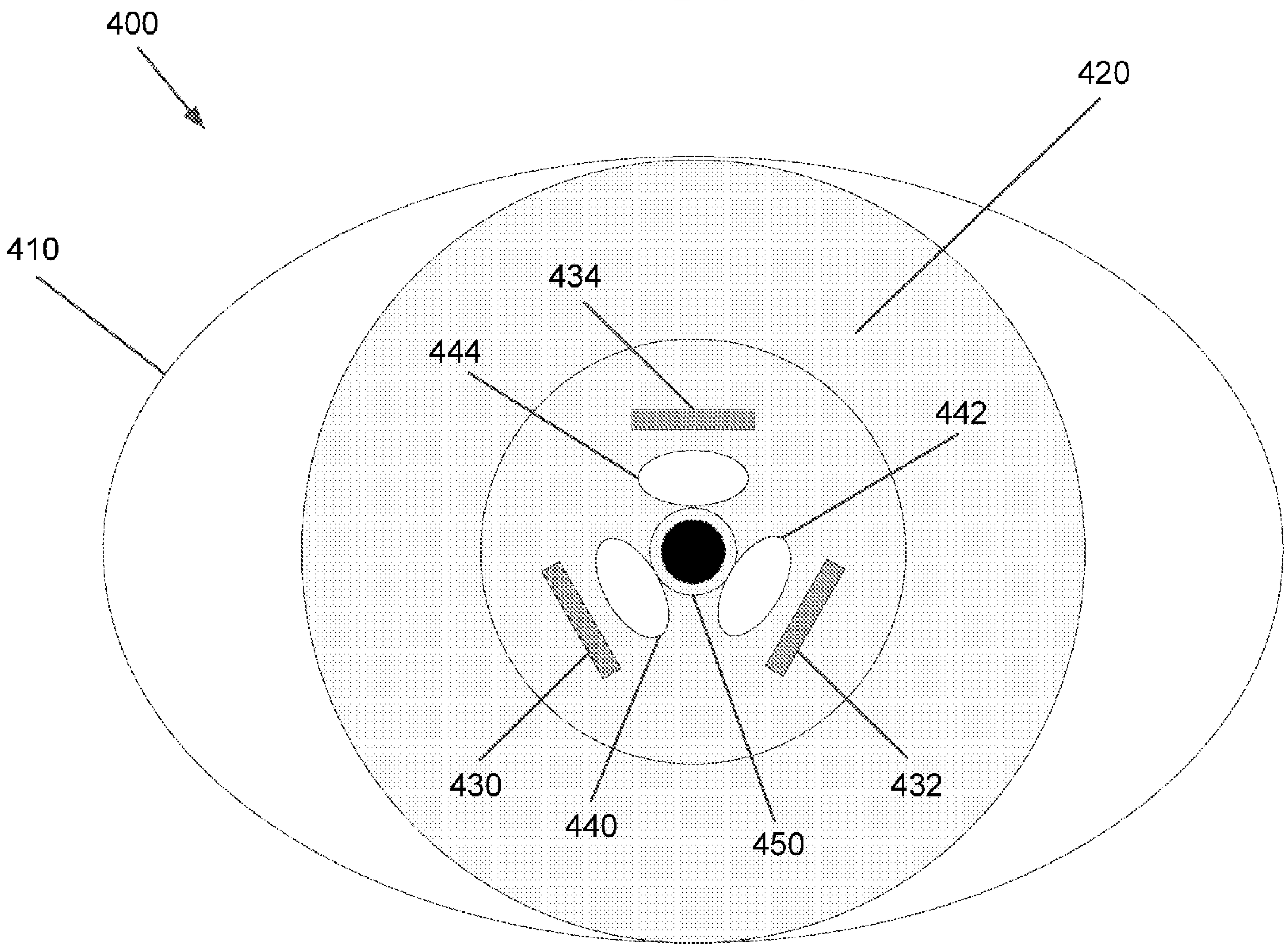


FIG. 5A

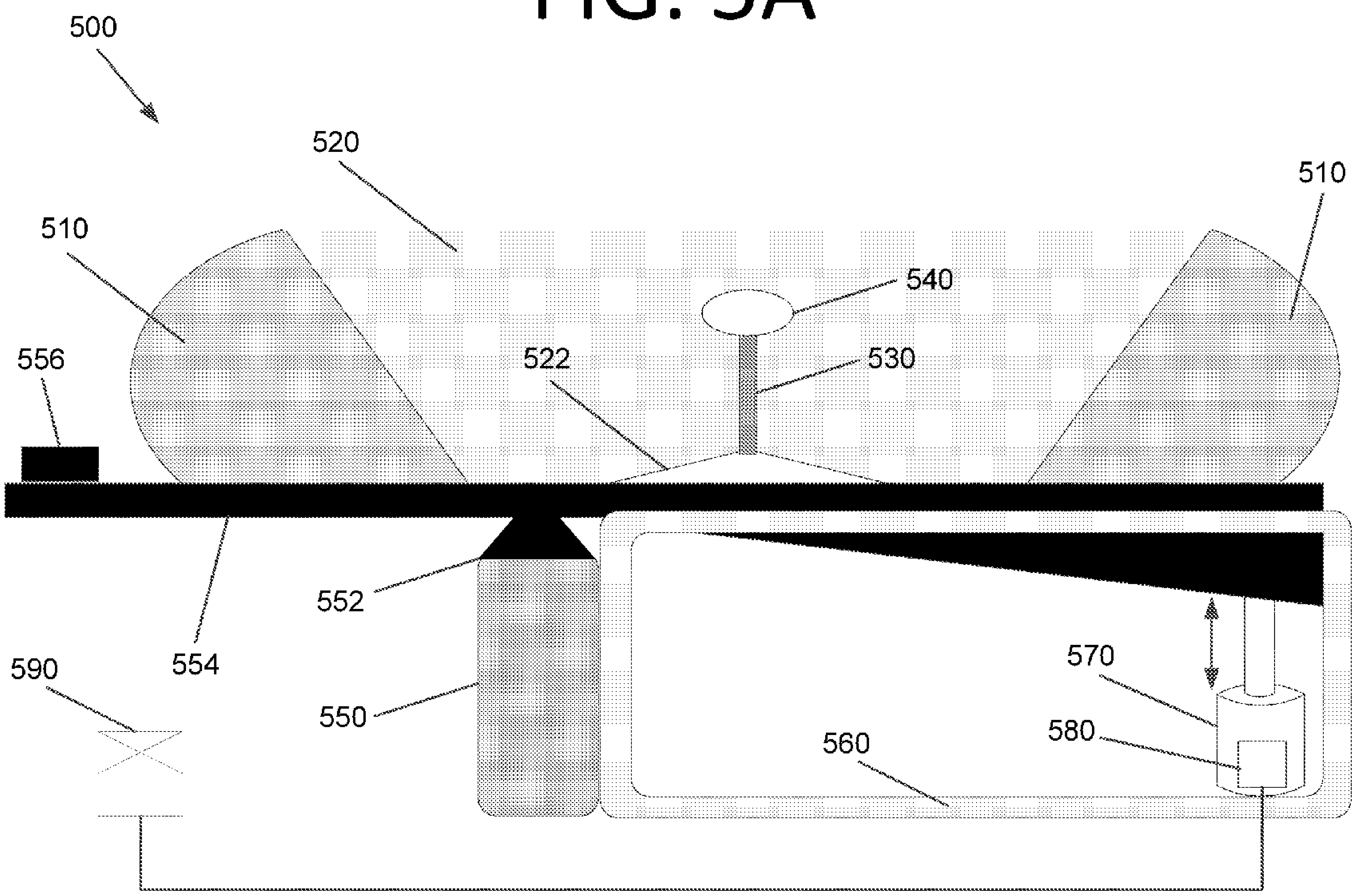


FIG. 5B

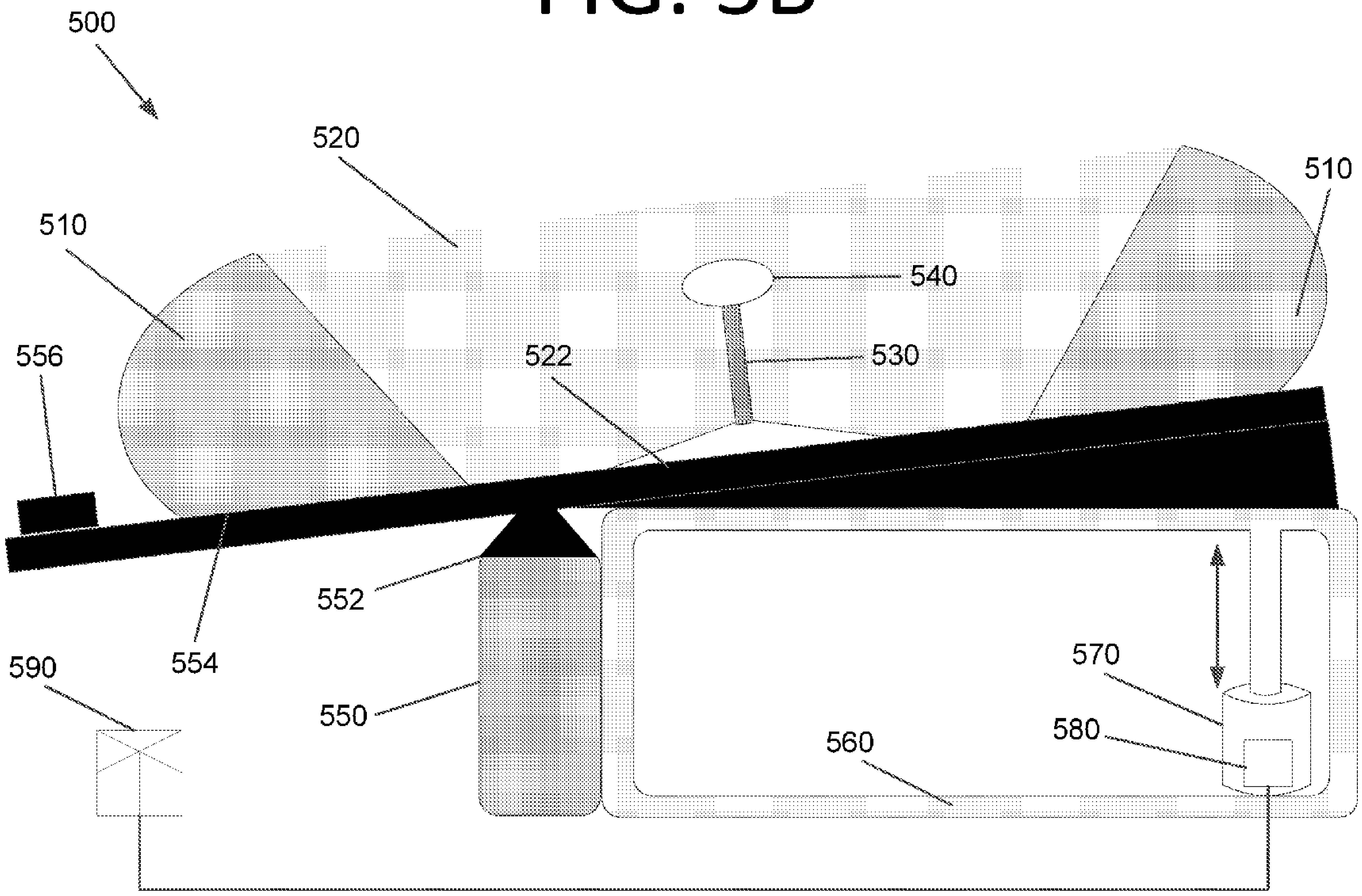


FIG. 6

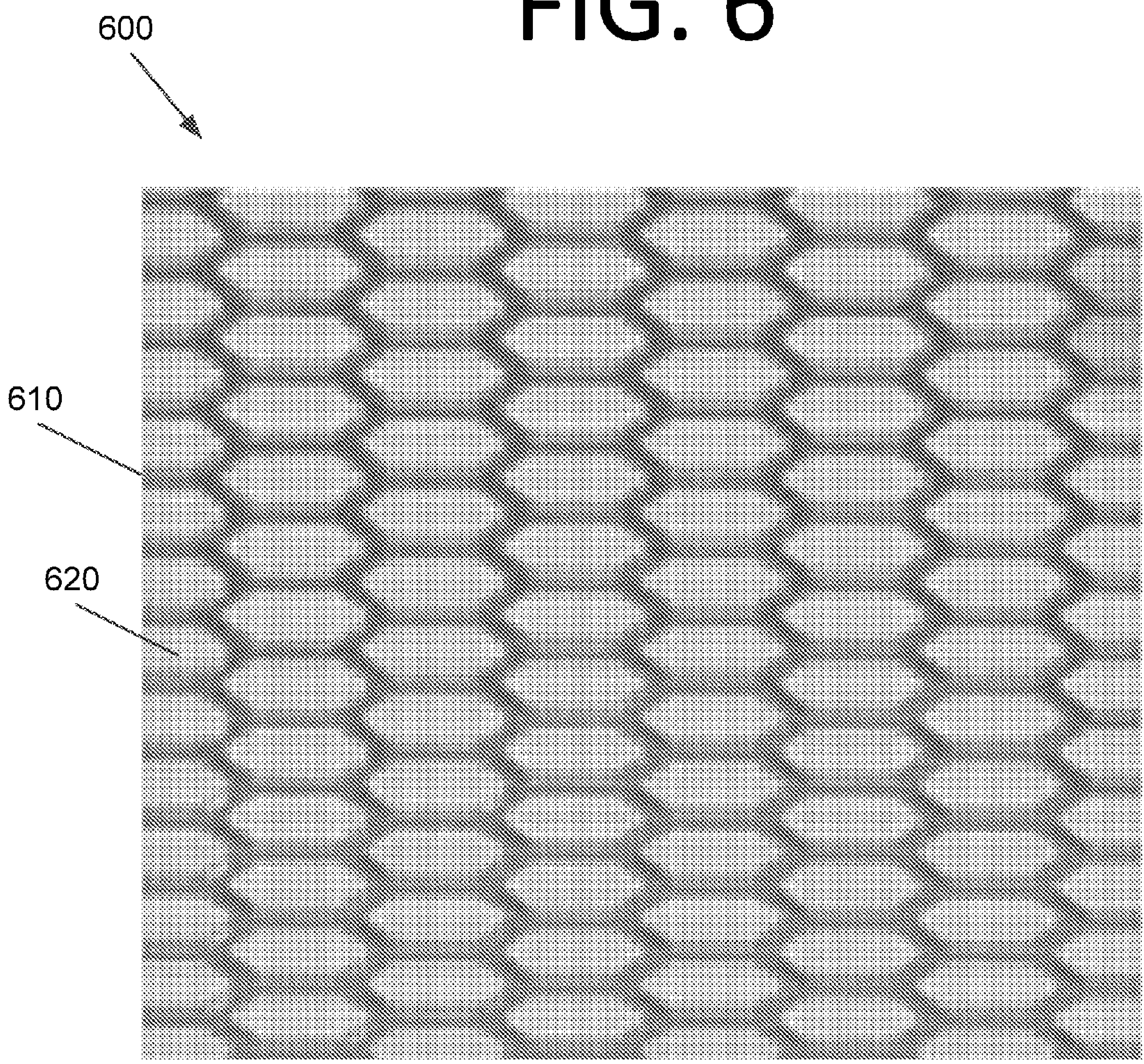


FIG. 7A

