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(54) **HIGH GROUND COVER RATIO SOLAR COLLECTION SYSTEM**

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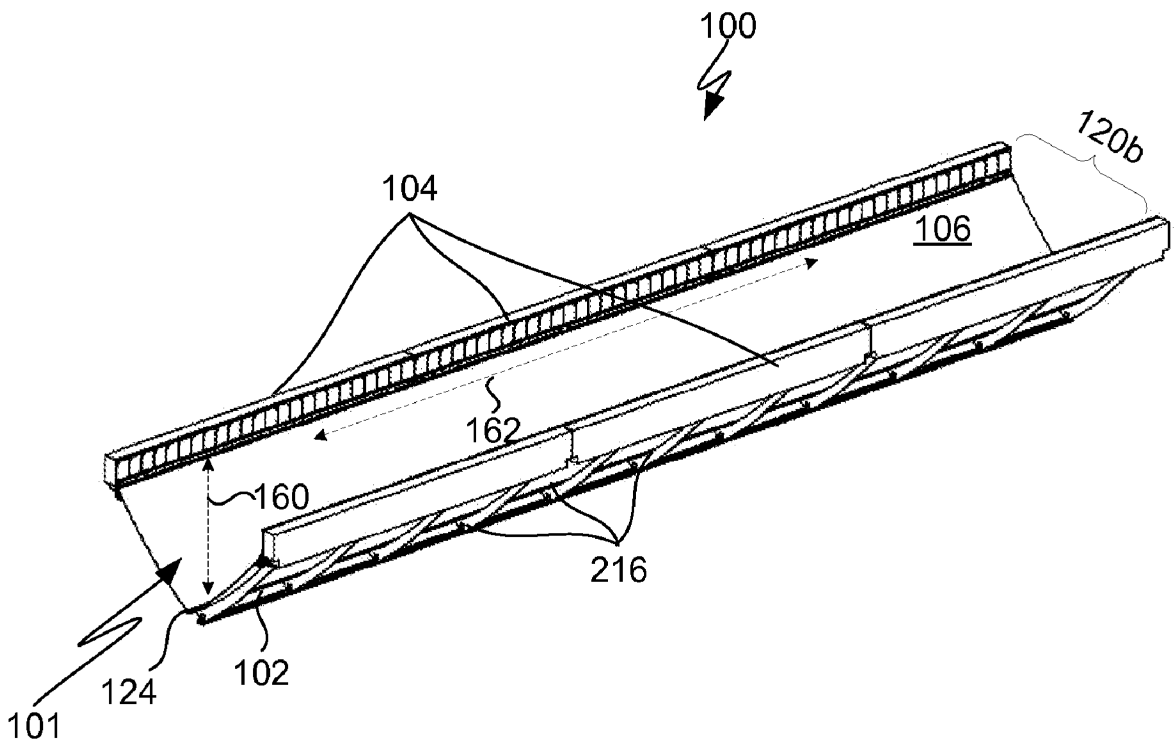
(52) **U.S. Cl.** **126/573**

(57) **ABSTRACT**

In one embodiment, a solar energy collection system that includes an array of collectors to track movements of the sun, each collector having a plurality of reflector panels, a support structure that supports the reflector panels, wherein the support structure supports the reflector panels in a manner that defines a trough, a pair of reflective side walls and a trough aperture suitable for receiving incident sunlight during operation of the collector, a plurality of solar receivers, each solar receiver being positioned generally adjacent an edge of an associated trough and including at least one photovoltaic cell, wherein the reflector panels are arranged to direct incident sunlight towards the solar receivers using a single reflection during operation of the collector, and a tracking mechanism to rotate the collector about an axis perpendicular to the longitudinal axis to track movements of the sun and direct incident sunlight along the longitudinal axis.



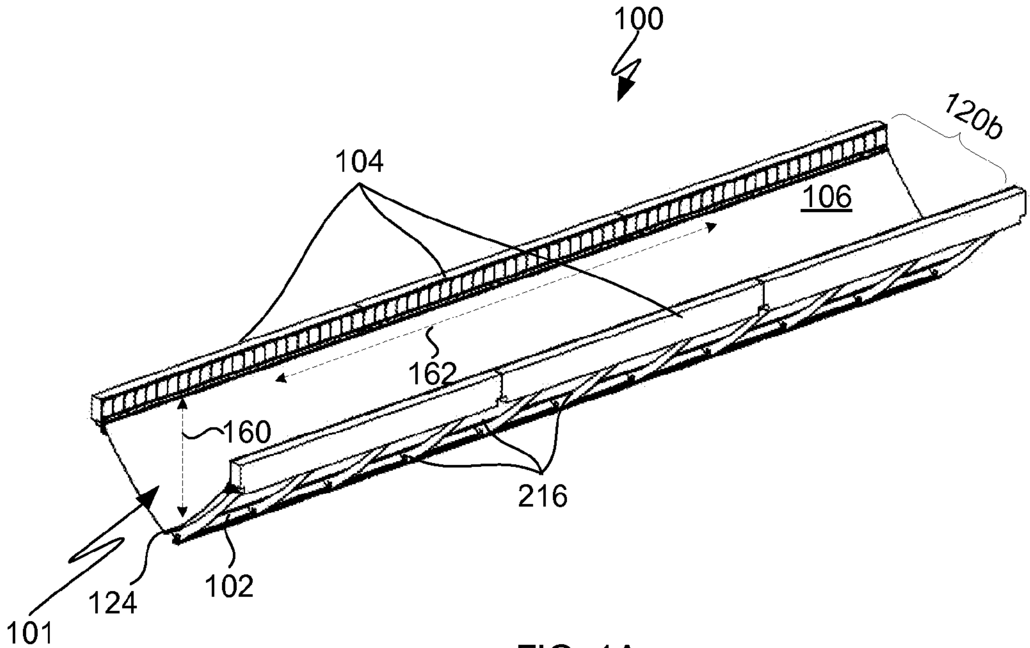

100
120b
104
106
162
160
216
124
102
101

FIG. 1A

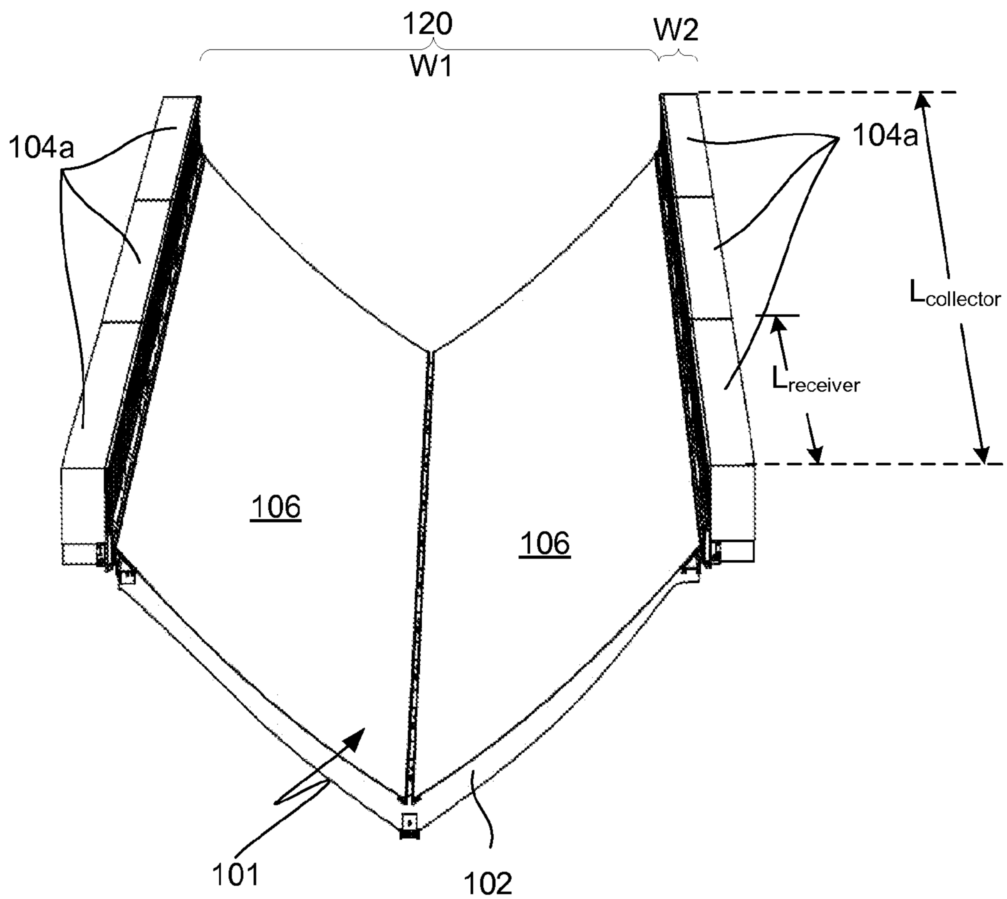

120
W2
W1
104a
104a
$L_{collector}$
$L_{receiver}$
106
106
101
102

FIG. 1B

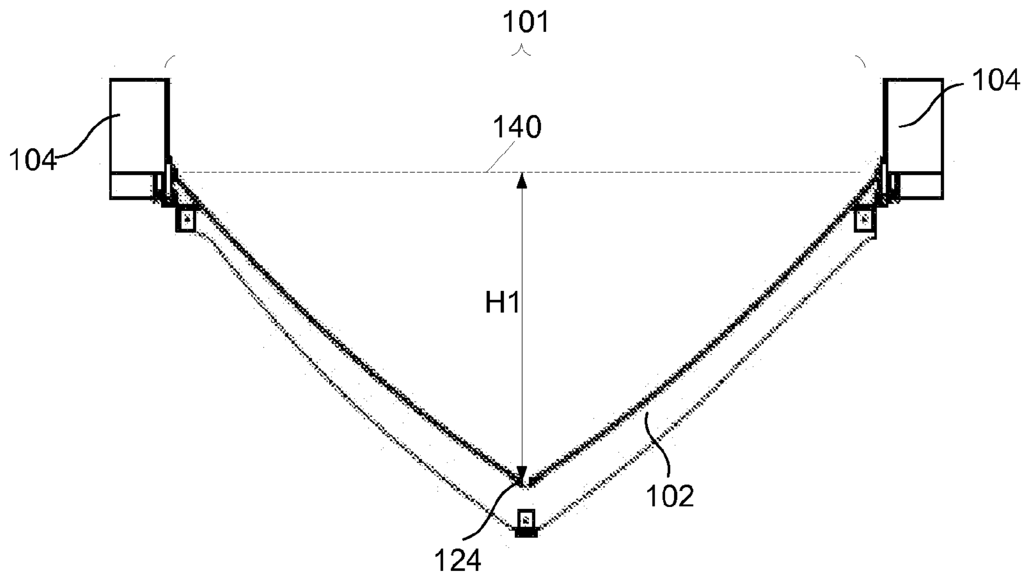


FIG. 1C

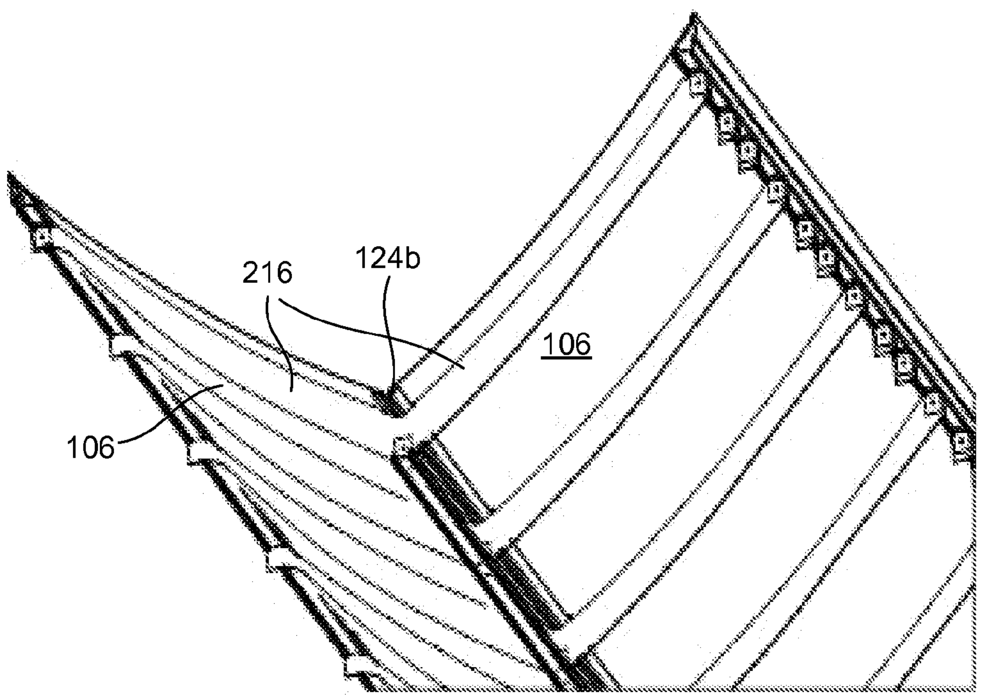


FIG. 1D

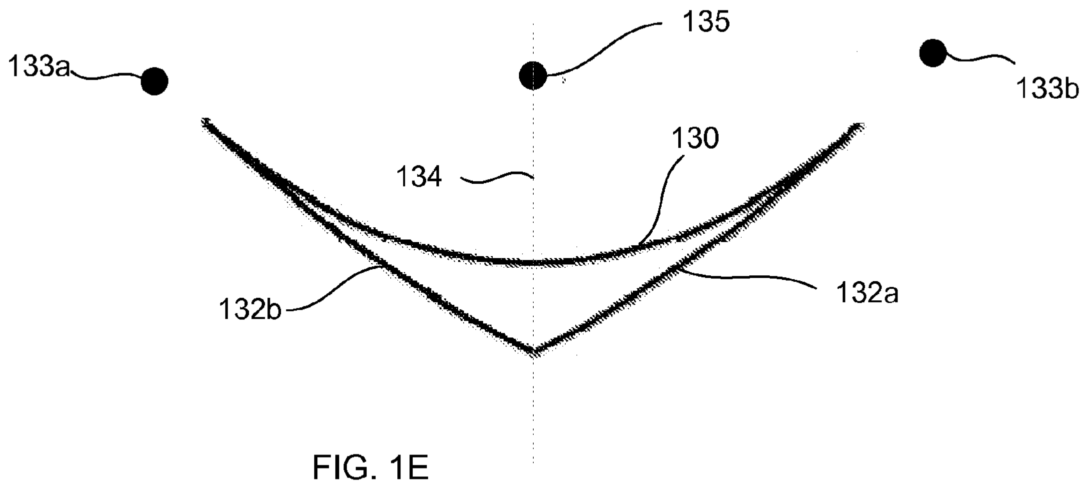

135
133a
133b
130
134
132b
132a

FIG. 1E

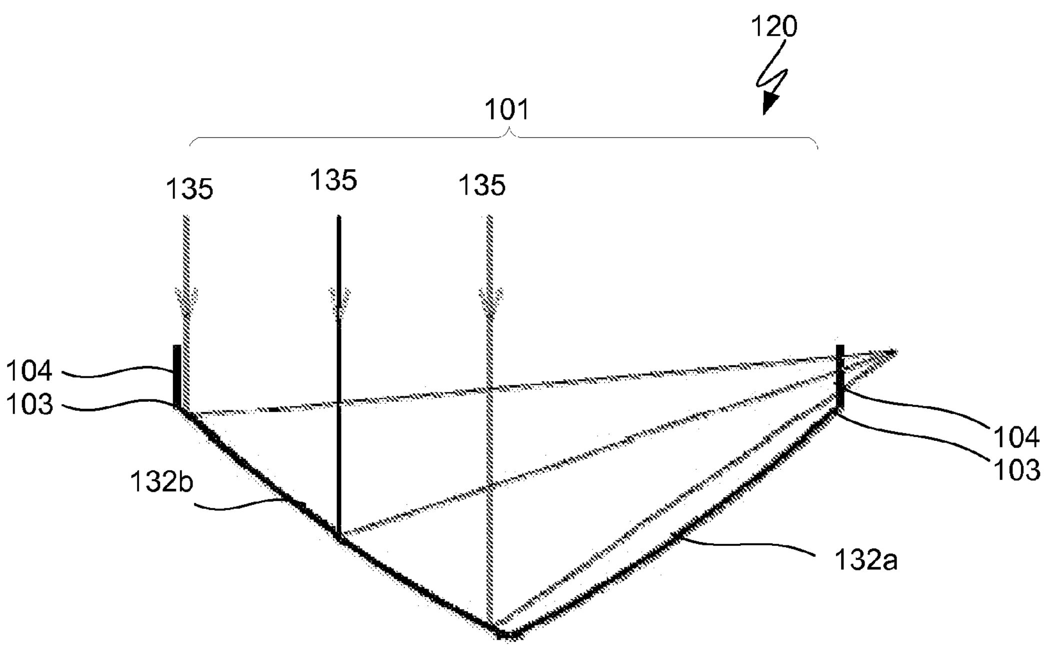