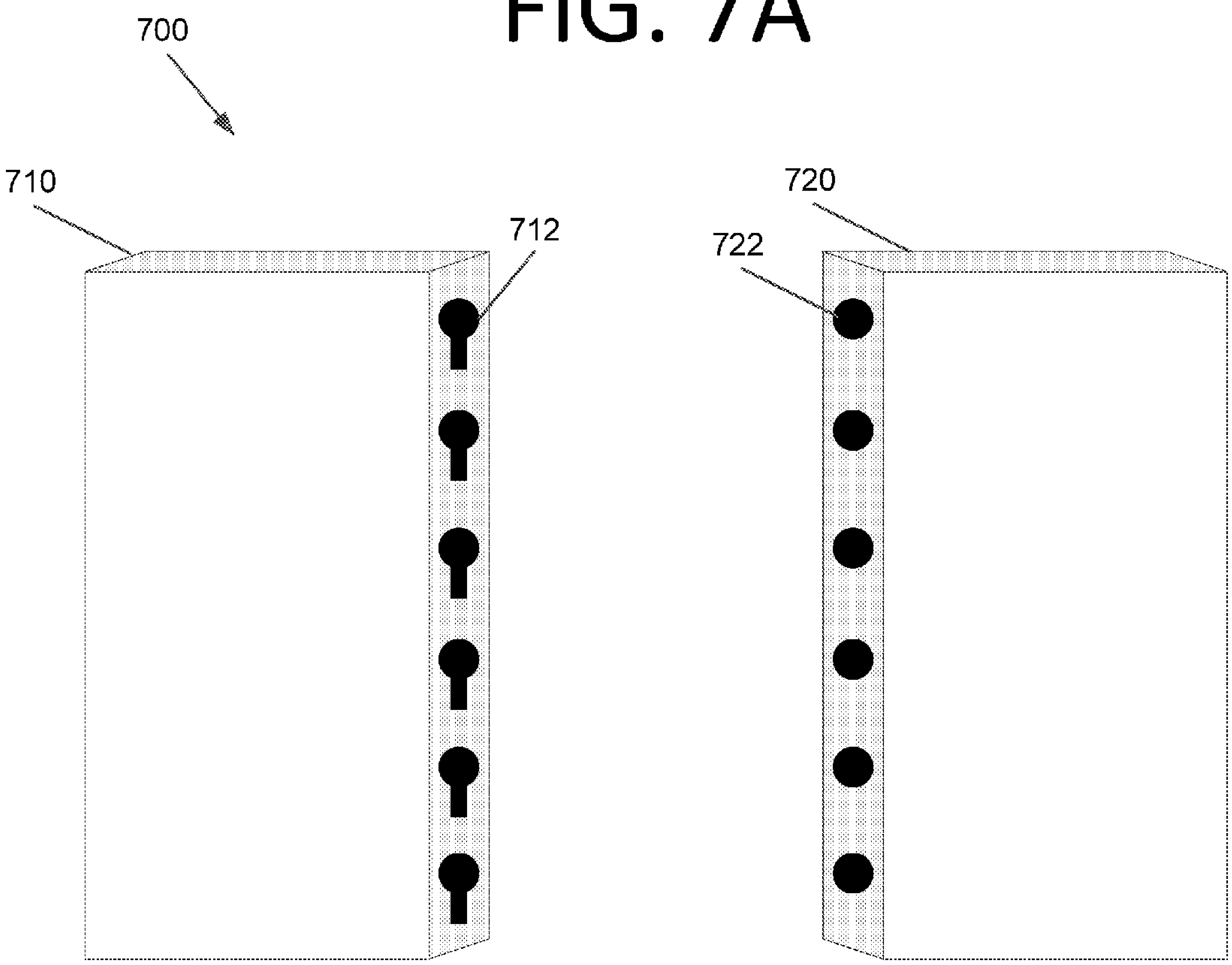


FIG. 7B

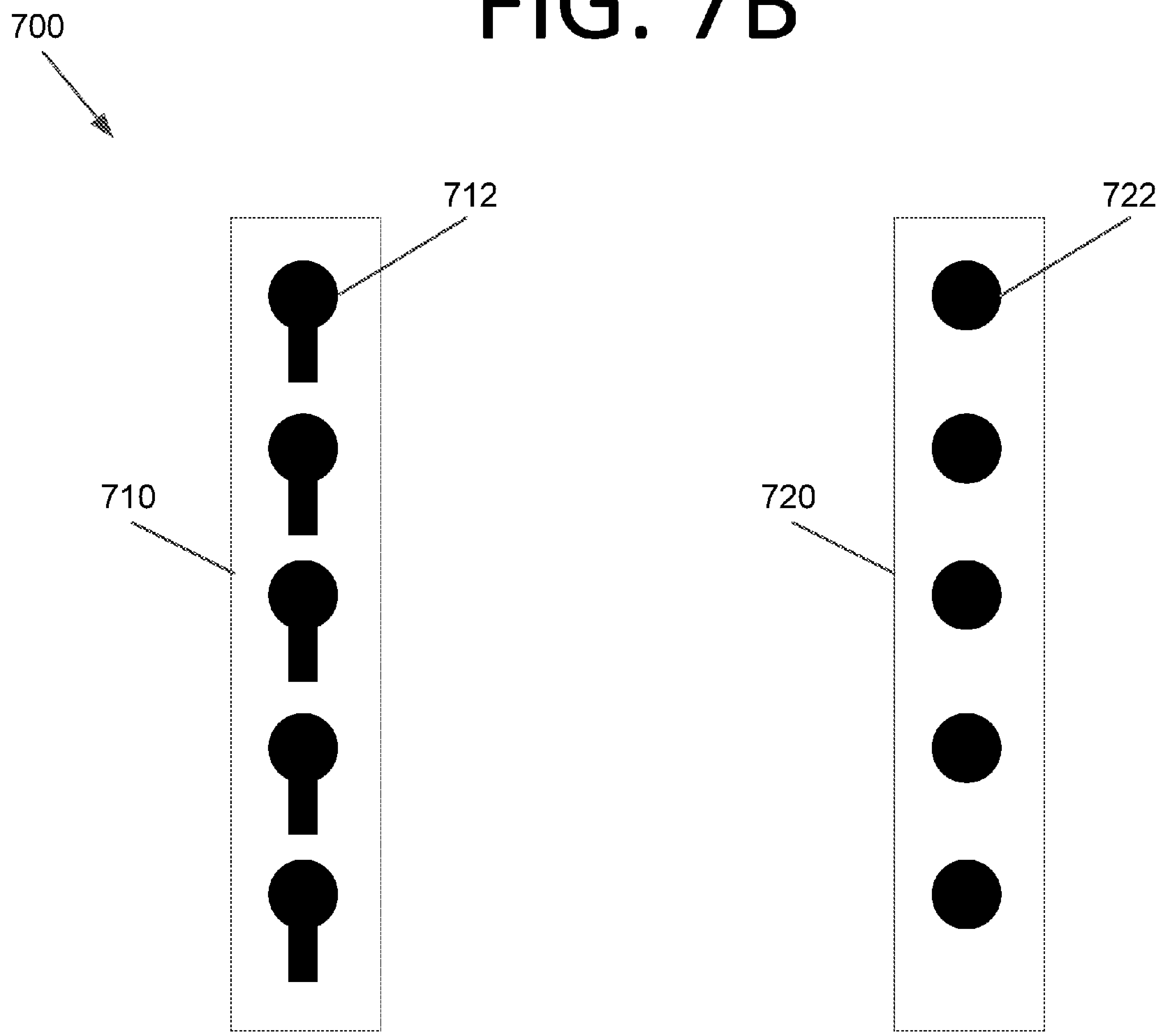


FIG. 8

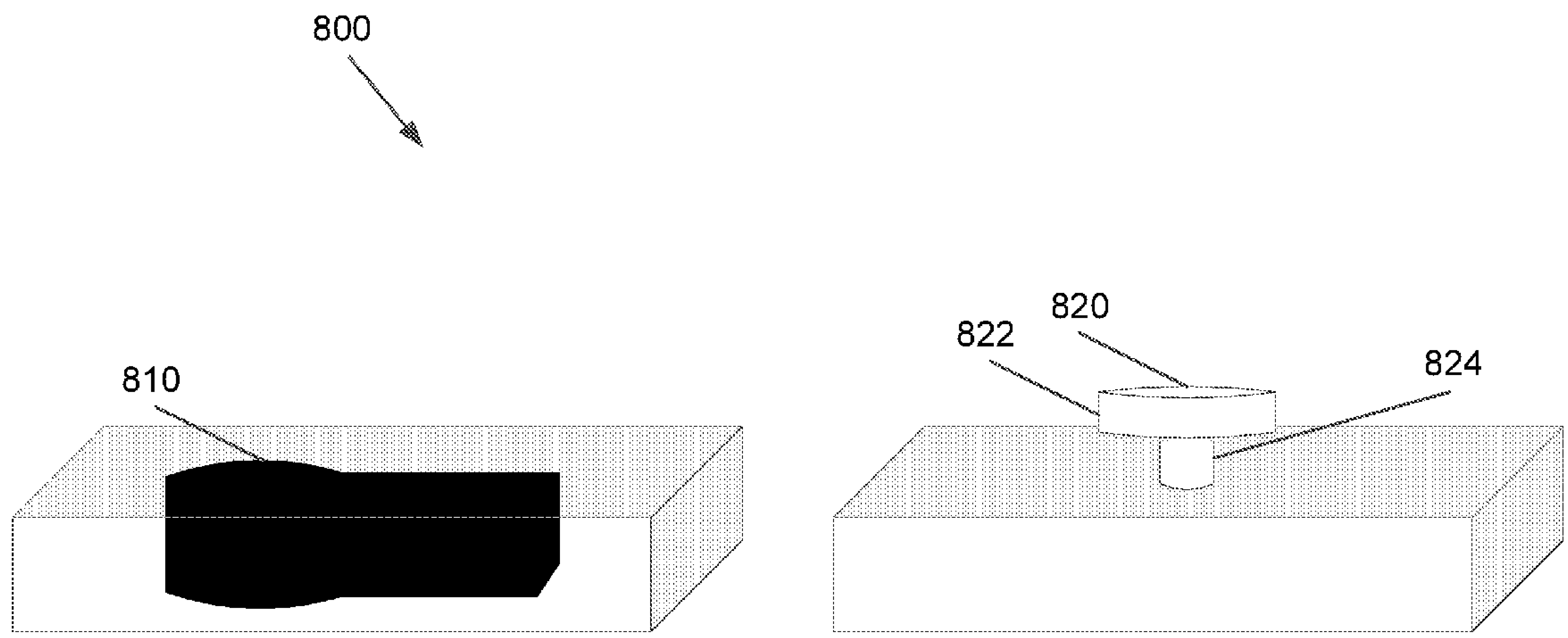


FIG. 9

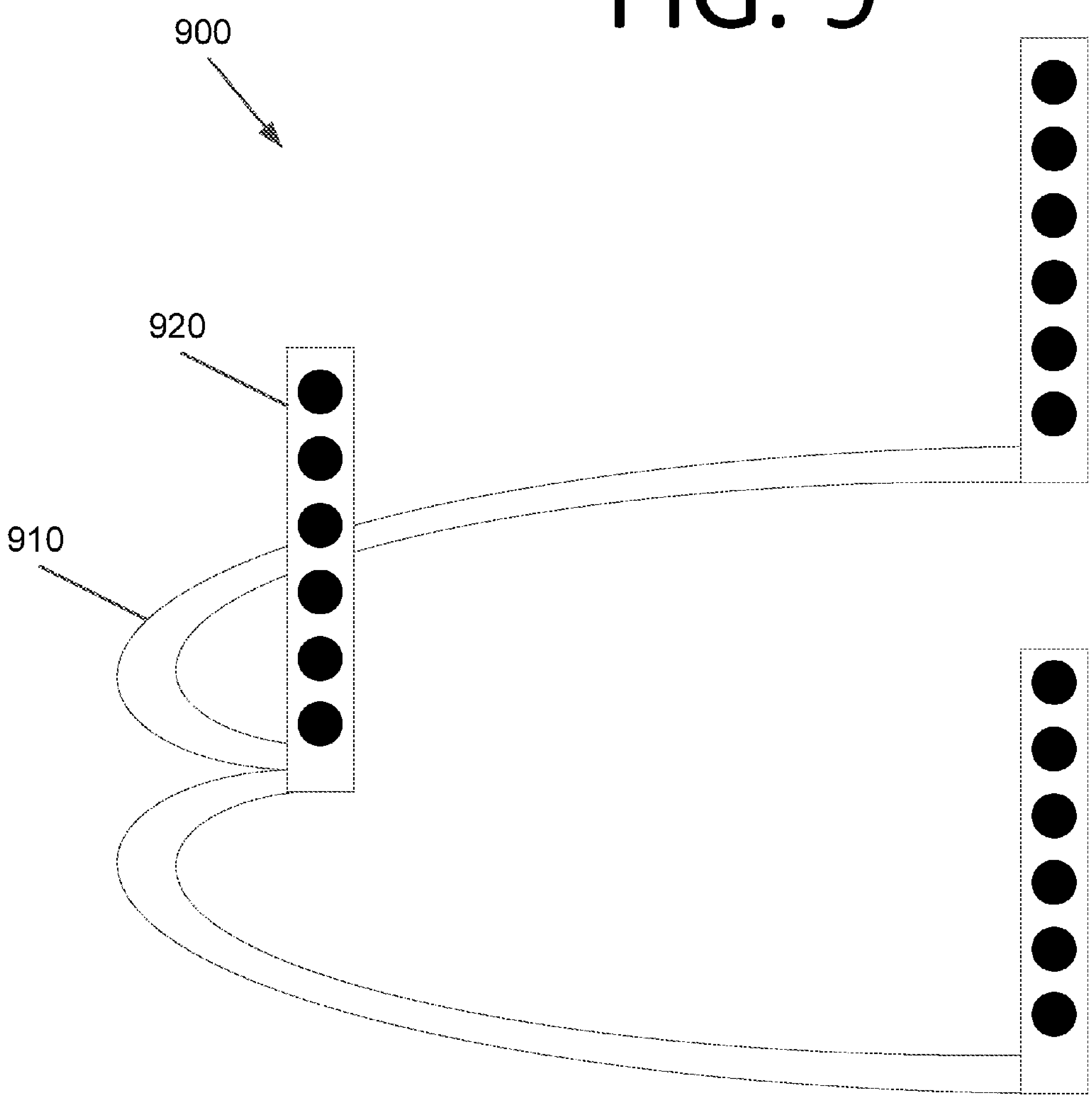


FIG. 10

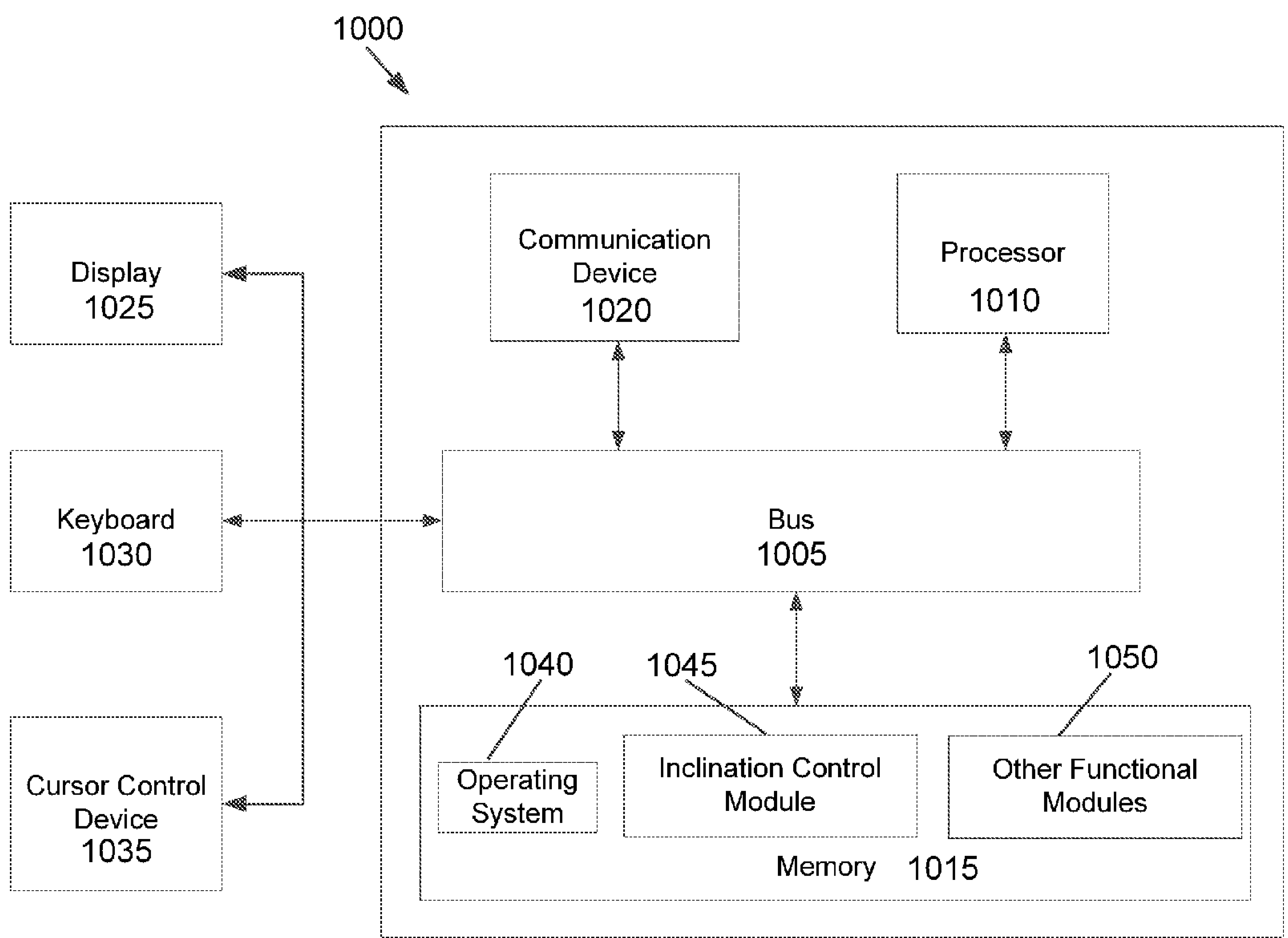

1000
Communication Device 1020
Processor 1010
Display 1025
Keyboard 1030
Bus 1005
Cursor Control Device 1035
1040
1045
1050
Operating System
Inclination Control Module
Other Functional Modules
Memory 1015