120
101
135
135
135
104
103
104
103
132b
132a

FIG. 1F

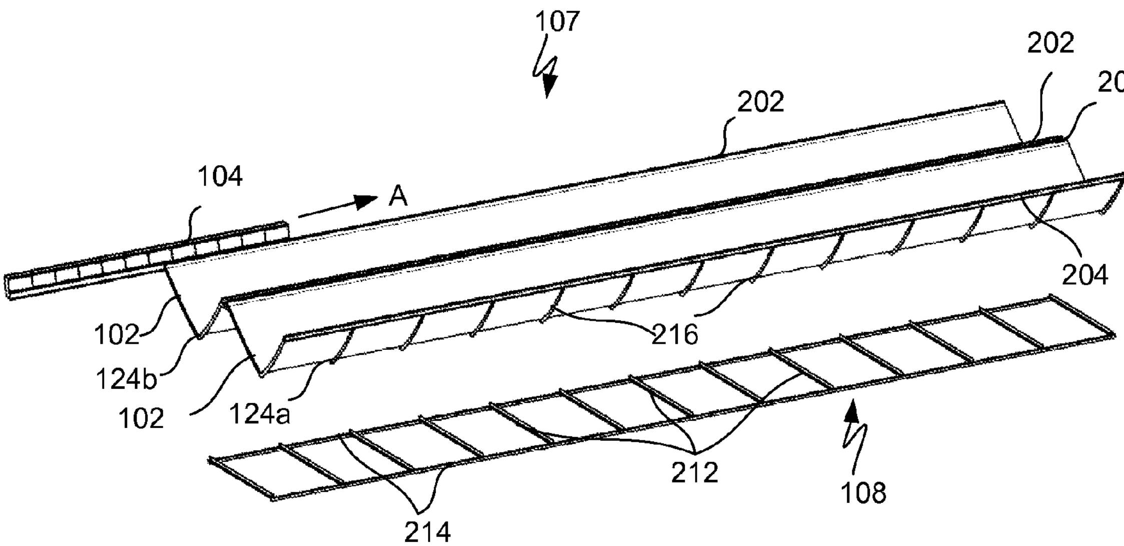

107
202
202
204
104
A
204
102
216
124b
102
124a
212
108
214

FIG. 2A

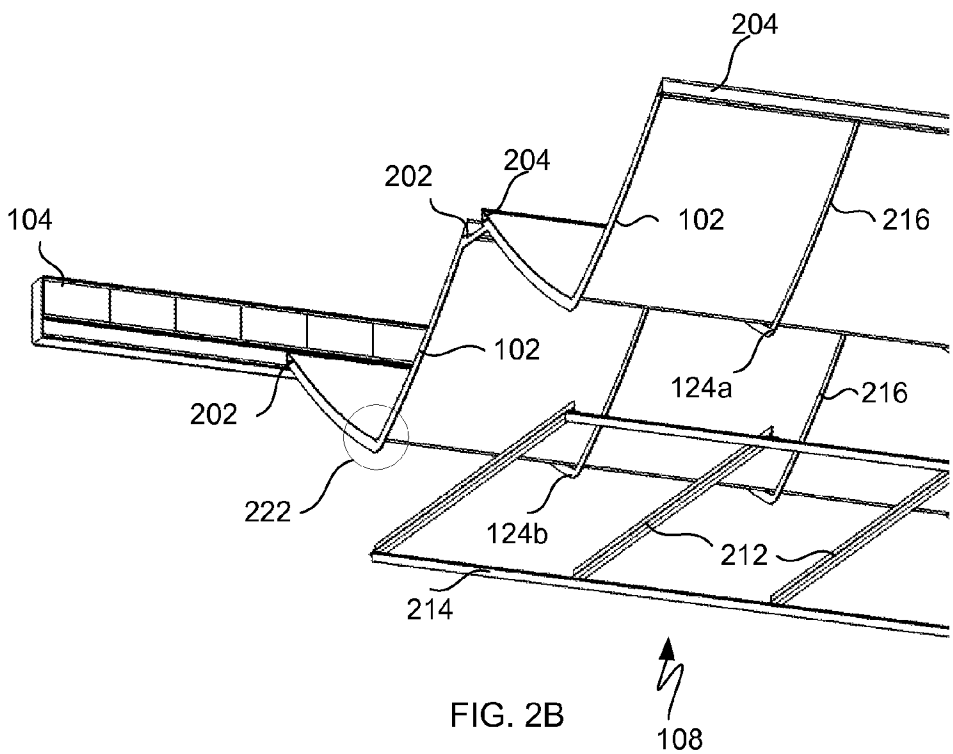

204
204
202
104
102
216
102
124a
216
202
222
124b
212
214
108

FIG. 2B

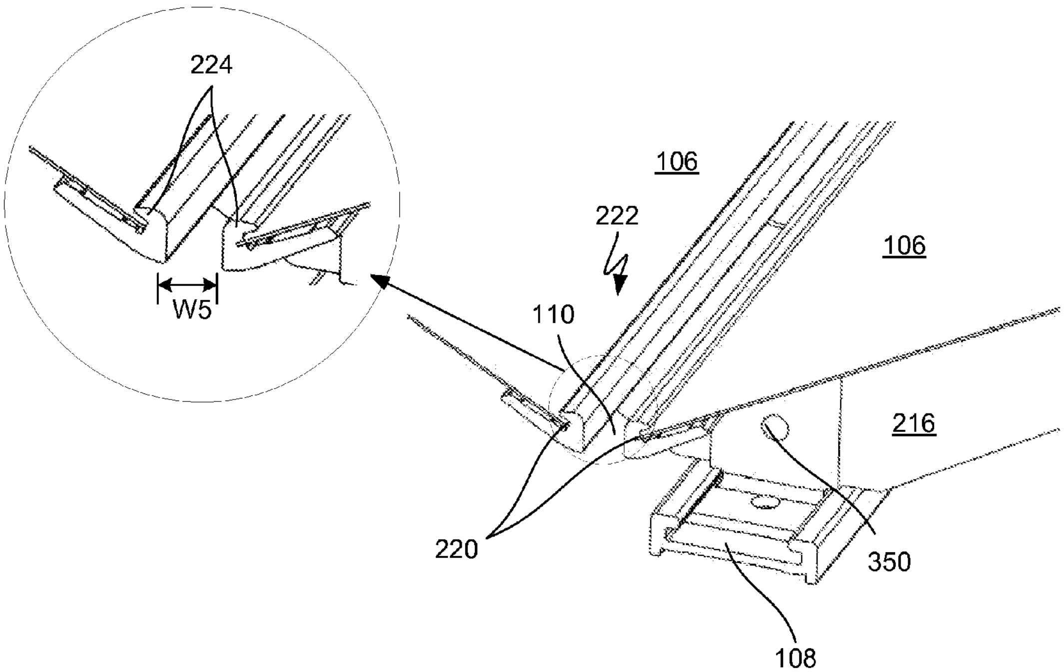


FIG. 2C

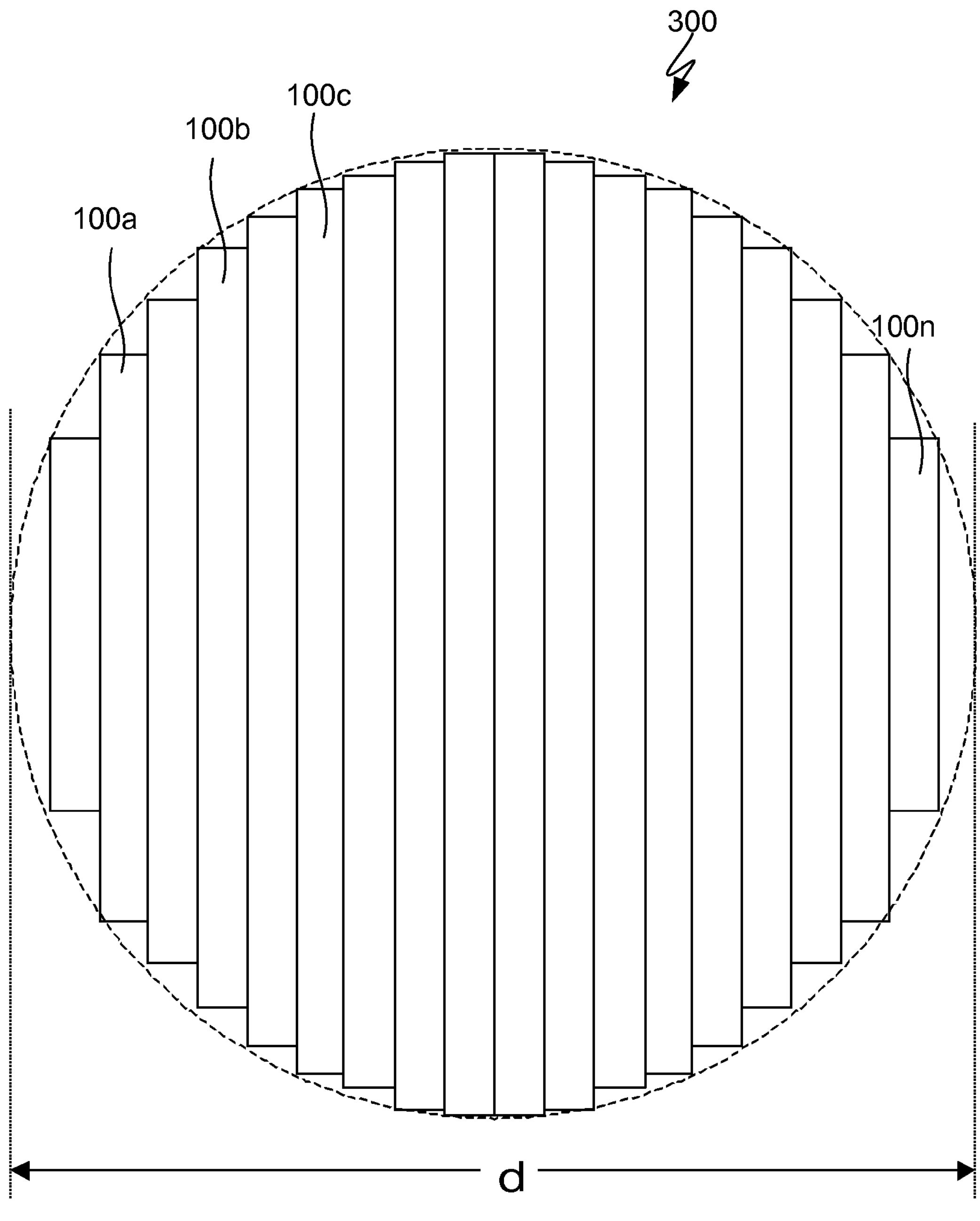


FIG. 3A