FIG. 11A

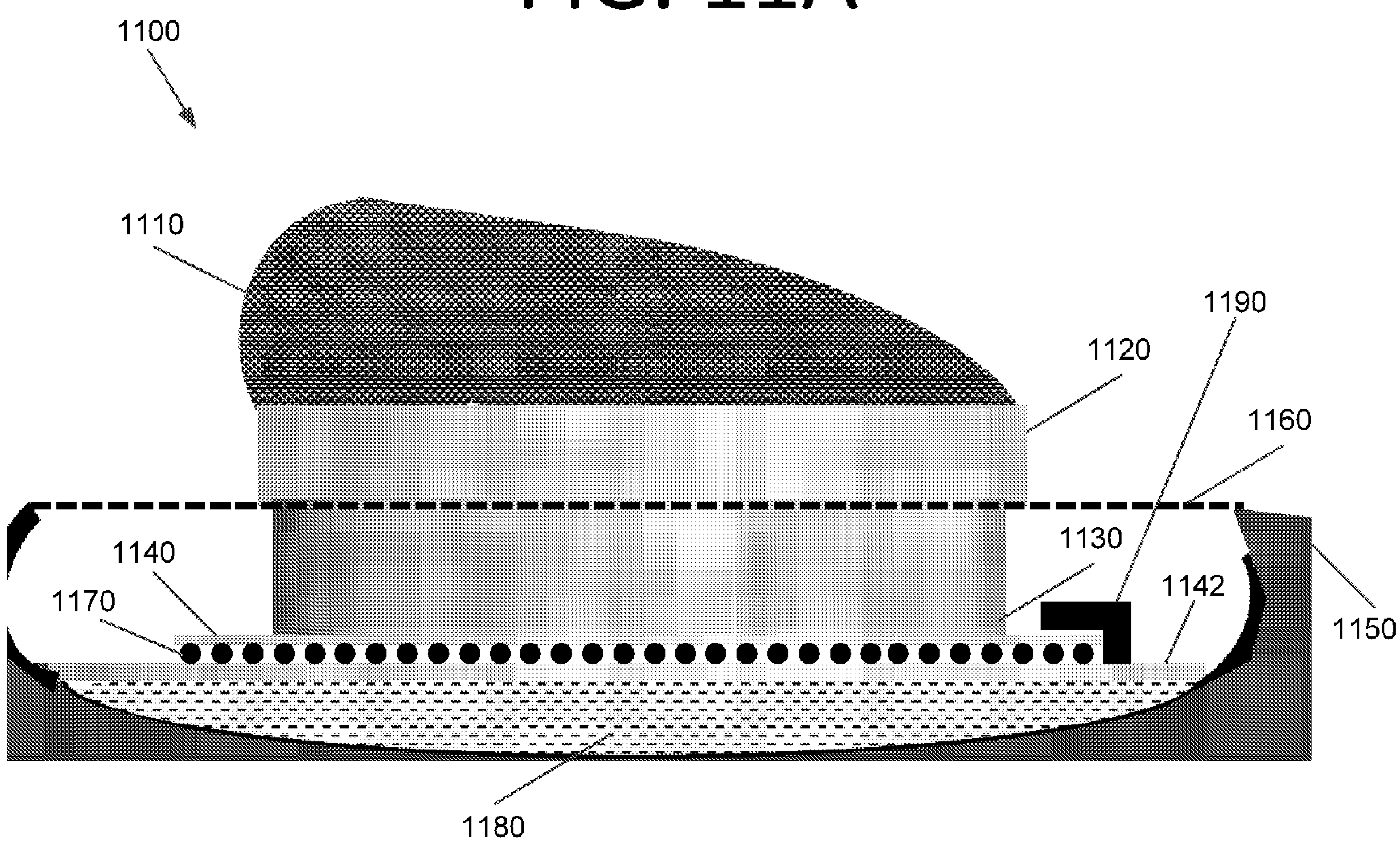


FIG. 11B

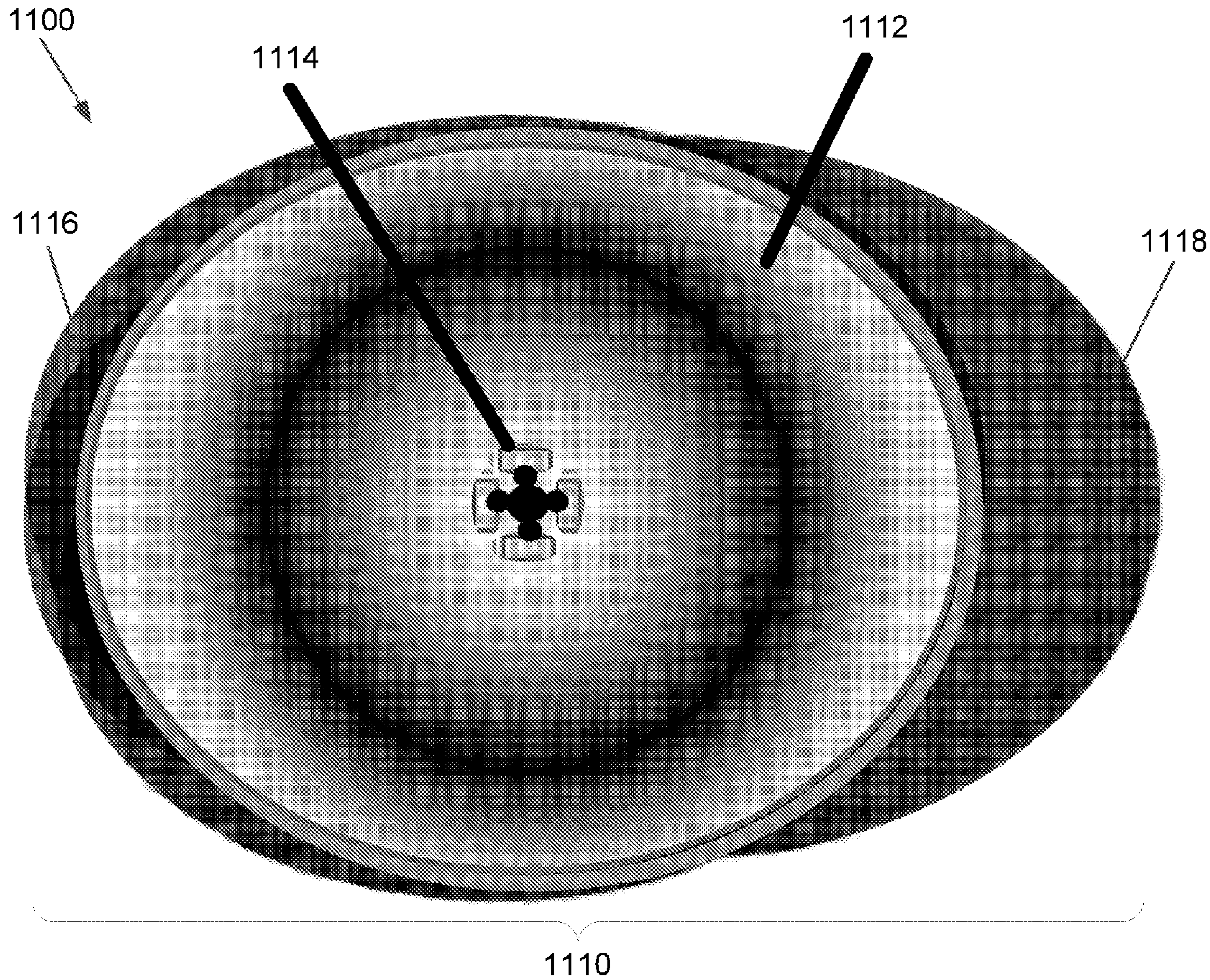
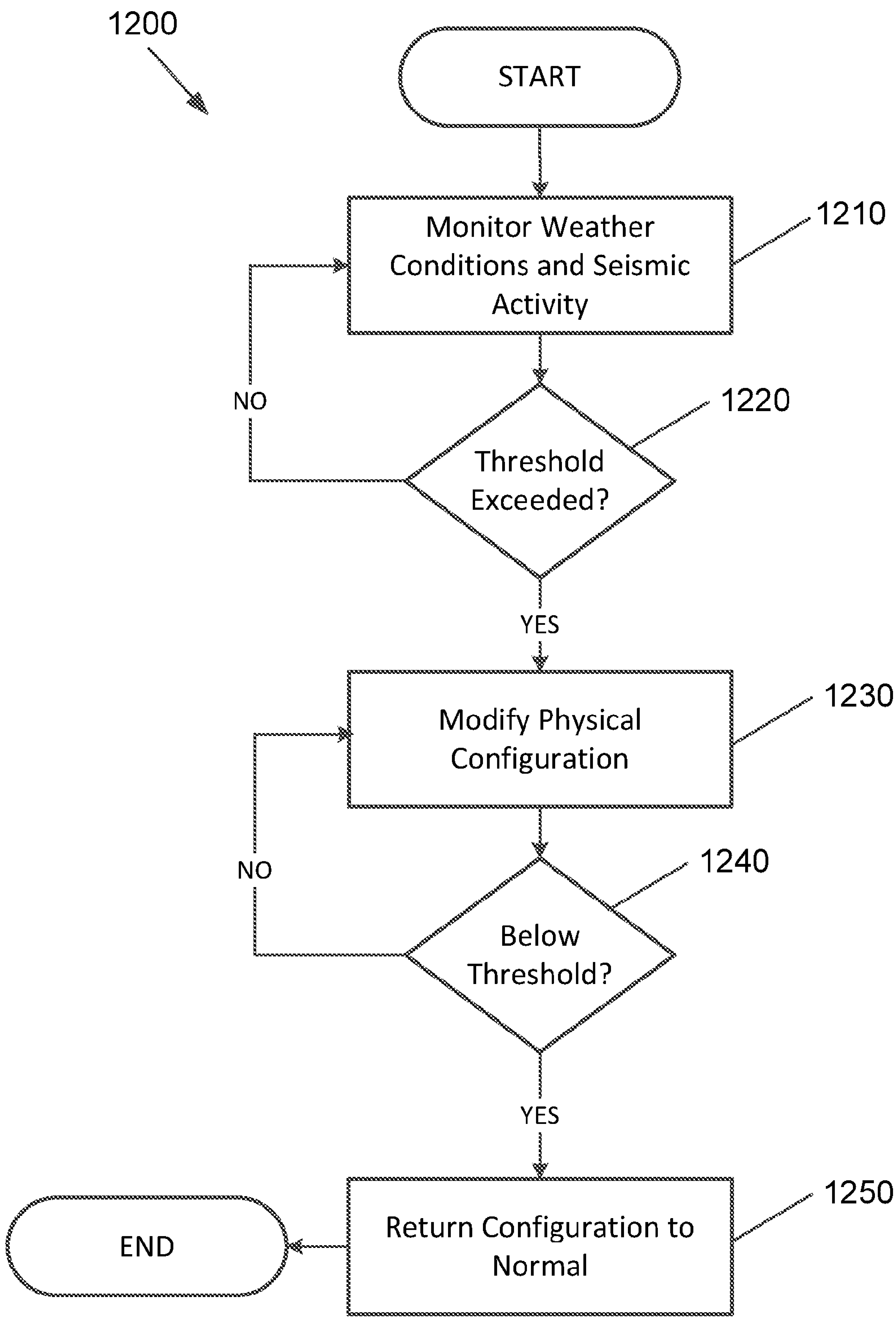


FIG. 12


1200
START
Monitor Weather Conditions and Seismic Activity
1210
NO
Threshold Exceeded?
1220
YES
Modify Physical Configuration
1230
NO
Below Threshold?
1240
YES
Return Configuration to Normal
1250
END

NON-TRACKING SOLAR RADIATION COLLECTOR

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation-in-part of, and claims priority to, U.S. patent application Ser. No. 13/417,133, filed Mar. 9, 2012. The subject matter of this earlier filed application is hereby incorporated by reference in its entirety.

FIELD

[0002] The present invention generally relates to a solar radiation collector, and more specifically, to a non-tracking solar radiation collector that is highly resistant to seismic activity and extreme weather conditions.

BACKGROUND

[0003] Solar energy is, for all intents and purposes, an inexhaustible clean energy supply that can be collected using solar thermal collection systems, for example. With the rising costs of, and competition for, increasingly scarce fossil fuel resources, solar thermal systems are becoming an increasingly attractive option for providing power at residential, commercial, industrial, and grid-level scales. However, in zones of frequent seismic activity and/or extreme weather conditions, conventional systems may be suboptimal due to the risk that such systems will be damaged before they are able to generate a reasonable return-on-investment. Furthermore, conventional solar thermal systems do not harness a broad spectrum of solar energy, instead they only make use of visible light and ultraviolet (UV) wavelengths in significant quantities.

SUMMARY

[0004] Certain embodiments of the present invention may provide solutions to the problems and needs in the art that have not yet been fully identified, appreciated, or solved by current solar radiation collection technologies. For example, some embodiments of the present invention utilize a non-tracking design having a unique architecture that facilitates broad spectrum collection and uses one or more lenses to focus solar energy into one or more light traps. Some embodiments also have a non-tracking architecture that is also highly resistant to seismic activity and extreme weather conditions, such as hurricane-force winds.

[0005] In one embodiment, an apparatus includes a double parabolic reflector and a light trap. The apparatus also includes a lens configured to receive light from the double parabolic reflector and focus the reflected light into the light trap.

[0006] In another embodiment, a solar energy collection system includes a reflector configured to reflect a broad spectrum of solar energy and a lens or mirror configured to focus concentrated light received from the reflector. The solar energy collection system also includes a light trap configured to receive focused light from the lens or minor and a black body exposed within the light trap. The black body is configured to absorb solar energy as thermal energy and transfer the thermal energy to a thermal transfer medium.

[0007] In yet another embodiment, a system includes a reflector and a plurality of Fresnel lenses configured to receive and focus light reflected by the reflector. The system also includes a plurality of light traps configured to receive the focused light from a respective one of the plurality of Fresnel lenses.

[0008] In still another embodiment, an apparatus includes a reflector and an aerodynamic cowling configured to reduce wind resistance of the apparatus.

[0009] In another embodiment, a computer-implemented method includes automatically detecting inclement weather conditions or seismic activity that exceed a predetermined threshold. The computer-implemented method also includes modifying a physical configuration of a solar collection system, via at least one drive mechanism, to prepare the system for the inclement weather conditions or seismic activity when the predetermined threshold is exceeded.

[0010] In another embodiment, a system includes a reflector and a controller. The system also includes a drive mechanism configured to automatically alter an inclination of the reflector responsive to commands from the electronic controller such that the reflector closely tracks an azimuth of the Sun.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] For a proper understanding of the invention, reference should be made to the accompanying figures. These figures depict only some embodiments of the invention and are not limiting of the scope of the invention. Regarding the figures:

[0012] FIG. **1** illustrates a double parabolic collector, according to an embodiment of the present invention.

[0013] FIG. **2** illustrates a side view of a solar energy collection system, according to an embodiment of the present invention.

[0014] FIG. **3** illustrates a side view of a solar energy collection system, according to an embodiment of the present invention.

[0015] FIG. **4** illustrates a top view of a solar energy collection system, according to an embodiment of the present invention.

[0016] FIG. **5**A illustrates a side view of a solar energy collection system with a wind and seismic activity protection configuration, according to an embodiment of the present invention.

[0017] FIG. **5**B illustrates the solar energy collection system of FIG. **5** after inclination, according to an embodiment of the present invention.

[0018] FIG. **6** illustrates a cowling design configured to reduce wind resistance, according to an embodiment of the present invention.

[0019] FIG. **7**A illustrates a perspective view of a pair of interlocking panels, according to an embodiment of the present invention.

[0020] FIG. **7**B illustrates an end view of the pair of interlocking panels, according to an embodiment of the present invention.

[0021] FIG. **8** illustrates a perspective view of a single key-shaped hole and round interlocking notch, according to an embodiment of the present invention.

[0022] FIG. **9** illustrates a frame to which interlocking panels may be attached, according to an embodiment of the present invention.

[0023] FIG. **10** illustrates a controller for controlling the inclination of a solar collector, according to an embodiment of the present invention.

[0024] FIG. 11A illustrates a side view of a solar collection system retracted into a lockdown position within a bunker, according to an embodiment of the present invention.

[0025] FIG. 11B illustrates a top view of the solar collection system with the bunker, according to an embodiment of the present invention.

[0026] FIG. 12 is a flowchart illustrating a method for detecting and responding to weather and seismic events, according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0027] It will be readily understood that the components of the present invention, as generally described and illustrated in the figures herein, may be arranged and designed in a wide variety of different configurations. Thus, the following detailed description of the embodiments, as represented in the attached figures, is not intended to limit the scope of the invention as claimed, but is merely representative of selected embodiments of the invention.

[0028] The features, structures, or characteristics of the invention described throughout this specification may be combined in any suitable manner in one or more embodiments. For example, the usage of "certain embodiments," "some embodiments," or other similar language, throughout this specification refers to the fact that a particular feature, structure, or characteristic described in connection with the embodiment may be included in at least one embodiment of the present invention. Thus, appearances of the phrases "in certain embodiments," "in some embodiments," "in other embodiments," or other similar language, throughout this specification do not necessarily all refer to the same group of embodiments, and the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

[0029] Some embodiments of the present invention are directed to non-tracking solar collectors that may be highly resistant to seismic activity and extreme weather conditions. The solar collection panels in some embodiments are unique in that they are as strong as, or stronger than, conventional metal panels, but are composed of light structural plastics that act as a dampening agent, as well as provide a stable platform for precisely focusing solar energy for solar thermal applications. Although metals such as aluminum may be used for some components and framing, the weight of embodiments of the present invention tends to be significantly less than conventional solar thermal systems.