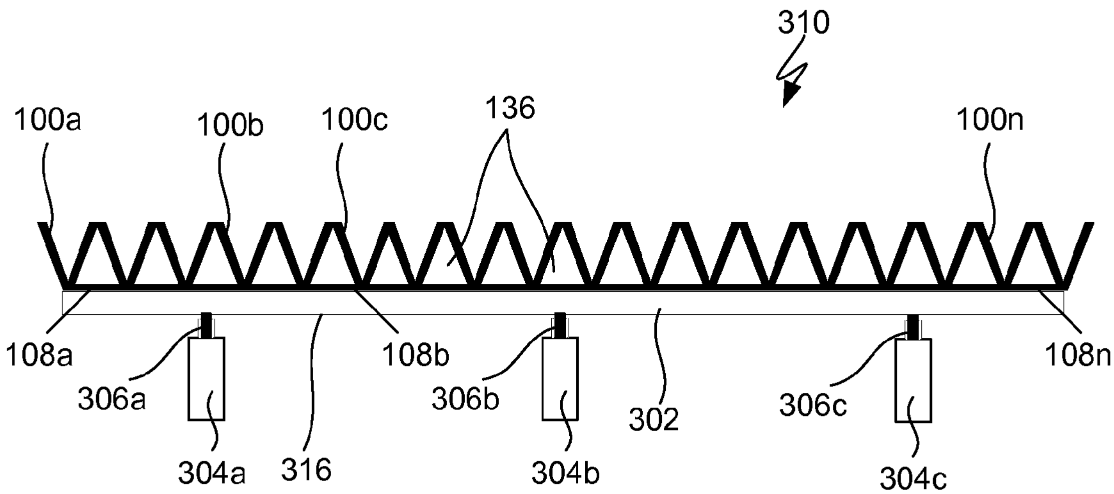

310
100a
100b
100c
136
100n
108a
306a
304a
316
108b
306b
304b
302
306c
304c
108n

FIG. 3B

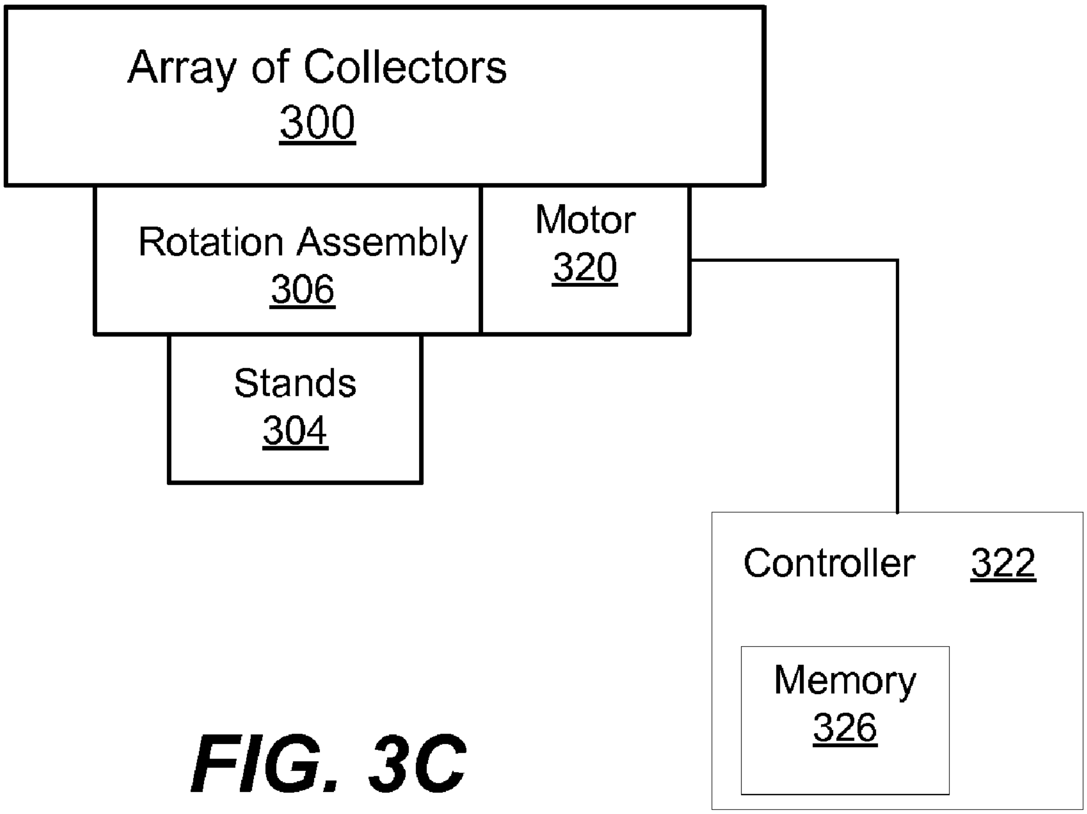

Array of Collectors
300
Rotation Assembly
306
Motor
320
Stands
304
Controller 322
Memory
326

FIG. 3C

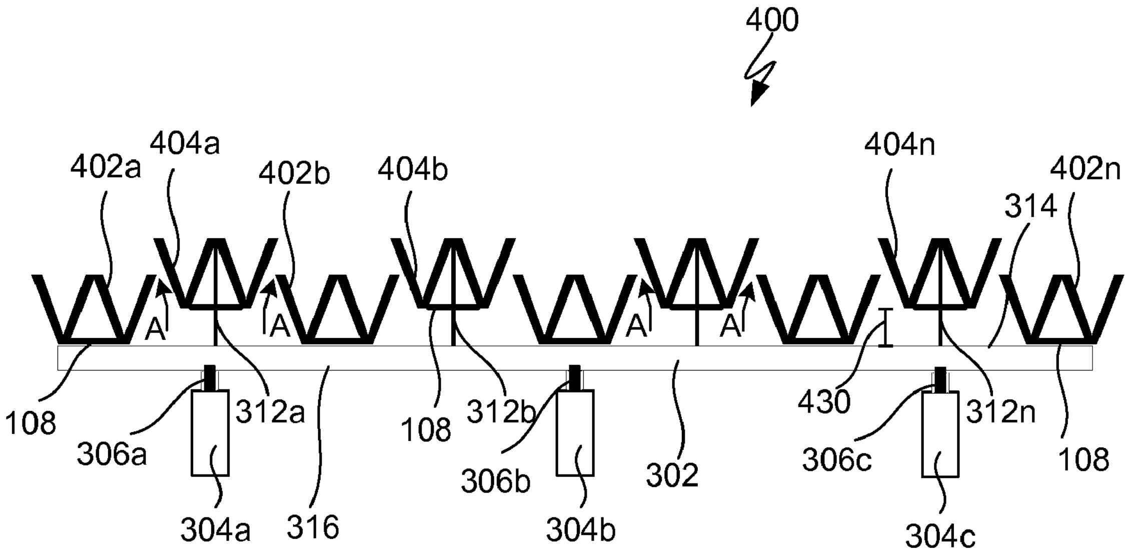

400
404a
402a
402b
404b
404n
402n
314
A
A
A
A
108
306a
312a
316
108
312b
306b
304b
302
430
306c
312n
108
304a
304c