[0030] In some embodiments, the panels are covered with a highly solar reflective film that reflects a broad spectrum of solar energy to a high degree. In certain embodiments, reflectivity in the infrared, visible light, and ultraviolet (UV) ranges may exceed 90% across most wavelengths. Some of these concepts are discussed in more detail in parent U.S. patent application Ser. No. 13/417,133.

[0031] Panels in some embodiments of the present invention provide a greater amount of thermal energy than conventional systems, yet are approximately the same weight as a typical high quality photovoltaic panel, without the complexity and durability issues. In other words, some embodiments of the present invention both collect more energy and cost considerably less than conventional systems.

[0032] Some embodiments use structural plastic foam for panel construction. Foams such as acrylonitrile-butadiene-styrene (ABS) foams may be suitable for many embodiments. These foams have proven strength and durability and are used frequently in the automotive industry. ABS plastics can be molded into complex reinforced shapes that are stronger than steel. Further, ABS foams present a less expensive, stronger, lightweight alternative to metals in the construction of broad spectrum solar collection assemblies.

[0033] Most advanced solar thermal technologies include components that are relatively massive. Because of their size, these components require stout foundations and must be designed to manage substantial wind loads. These assemblies typically only meet the standards for minimum seismic loading. Further, these assemblies will generally not survive extremely strong winds, such as those generated by strong hurricanes and typhoons.

[0034] These considerations have limited locations in the world where concentrated solar thermal systems can be deployed. Photovoltaics have dominated rooftop and urban deployments. However, advanced solar thermal systems generally have a larger solar operating window. Most have some storage capabilities, but the limitation of the sheer mass of the typical concentrated solar thermal system causes this advantage to be forsaken since concentrated solar thermal systems are not suited for the vast majority of urban settings.

[0035] There is a need for solar thermal solutions for environments that experience high winds, violent storms, and other forms of severe weather. Islands in the Caribbean and parts of the southeastern United States, for instance, experience hurricanes more frequently than many other areas. Many parts of the Caribbean, in particular, are desperately in need of stable and economical energy sources. Similarly, there is a need for solar thermal systems in areas with significant levels of seismic activity. For example, the Japanese Government is aggressively searching for replacements for its nuclear power systems. Some embodiments of the present invention can be deployed in areas where there is a serious danger of seismic activity or inclement weather. Broad spectrum solar thermal systems, such as those discussed in the present application and parent application, have significant advantages over other energy collection technologies in that they are green, collect energy at any time of the day regardless of cloud cover, and may be manufactured and deployed at relatively low cost.

[0036] Some embodiments of the present invention may be used in a parabola trough or a deep elliptical-shaped dish. The panels of these embodiments may be covered in a highly solar reflective film that reflects a broad spectrum of solar energy. Embodiments also generally use light traps having black bodies. However, in order to accommodate the Sun's daily movement across the trough or dish's reflective surface, lenses and clusters of light traps with black bodies may be used. In many embodiments, Fresnel lenses may be particularly useful due to their compact size. A Fresnel lens generally is divided into a set of concentric annular sections with a nearly flat convex center. Such lens designs may be found in the headlamps, brake lights, and turn signal lights of many automobiles, for example.

[0037] One unique aspect of this family of dishes is that they can be configured in a similar fashion to solar photovoltaic panels due to the low weight. In fact, such collectors can be sized to directly compete with solar photovoltaic (SPV) panels and have the further benefit of the production of thermal energy, and potential thermal storage. This thermal energy may then be used directly, or used to generate electricity by creating steam and driving a generator, for instance. Such solar thermal systems exhibit distinct advantages over

SPV systems, particularly for air conditioning and heating applications. Rooftop concentrated solar thermal systems are possible with these dishes.

[0038] Because some embodiments of the present invention only need to be adjusted to follow the Sun's azimuth, these embodiments need to move on only one axis. Generally, most embodiments should be aligned in a specific direction when collecting solar energy in order to optimally track the azimuth of the Sun, as well as to allow the dish shape to collect radiation anywhere along the Sun's elevation. Some embodiments may be aligned so as to always face this direction, and other embodiments may be configured to rotate such that they can face in this direction, or in another desired direction. For locations where there is the potential for severe weather, these systems can be covered in a manner that provides a wind-deflecting shape with an aerodynamic cowling that, when in a lockdown position, creates an aerodynamic "teardrop" shape and may be free to rotate to self-orient into an optimal or near-optimal wind deflecting position. Particularly, such designs can be lowered into storm bunkers, which can rotate and adjust position so as to present the most aerodynamic shape to the oncoming wind when the need arises, which changes the dish's effective shape from a circular ovoid egg shape to a teardrop.

[0039] Because of the low weight and extremely good strength-to-weight ratio of some embodiments, foundations can be designed to accommodate the movement of the Earth even during severe earthquakes. The system literally "floats" on top of the quake since the various sections have the freedom to move, and are designed to return to the correct position after the initial quake and subsequent aftershocks have subsided.

[0040] Some embodiments may be deployed as panels that can be sized such that assembly by hand is possible. These panels may interlock and may be easily assembled on a frame made from a material such as aluminum, for example. The interlocking of some embodiments is better illustrated in FIGS. **7A-8**. Each piece of the frame may be of a common size and shape, one or more pieces may have different shapes and/or sizes, or all pieces may have different shapes and/or sizes as a matter of design choice. Various methods can be used to raise and lower the assembly, including hydraulics, counter levers, semicircular lifts, and ratchet assemblies, among others, any of which generally have a low parasitic load on the system.

[0041] For the transport of collected thermal energy, some embodiments use a solid state thermal transport system, with proximity heat exchangers to accommodate moving joints. The system may use a graphite composite thermal transfer medium such as PocoFoam® in some embodiments. Some embodiments also use thermal expansion-driven switches similar to those described in U.S. patent application Ser. No. 13/326,454, which is incorporated herein by reference.

[0042] FIG. **1** illustrates a double parabolic collector **100**, according to an embodiment of the present invention. FIG. **1** is merely meant to illustrate the principles of some embodiments of the present invention and is not necessarily drawn to scale, or with the appropriate angles/curves. Also, while a double parabolic collector is discussed with respect to many embodiments of the present invention, any suitable shape, such as a flattened parabola, may be used. However, the double parabolic embodiments may be more compact than many other embodiments, potentially reducing size and cost, and increasing the number of applications for which such architectures may be used. Double parabolic collector **100** includes a double parabolic reflector **110** having a left parabola **112** and a right parabola **114**. Double parabolic collector **100** also includes a light trap **120**.

[0043] Left parabola **112** and right parabola **114** are shaped such that a majority of the solar energy striking the surface thereof is reflected into light trap **120**. This is regardless of the angle of incidence of photons striking the reflective surface. In FIG. **1**, solar energy rays **130** are reflected off of the same relative position of the surfaces of left parabola **112** and right parabola **114** into light trap **120**.

[0044] FIG. **2** illustrates a side view of a solar energy collection system **200**, according to an embodiment of the present invention. Solar energy collection system **200** includes a Fresnel lens **210** and a light trap **220**. While Fresnel lenses are discussed with respect to the embodiment of FIG. **2**, concentrating lenses of any type and/or mirrors could be configured to focus the energy into the light trap in some embodiments. It is generally beneficial to consider broad solar spectrum reflectivity, and few plastics are transparent enough for such applications, but there are some monocrystal substances that could be used for lens material. Such monocrystal substances may include, but are not limited to, yttrium aluminum garnet (YAG), infrared transparent glass ceramics, IR transparent plastics such as polymethyl methacrylate, synthetic diamonds, CdO nanocrystals, and ZnSe and NiZnSe crystals, among others.

[0045] In some embodiments, light trap **220** may be consistent with the light traps described in the parent application. Solar energy passes through Fresnel lens **210** and is focused through focal point F into light trap **220**. f is the focal length of Fresnel lens **210**, and lens power P is determined by

$$P = \frac{1}{f}.$$

In some embodiments, light trap **220** may contain two opposing elliptical minors that concentrate the majority of solar energy entering light trap **220** onto a black body **222**.

[0046] Black body **222** may include a high temperature ceramic mixture of zirconium diboride (ZrB_2), possibly in a mixture of silicon carbide (SiC), or pure ZrB_2 coated with a thin coating of various ceramics such as cubic boron nitride (BN), or other materials such as stabilized zirconium dioxide (ZrO_2). Black body **222** absorbs solar energy that enters light trap **220** and converts the absorbed solar energy into thermal energy. Black body **222** is integrated with a solid state thermal transfer medium **230** that may include a graphite foam material such as PocoFoam®. Thermal transfer medium **230** transfers heat away from black body **222** for subsequent use, such as for direct heat applications, to heat water for purposes such as electrical generation, for storage in a thermal storage medium such as those discussed in U.S. patent application Ser. No. 13/361,877, which is incorporated herein by reference, or for any other suitable use.

[0047] FIG. **3** illustrates a side view of a solar energy collection system **300**, according to an embodiment of the present invention. Solar energy collection system **300** is not drawn to scale or with the appropriate supporting members in order to better illustrate the underlying concept. Solar energy collection system **300** includes a double parabolic reflector **310** that may be double parabolic reflector **110** of FIG. **1** in some embodiments. Double parabolic reflector **310** is configured to reflect solar energy into one of three Fresnel lenses **320**, **322**, and **324** depending on where the solar energy strikes double parabolic reflector **310**. A Fresnel lens **326** is also positioned above solar energy collection system **300** and focuses light that strikes its upper surface.

[0048] Each of Fresnel lenses **320**, **322**, **324**, and **326** is positioned so as to focus solar energy into a respective light trap **330**, **332**, **334**, and **336**. While four light traps and Fresnel lenses are shown in FIG. **3**, any desired number of light traps and lenses, minors, or combinations thereof may be used as a matter of design choice, and the light traps and lenses may be configured in any direction or orientation in three dimensions, depending on the architecture. Each of light traps **330**, **332**, **334**, and **336** may be similar to light trap **220** of FIG. **2** in some embodiments, and may have opposing flattened elliptical reflective surfaces within to effectively capture solar energy. Each of light traps **330**, **332**, **334**, and **336** also has a respective black body **340**, **342**, **344**, and **346** that is configured to absorb solar energy within the respective light trap and convert the absorbed solar energy into thermal energy.