FIG. 4A

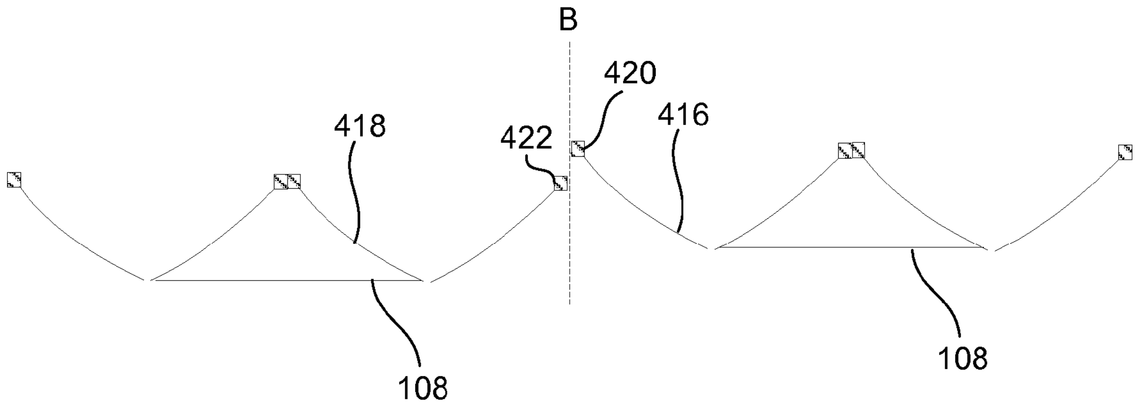


FIG. 4B

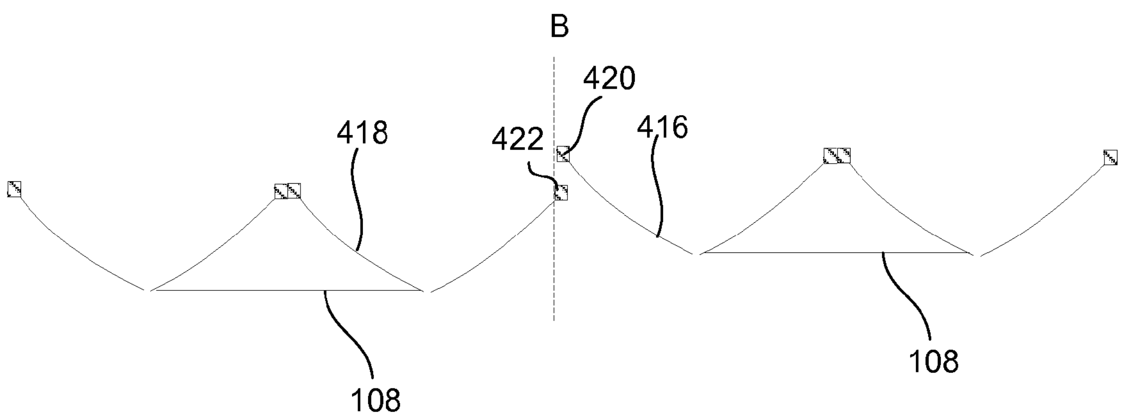


FIG. 4C

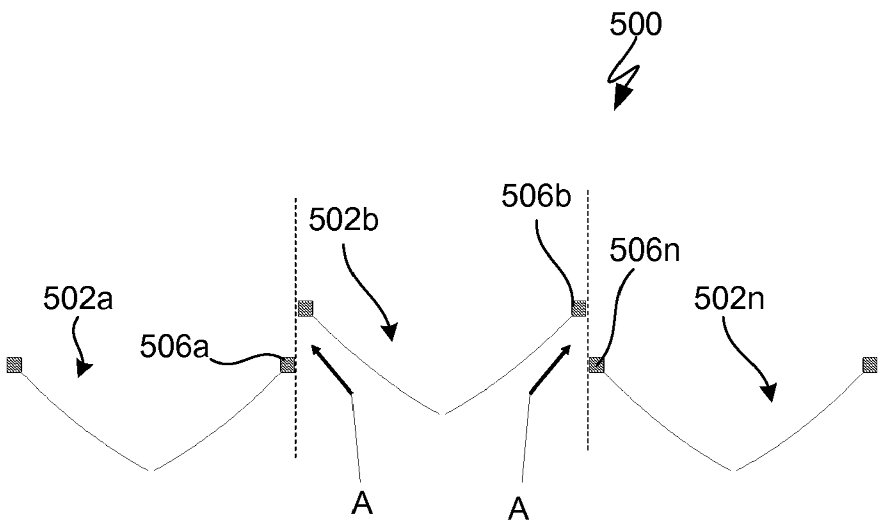

500
502a
502b
502n
506a
506b
506n
A
A

FIG. 5A

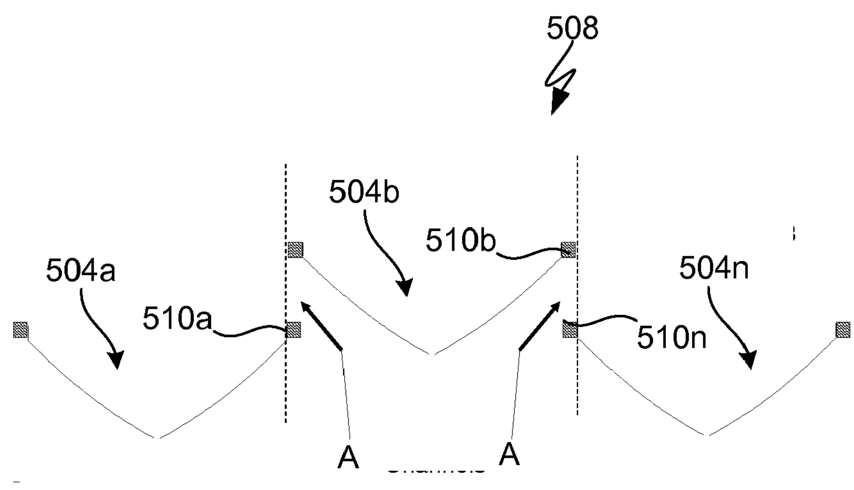

508
504a
504b
504n
510a
510b
510n
A
A

FIG. 5B

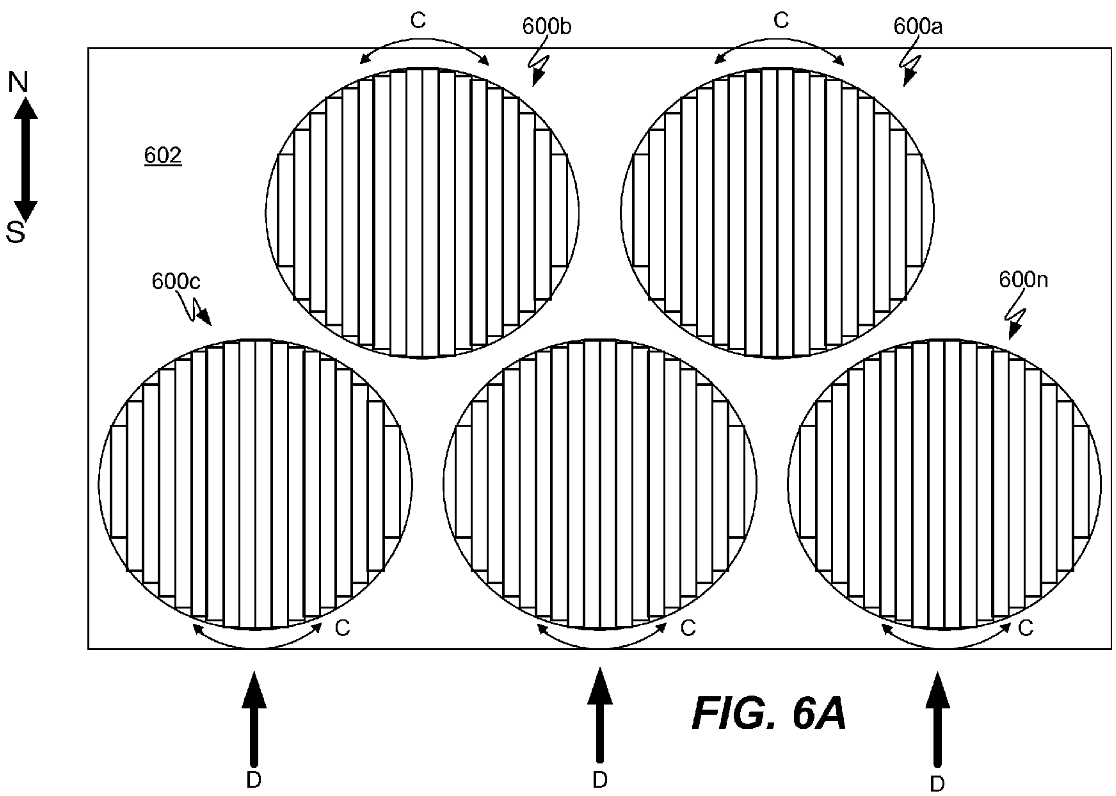