[0049] A thermal transfer conduit **350** containing a thermal transfer medium such as PocoFoam® is positioned in between light traps **330**, **332**, **334**, **336**, and the thermal transfer medium is operably connected to each of black bodies **340**, **342**, **344**, and **346** (not shown). In some embodiments, thermal transfer conduit **350** may run the length of the trough. Also, while shown running horizontally here, in some embodiments, thermal transfer conduit **350** may run vertically.

[0050] FIG. **4** illustrates a top view of a solar energy collection system **400**, according to an embodiment of the present invention. The shape may not be accurate, but simulates the geometry of a linear trough **420** having a double parabolic shape using nested circles. Three Fresnel lenses **430**, **432**, and **434** focus light into three respective light traps **440**, **442**, and **444**. While three light traps **440**, **442**, and **444** and Fresnel lenses **430**, **432**, and **434** are shown here, in some embodiments, there may be more light traps depending on the latitude. Also, a light trap and Fresnel lens may be placed above the others in some embodiments (not shown). A thermal transfer conduit **450** runs between light traps **340**, **342**, and **344**, and is operably connected to black bodies thereof (not shown).

[0051] An aerodynamic cowling **410** surrounds linear trough **420**. Aerodynamic cowling **410** may be oval shaped, egg shaped, or any other shape suitable for withstanding strong prevailing winds in some embodiments. Further, in some embodiments, the entire assembly may be moved so that aerodynamic cowling **410** presents a more narrow profile in the general direction of the wind.

[0052] FIG. **5**A illustrates a side view of a solar energy collection system **500** with a wind protection configuration, according to an embodiment of the present invention. Solar energy collection system **500** includes an aerodynamic cowling **510**. In some embodiments, aerodynamic cowling **510** is composed of structural woven plastics reinforced with aluminum structural members. The woven plastics may allow some air to pass through (not shown). The specific pattern of one embodiment of aerodynamic cowling **510** is shown in more detail in FIG. **6**. A double parabola trough **520** has a highly mirrored surface that reflects solar energy. A base **522** supports a thermal transfer conduit **530** which, in turn, supports a collection assembly **540** having one or more light traps receiving light from Fresnel lenses.

[0053] A base **550** supports a fulcrum **552** that permits a lever arm **554** to move in a vertical direction. Lever arm **554** is counterbalanced by a counterweight **556**. A foundation bunker **560** allows retraction of cowling **510** and double parabola trough **520** to form a teardrop shape. This vertical movement is enabled by a hydraulic lift **570**.

[0054] The aerodynamics of the shape of solar energy collection system **500** are easier to manage in high winds. Further, it is generally optimal for double parabolic trough **520** to be oriented to the Sun's in a permanent alignment position with respect to the Sun's elevation and adjust the angle of the azimuth. This requires double parabolic trough **520** to be inclined, which is accomplished by hydraulic lift **570**. Generally speaking, the highest angle of inclination should be at the Winter Sol Invictus and the lowest angle of inclination should be at the Summer Solaces.

[0055] An electronic controller **580** controls hydraulic lift **570** in order to change the angle of inclination of double parabolic trough **520**. Electronic controller is also connected to monitoring equipment **590** in this embodiment. Monitoring equipment **590** may be in any suitable location and may communicate with electronic controller **580** through a wired connection, wirelessly, via an intermediary device, or by any other suitable means. Monitoring equipment **590** may include a seismometer, a barometer, an anemometer, and/or any other device for detecting weather conditions and seismic activity. When weather conditions and/or seismic activity exceed a certain threshold, electronic controller **580** may move double parabolic trough **520** accordingly. For instance, in strong winds, double parabolic trough **520** may be positioned horizontally so as to present a smaller profile. During an earthquake, double parabolic trough **520** may be inclined significantly away from the azimuth so large amounts of energy are not being collected. In certain embodiments, double parabolic trough **520** may be moved as far away from the azimuth as possible and/or the light traps or lenses may be turned so as to reflect light back into the atmosphere. This motion could, for example, be accomplished by a simple servo. In some embodiments, double parabolic trough **520** may retract into a bunker.

[0056] FIG. **5**B illustrates solar energy collection system **500** after inclination, according to an embodiment of the present invention. The inclination causes solar energy collection system **500** to assume the winter position. In some practical embodiments, dishes may range from 12 meters to over 25 meters in diameter, depending on terrain and the cost of excavation for the bunkers. As the dishes are deep parabolas in many embodiments, the sizes will generally be smaller than for many other dish designs, with a number of these dishes populating a field.

[0057] FIG. **6** illustrates a cowling design **600** that is configured to reduce wind resistance, according to an embodiment of the present invention. Cowling design **600** includes a hexagonal mesh **610** forming hexagonal holes **620** that wind may pass through. Such a design greatly reduces drag. While a hexagonal pattern is shown here, any polygonal shape, spherical shape, or other shape forming holes may be used as a matter of design choice. Further, the shapes of the holes may be heterogeneous in some embodiments.

[0058] FIG. **7**A illustrates a perspective view of a pair of interlocking panels **700**, according to an embodiment of the present invention. Left interlocking panel **710** has a plurality of key-shaped holes **712**, and right interlocking panel **720** has a corresponding series of round interlocking notches **722**.

Round interlocking notches **722** may be inserted into key-shaped holes **712** and moved downward to lock into position. In some embodiments, an additional fastening mechanism, such as solder, epoxy, tape, or any other suitable mechanism may be used. Also, in other embodiments, alternative fastening mechanisms such as bolts, screws, tape, glue, solder, or any other suitable fastening mechanism may be used in pace of the mechanism of FIG. **7**A. FIG. **7**B illustrates an end view of the pair of interlocking panels **700**, according to an embodiment of the present invention.

[0059] FIG. **8** illustrates a perspective view **800** of a single key-shaped hole **810** and a round interlocking notch **820**, according to an embodiment of the present invention. Key-shaped hole **810** forms a recess within its respective interlocking panel. Round interlocking notch **820** protrudes from its respective interlocking panel and has a neck portion **822** that is thinner than a head portion **824**.

[0060] FIG. **9** illustrates a frame **900** to which interlocking panels may be attached, according to an embodiment of the present invention. Frame **900** includes a track **910** that interlocked ABS panels may slide into and be bolted to in order to lock them in place in some embodiments. Track **910** may be on each end of a panel set, and the panels may be compressed between two W-shaped tracks in some embodiments. Track **910** may be composed of aluminum, for example. In this frame, the mechanism that follows the azimuth may be mounted. Frame **900** also includes boxed U-shaped support members **920** that may run the entire length of the panels and be bolted or otherwise attached thereto. In some embodiments, the support members may have other shapes as a matter of design choice.

[0061] FIG. **10** illustrates a controller **1000** for controlling the inclination of a solar collector, according to an embodiment of the present invention. In some embodiments, controller **1000** may control operation of hydraulic lift **570** and other operational aspects of solar energy collection system **500** of FIGS. **5**A and **5**B. Controller **1000** includes a bus **1005** or other communication mechanism for communicating information, and a processor **1010** coupled to bus **1005** for processing information. Processor **1010** may be any type of general or specific purpose processor, including a central processing unit (CPU) or application specific integrated circuit (ASIC). Controller **1000** further includes a memory **1015** for storing information and instructions to be executed by processor **1010**. Memory **1015** can be comprised of any combination of random access memory (RAM), read only memory (ROM), flash memory, cache, static storage such as a magnetic, optical disk, or solid state memory devices, or any other types of non-transitory computer-readable media or combinations thereof. Additionally, controller **1000** includes a communication device **1020**, such as a wireless network interface card, to provide access to a network.

[0062] Non-transitory computer-readable media may be any available media that can be accessed by processor **1010** and may include both volatile and non-volatile media, removable and non-removable media, and communication media. Communication media may include computer-readable instructions, data structures, program modules, lookup tables, or other data in a modulated data signal such as a carrier wave or other transport mechanism and includes any information delivery media.

[0063] Processor **1010** is further coupled via bus **1005** to a display **1025**, such as a Liquid Crystal Display ("LCD"), for displaying information to a user. A keyboard **1030** and a cursor control device **1035**, such as a computer mouse, are further coupled to bus **1005** to enable a user to interface with controller **1000**. Display **1025**, keyboard **1030**, and cursor control device **1035** may be located separately from controller **1000** and may communicate with controller **1000** via wireless communication, an Ethernet cable, or any other suitable means for transmitting and/or carrying data. For instance, a common control center may be used to control multiple solar energy collection devices.

[0064] In one embodiment, memory **1015** stores software modules that provide functionality when executed by processor **1010**. The modules include an operating system **1040** for controller **1000**. The modules further include an inclination control module **1045** that is configured to at least control the inclination of a solar collector. However, other functionality, such as lens and light trap orientation, for example, may also be controlled as a matter of design choice. Controller **1000** may include one or more additional functional modules **1050** that include additional functionality.

[0065] One skilled in the art will appreciate that a "controller" could be embodied as a personal computer, a server, a console, a personal digital assistant (PDA), a cell phone, or any other suitable computing device, or combination of devices. Presenting the above-described functions as being performed by a "controller" is not intended to limit the scope of the present invention in any way, but is intended to provide one example of many embodiments of the present invention. Indeed, methods, systems and apparatuses disclosed herein may be implemented in localized and distributed forms consistent with computing technology.

[0066] It should be noted that some of the controller features described in this specification have been presented as modules in order to more particularly emphasize their implementation independence. For example, a module may be implemented as a hardware circuit comprising custom very large scale integration (VLSI) circuits or gate arrays, off-the-shelf semiconductors such as logic chips, transistors, or other discrete components. A module may also be implemented in programmable hardware devices such as field programmable gate arrays (FPGAs), programmable array logic, programmable logic devices, graphics processing units, or the like.

[0067] A module may also be at least partially implemented in software for execution by various types of processors. An identified unit of executable code may, for instance, comprise one or more physical or logical blocks of computer instructions that may, for instance, be organized as an object, procedure, or function. Nevertheless, the executables of an identified module need not be physically located together, but may comprise disparate instructions stored in different locations which, when joined logically together, comprise the module and achieve the stated purpose for the module. Further, modules may be stored on a non-transitory computer-readable medium, which may be, for instance, a hard disk drive, flash device, random access memory (RAM), tape, or any other such medium used to store data.

[0068] Indeed, a module of executable code could be a single instruction, or many instructions, and may even be distributed over several different code segments, among different programs, and across several memory devices. Similarly, operational data may be identified and illustrated herein within modules, and may be embodied in any suitable form and organized within any suitable type of data structure. The operational data may be collected as a single data set, or may be distributed over different locations including over different storage devices, and may exist, at least partially, merely as electronic signals on a system or network.

[0069] FIG. **11**A illustrates a side view of a solar collection system **1100** with a bunker **1110**, according to an embodiment of the present invention. Solar collection system **1100** includes a reflector assembly **1110** that includes a reflector and an aerodynamic cowling similar to those illustrated in FIGS. **5**A and **5**B. In FIG. **11**A, reflector assembly **1110** is tilted to form a teardrop shape. An upper base portion **1120** surrounds and houses reflector assembly **1110**.

[0070] Upper base portion **1120** is seated upon hydraulic lift **1130**. In some embodiments, hydraulic lift **1130** may be configured to raise and lower the entire reflector assembly into a lockdown position, tilt the reflector assembly, etc. Hydraulic lift **1130** is seated upon a first lower base portion **1140**, which is operably connected to ball bearings **1170**. However, in some embodiments, ball bearings **1170** may be connected to second lower base portion **1142**, or to neither first lower base portion **1140** nor second lower base portion **1142**. Ball bearings **1170** sit upon, or within a track or groove of, second lower base portion **1142**, forming a turntable. However, in some embodiments, the track or groove may be in first upper base portion **1140**. Second lower base portion **1142** rests upon a foundation **1180** within bunker **1150**.

[0071] In FIG. **11**A, the entirety of bunker **1150** is not shown. Ground level is indicated by dashed line **1160**. In order to provide further protection from wind, a berm (not shown) made of earth, concrete, or any other suitable material may surround bunker **1150** to provide further protection from the wind and from flooding.

[0072] Bunker **1150** may be fabricated from concrete foam or from any other suitable material. Individual pieces, or blocks, of bunker **1150** may have a key-lock configuration similar to that of FIGS. **7**A-**8**, or may be joined together by any desired means, such as fabrication as a single piece, bolts, screws, etc. In many embodiments, first lower base portion **1140** can be freed such that the components above rotate freely like a weather vane, and the bulbous head of the teardrop shape would point in the direction of the wind given sufficient strength. A locking mechanism **1190** of any desired type may be used to lock first lower base portion **1140** in place and to release first lower base portion **1140**. Such a lock may be manually or automatically controlled via electronic controls, for example.

[0073] Rotation may be accomplished by ball bearings **1170**, or by any other suitable mechanism such as an oiled low-friction track or magnetic levitation (mag-lev) similar in principle to the operation of certain trains, and all such mechanisms of rotation are included within the definition of a "turntable" as described herein. Ball bearings **1170** may provide reasonable resistance such that the rotation will be moderate. Ball bearings **1170** may be seated in a track or groove of second lower base portion **1142**, or otherwise positioned so as to enable rotation of a turntable. While rotation in certain embodiments may be controlled by a drive mechanism, freely rotating embodiments may provide superior performance and be more cost-effective due to reduced machinery and complexity. It may be complex to predict winds in areas where rapidly circulating winds are common, and it is particularly complex to predict swirling winds in powerful storms such as hurricanes, typhoons, tornadoes, and strong thunderstorms. Rather, it may be better to let the entire bunker freely rotate with the wind and optimally position itself.

[0074] FIG. **11**B illustrates a top view of the solar collection system **1100** with the bunker, according to an embodiment of the present invention. In this view, bunker **1150** is not shown, and the components of reflector assembly **1110** are illustrated. Reflector assembly **1110** includes a reflector or dish **1112** and collection assembly **1114**, which includes four light traps, four respective Fresnel lenses, and a thermal transfer medium. Left half **1116** of the aerodynamic cowling is tilted up, while right half **1118** of the aerodynamic cowling is tilted down.

[0075] FIG. **12** is a flowchart **1200** illustrating a method for detecting and responding to weather and seismic events, according to an embodiment of the present invention. The method begins with monitoring weather conditions and seismic activity at **1210**. For example, monitoring mechanisms such as an anemometer, a barometer, and a seismometer may be used to monitor wind speed, air pressure, and the movement of the Earth, respectively. If a threshold is exceed for a weather condition or seismic activity at **1220**, such as wind over 30 MPH, seismic activity over 4.0 on the Richter scale, etc., a physical configuration of a solar collection system is modified via at least one drive mechanism at **1230**. Otherwise, monitoring continues. A person of ordinary skill in the art will understand that the specific thresholds for each monitoring device type may vary as a matter of design choice.

[0076] Some of the modifications that may be made in some embodiments include rotating the solar collection system so as to present a lower profile to the wind, moving a reflector to a horizontal position when the wind speed exceeds a predetermined threshold, altering an inclination of the reflector, a direction of a mirror, or a direction of a light trap when seismic activity exceeding the predetermined threshold is detected, and lowering the solar collection system at least partially into a bunker. Once modified, the system tracks whether the weather conditions or seismic activity have fallen below the predetermined threshold at **1240**. If not, the system stays in the protected configuration. If below the threshold, the system returns to the normal configuration at **1250** and the process ends.

[0077] The method steps performed in FIG. **12** may be at least partially performed by a computer program, encoding instructions for the nonlinear adaptive processor to perform at least the methods described in FIG. **12**, in accordance with an embodiment of the present invention. The computer program may be embodied on a non-transitory computer-readable medium. The computer-readable medium may be, but is not limited to, a hard disk drive, a flash device, a random access memory, a tape, or any other such medium used to store data. The computer program may include encoded instructions for controlling the nonlinear adaptive processor to implement the methods described in FIG. **12**, which may also be stored on the computer-readable medium.

[0078] The computer program can be implemented in hardware, software, or a hybrid implementation. The computer program can be composed of modules that are in operative communication with one another, and which are designed to pass information or instructions to display. The computer program can be configured to operate on a general purpose computer, or an application specific integrated circuit ("ASIC").

[0079] Some embodiments of the present invention are directed to a solar collector that reflects a broad spectrum of solar energy and focuses the solar energy through one or more lenses. The one or more lenses then direct the focused solar energy into one or more light traps where a black body absorbs a large portion of the solar energy and converts it into thermal energy. The thermal energy is then transferred via a thermal transfer medium for subsequent use, such as for storage in a thermal storage unit or for direct use to heat water, for example.

[0080] In some embodiments, the solar collector may have an aerodynamic design that is configured to resist high levels of wind. Such embodiments may have an aerodynamic cowling that may offer low wind resistance and may be positioned so as to present a low profile to the wind. In some embodiments, the inclination of the system may be changed to track the azimuth of the Sun and/or to move the inclination away from the azimuth in the event of an earthquake.

[0081] One having ordinary skill in the art will readily understand that the invention as discussed above may be practiced with steps in a different order, and/or with hardware elements in configurations which are different than those which are disclosed. Therefore, although the invention has been described based upon these preferred embodiments, it would be apparent to those of skill in the art that certain modifications, variations, and alternative constructions would be apparent, while remaining within the spirit and scope of the invention. In order to determine the metes and bounds of the invention, therefore, reference should be made to the appended claims.

We claim:

1. An apparatus, comprising:

a double parabolic reflector;

a light trap; and

a lens configured to receive light from the double parabolic reflector and focus the reflected light into the light trap.

2. The apparatus of claim **1**, further comprising:

a black body contained within the light trap; and

a thermal transfer medium operably connected to the black body, wherein

the black body is configured to absorb solar energy in the light trap and convert the absorbed solar energy into thermal energy, and

the thermal transfer medium is configured to transport the thermal energy away from the black body.

3. The apparatus of claim **1**, further comprising:

a plurality of light traps with a corresponding plurality of lenses, wherein at least one of the lenses is configured to receive solar energy concentrated by a section of the double parabolic reflector.

4. The apparatus of claim **3**, wherein at least one of the plurality of lenses is positioned above the other lenses and light traps to directly receive solar energy and deliver focused solar energy to a corresponding light trap.

5. The apparatus of claim **1**, further comprising:

a drive motor configured to move the apparatus along only a single axis of inclination.

6. The apparatus of claim **1**, wherein the lens comprises a Fresnel lens.

7. The apparatus of claim **1**, wherein the double parabolic reflector comprises a highly reflective film that reflects a majority of infrared, visible light, and ultraviolet solar energy.

8. The apparatus of claim **1**, wherein the double parabolic reflector is operably positioned on a lever arm driven by a hydraulic lift that is configured to position the double parabolic reflector to face an azimuth of the Sun.

9. The apparatus of claim **1**, wherein the double parabolic reflector comprises a frame having a plurality of panels bolted to otherwise secured thereto, wherein the frame includes a pair of W-shaped tracks between which the plurality of panels is compressed.

10. A solar energy collection system, comprising:

a reflector configured to reflect a broad spectrum of solar energy;

a lens or mirror configured to focus concentrated light received from the reflector;

a light trap configured to receive focused light from the lens or minor; and

a black body exposed within the light trap, wherein

the black body is configured to absorb solar energy as thermal energy and transfer the thermal energy to a thermal transfer medium.

11. The solar energy collection system of claim **10**, further comprising:

another lens or mirror positioned above the lens or mirror to directly receive solar energy and deliver focused solar energy to a corresponding light trap.

12. The solar energy collection system of claim **10**, further comprising:

a drive motor configured to move the solar energy collection system along only a single axis of inclination.

13. The solar energy collection system of claim **10**, wherein the lens comprises a Fresnel lens.

14. The solar energy collection system of claim **10**, wherein the reflector comprises a highly reflective film that reflects a majority of infrared, visible light, and ultraviolet solar energy.

15. The solar energy collection system of claim **10**, wherein the reflector is operably positioned on a lever arm driven by a hydraulic lift that is configured to position the reflector to face an azimuth of the Sun.

16. The solar energy collection system of claim **10**, wherein the reflector comprises a frame having a plurality of panels bolted to otherwise secured thereto, and the frame includes a pair of W-shaped tracks between which the plurality of panels is compressed.

17. A system, comprising:

a reflector;

a plurality of Fresnel lenses configured to receive and focus light reflected by the reflector; and

a plurality of light traps configured to receive the focused light from a respective one of the plurality of Fresnel lenses.

18. The system of claim **17**, further comprising:

a drive motor configured to move the system along only a single axis of inclination.

19. The system of claim **17**, wherein the reflector is operably positioned on a lever arm driven by a hydraulic lift that is configured to position the reflector to face an azimuth of the Sun.

20. The system of claim **17**, wherein the reflector comprises a frame having a plurality of panels bolted to otherwise secured thereto, and the frame includes a pair of W-shaped tracks between which the plurality of panels is compressed.

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