FIG. 6A

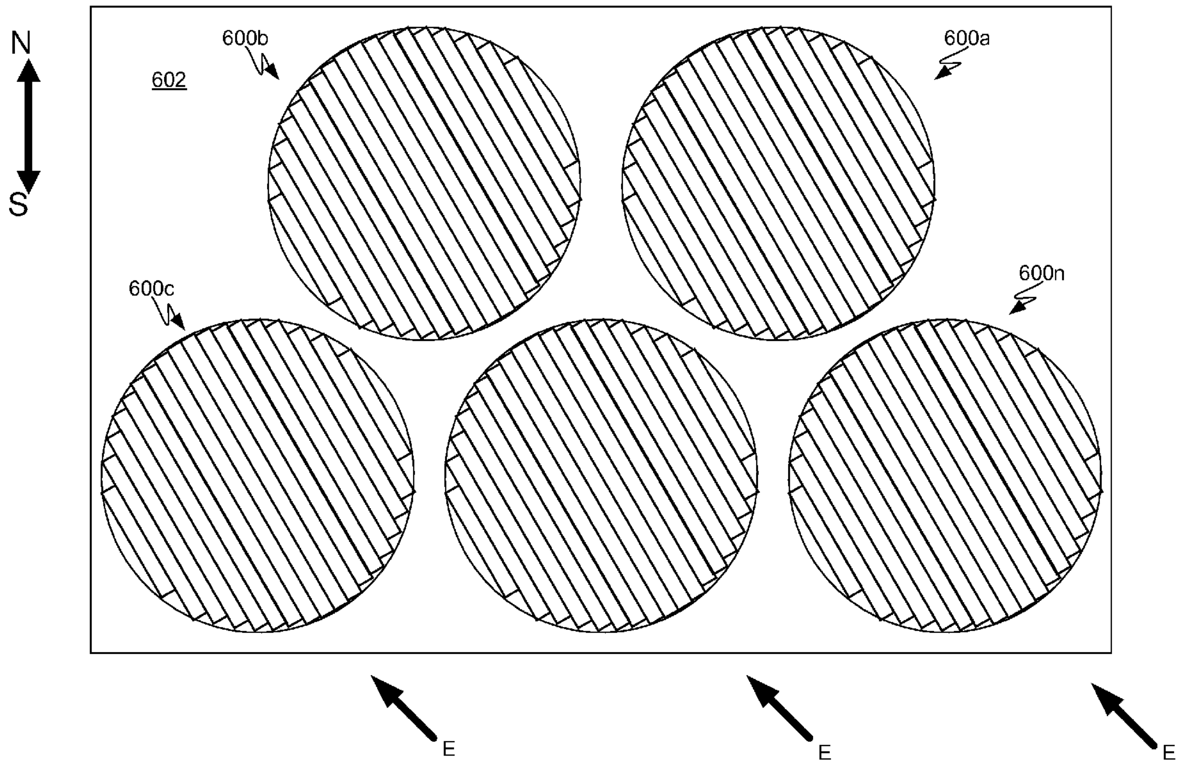


FIG. 6B

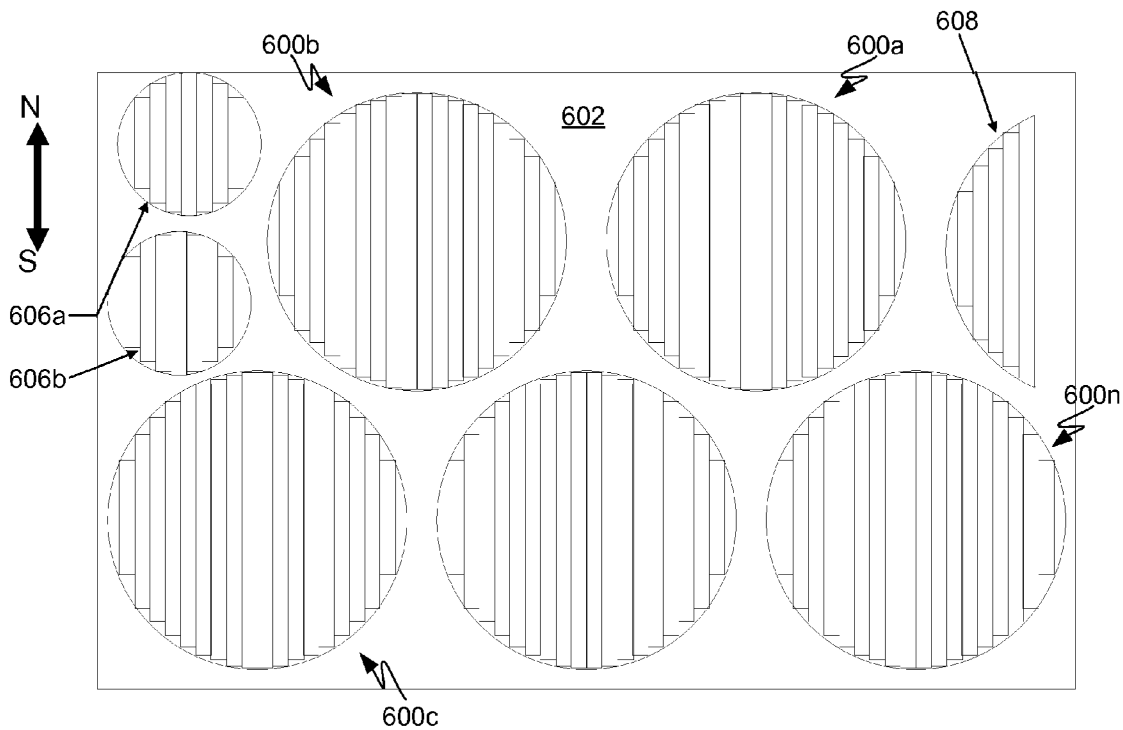


FIG. 6C

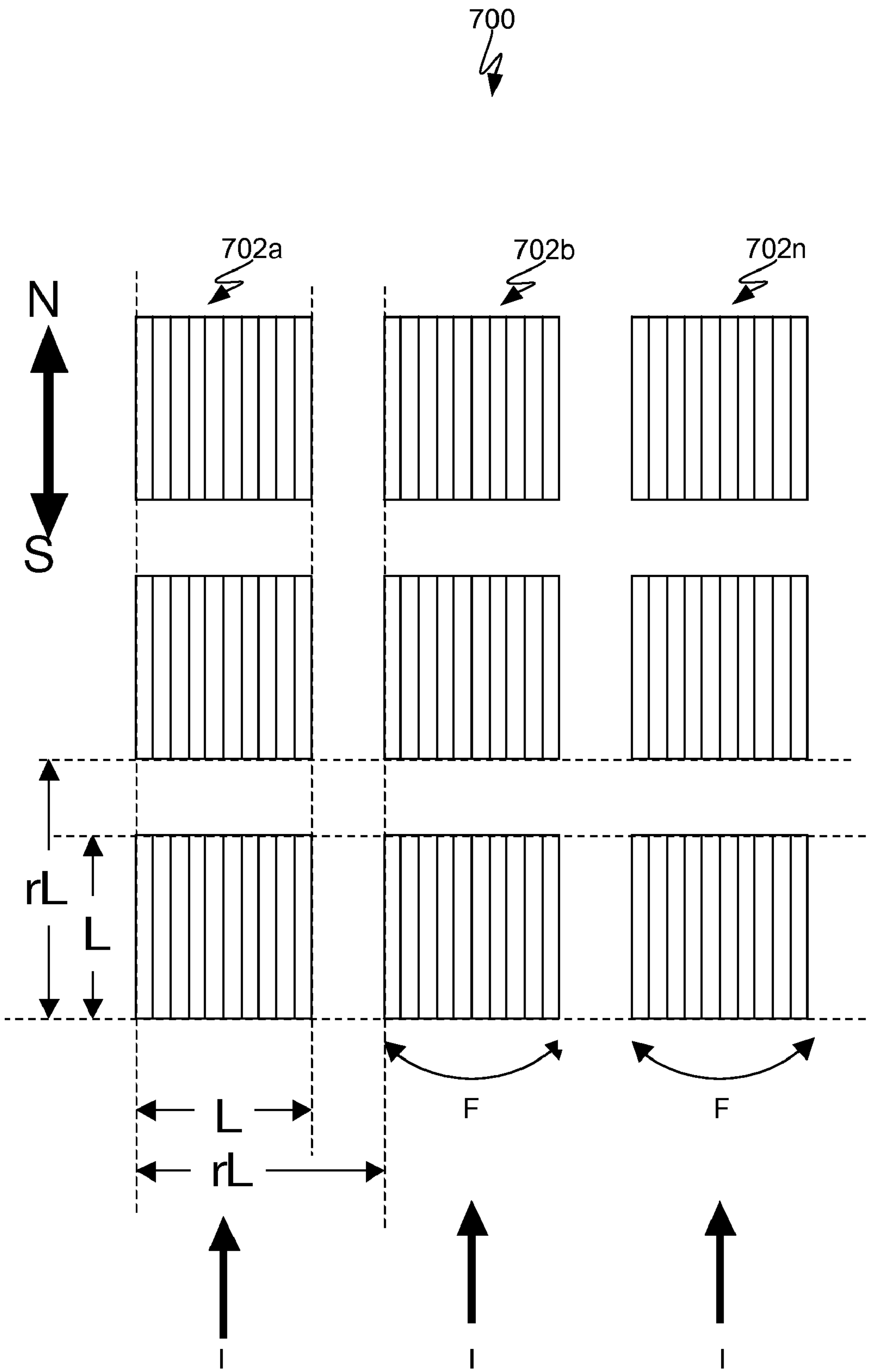


FIG. 7A

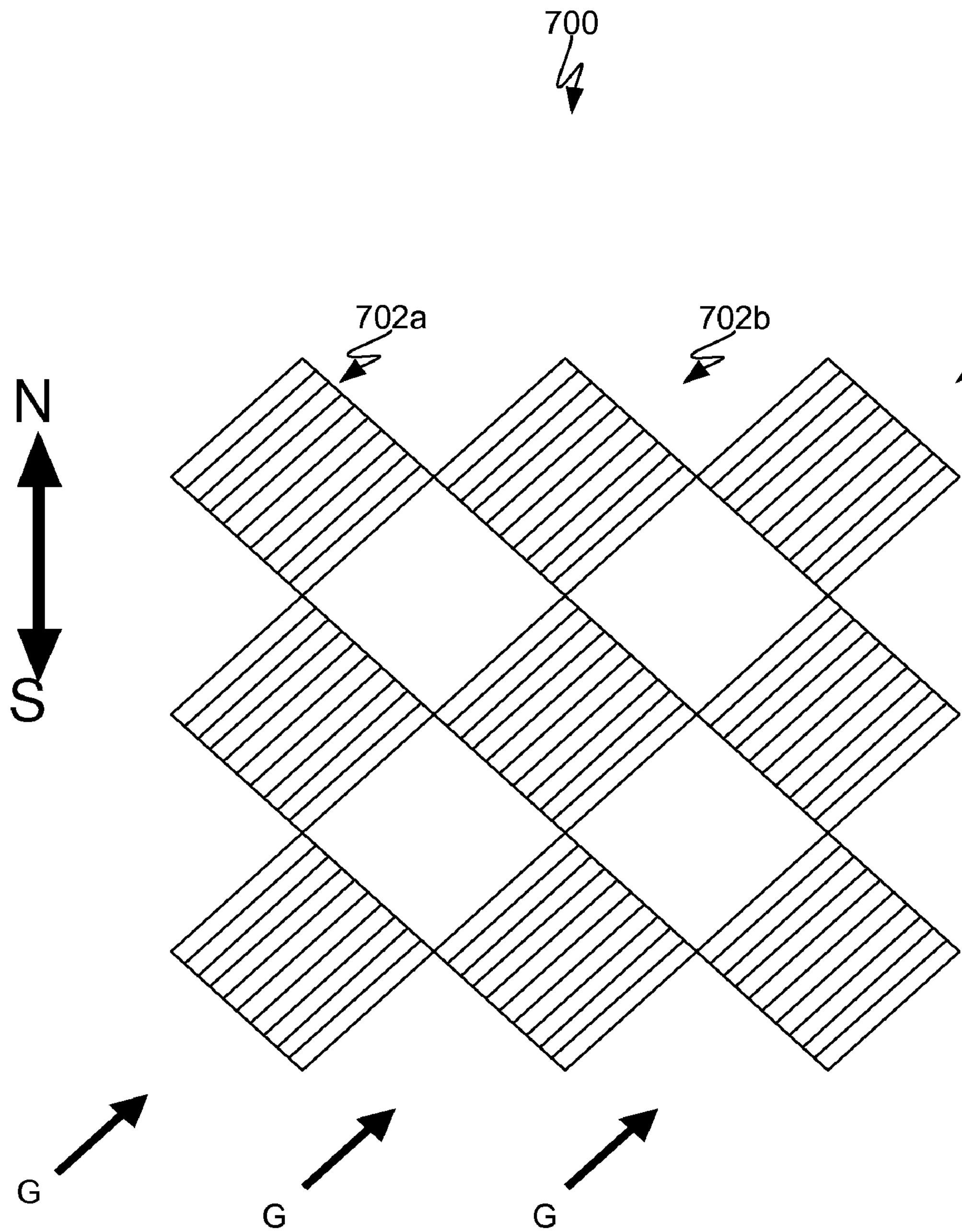


FIG. 7B

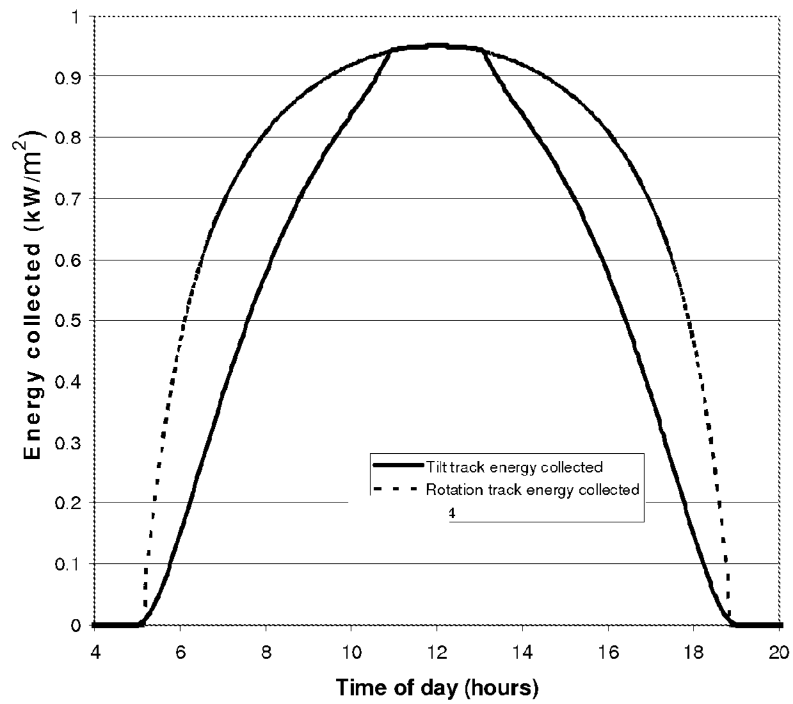

Energy collected (kW/m^2)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
4
6
8
10
12
14
16
18
20
Time of day (hours)
Tilt track energy collected
Rotation track energy collected

FIG. 8A

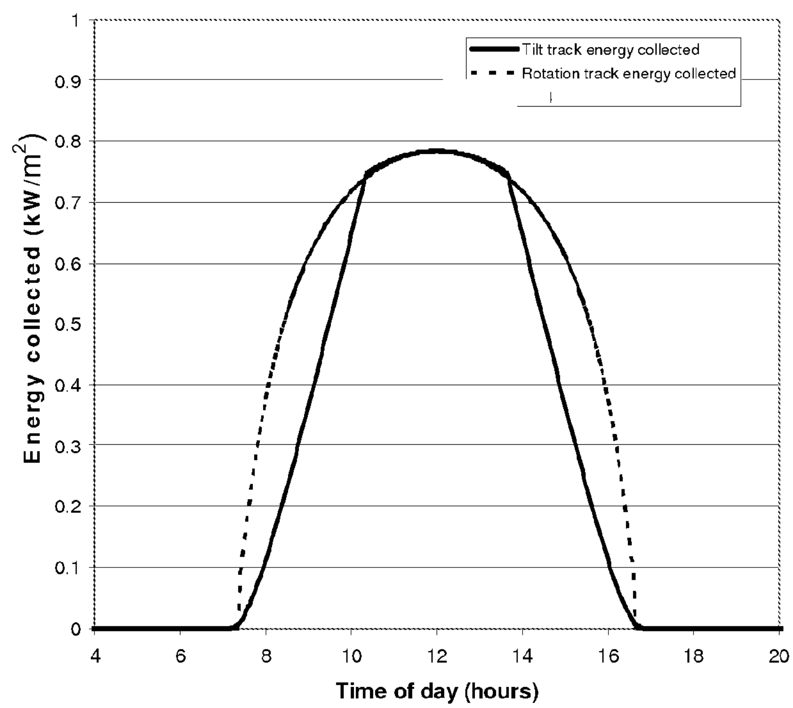

Energy collected (kW/m^2)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
4
6
8
10
12
14
16
18
20
Time of day (hours)
Tilt track energy collected
Rotation track energy collected

FIG. 8B

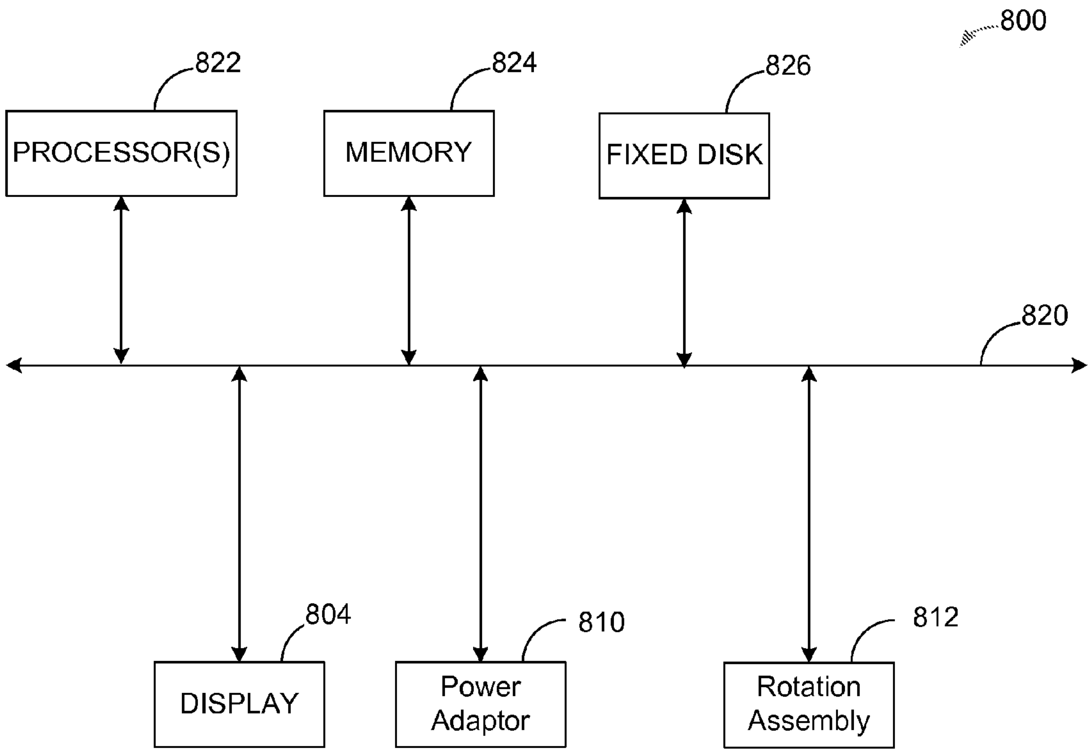

800
822
PROCESSOR(S)
824
MEMORY
826
FIXED DISK
820
804
DISPLAY
810
Power Adaptor
812
Rotation Assembly

Fig. 9

HIGH GROUND COVER RATIO SOLAR COLLECTION SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application No. 61/141,202, entitled "High Ground Cover Ratio Solar Collection System," filed Dec. 29, 2008, which is hereby incorporated by reference in its entirety for all purposes.

FIELD OF THE INVENTION

[0002] The present disclosure relates generally to the tracking of solar energy collectors.

BACKGROUND OF THE INVENTION

[0003] There is a need to economically collect solar energy in concentrated form prior to direct use or conversion to electricity or other useable forms of energy. Solar energy has a modest intensity at the earth's surface of about 1000 Watts per square meter.

[0004] It is thus highly desirable to concentrate the energy to higher intensity (usually expressed in Watts per square meter, or W/m^2) before use. This is particularly so where solar cells are used to convert the solar energy into electrical energy. The photovoltaic cells that are used to convert the solar energy into electrical energy are relatively expensive. Concentration of the incident solar energy into a smaller area allows the use of a smaller area of energy conversion cells, such as photovoltaic cells, with lower resulting costs of conversion cells. The key requirement in a concentrating collector is a means to concentrate the energy as much as possible with a system which is very low in cost per unit area and which can track the sun by rotation about one or two axes.

OVERVIEW

[0005] Described is a solar energy collection system that includes an array of collectors to track movements of the sun along at least one axis. Each collector has a plurality of reflector panels, a support structure that supports the reflector panels, wherein the support structure supports the reflector panels in a manner that defines a trough, the trough having a longitudinal axis, a pair of reflective side walls and a trough aperture suitable for receiving incident sunlight during operation of the collector. A plurality of solar receivers are positioned generally adjacent an edge of an associated trough and including at least one photovoltaic cell, wherein the reflector panels are arranged to direct incident sunlight towards the solar receivers using a single reflection during operation of the collector. A tracking mechanism to rotate the collector about an axis perpendicular to the longitudinal axis to track movements of the sun and to direct incident sunlight along the longitudinal axis may have a common platform to support the collector and means for rotating the common platform.

[0006] In another embodiment, a solar energy collection system having an array of collector carousels that track movements of the sun along at least one axis, each collector carousel in the array has a plurality of adjacent collectors having reflector panels, a support structure that supports the reflector panels, wherein the support structure supports the reflector panels in a manner that defines a reflector trough, each trough having a longitudinal axis, a pair of reflective side walls and a trough aperture suitable for receiving incident sunlight during operation of the collector, a plurality of solar receivers, each solar receiver being positioned generally adjacent an edge of an associated trough and including at least one photovoltaic cell, wherein the reflector panels are arranged to direct incident sunlight towards the solar receivers using a single reflection during operation of the collector, and a tracking mechanism to rotate the collector carousel about an axis perpendicular to the longitudinal axis to track movements of the sun and to direct incident sunlight at the trough aperture. The tracking mechanism may have a common platform to support the polarity of collectors, and means for rotating the common platform.

[0007] A collector carousel to track movements of the sun along at least one axis may have a plurality of collectors having reflector panels, a support structure that supports the reflector panels, wherein the support structure supports the reflector panels in a manner that defines a reflector trough, each trough having a longitudinal axis, a pair of reflective side walls and a trough aperture suitable for receiving incident sunlight during operation of the collector, a plurality of solar receivers, each solar receiver being positioned generally adjacent an edge of an associated trough and including at least one photovoltaic cell, wherein the reflector panels are arranged to direct incident sunlight towards the solar receivers using a single reflection during operation of the collector, and a tracking mechanism to rotate the collector to track movements of the sun and to direct incident sunlight at the trough aperture, wherein no component of the collector carousel shades the reflector panels during normal operation of the collector carousel.

[0008] The present invention provides other hardware configured to perform the methods of the invention, as well as software stored in a machine-readable medium (e.g., a tangible storage medium) to control devices to perform these methods. These and other features will be presented in more detail in the following detailed description of the invention and the associated figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The accompanying drawings, which are incorporated into and constitute a part of this specification, illustrate one or more example embodiments and, together with the description of example embodiments, serve to explain the principles and implementations.

[0010] In the drawings:

[0011] FIGS. **1**A-**1**F illustrate an embodiment of a single trough solar energy concentrator or collector suitable for use with various embodiments discussed herein.

[0012] FIGS. **2**A-**2**C illustrate an expanded perspective view of a pair of collectors using the collector illustrated in FIG. **1**A.

[0013] FIGS. **3**A-**3**C illustrate one embodiment of an array of solar collectors.

[0014] FIGS. **4**A-**4**C illustrate side views of other embodiments of an array of collectors.

[0015] FIGS. **5**A and **5**B illustrate side views of still other embodiments of vertically staggered single collectors.

[0016] FIGS. **6**A-**6**C illustrate an embodiment of a high ground cover ratio solar collection system.

[0017] FIGS. **7**A and **7**B illustrate top views of another embodiment of a high ground cover ratio solar collection system.

[0018] FIGS. **8**A and **8**B illustrate graphs comparing the energy collected at different times of the year.

[0019] FIG. **9** illustrates an example computer system suitable for implementing the software applications used in one or more embodiments of a high ground cover solar collection system.

DESCRIPTION OF EXAMPLE EMBODIMENTS

[0020] Embodiments are described herein in the context of a high ground cover ratio ("GCR") solar collection system. The following detailed description is illustrative only and is not intended to be in any way limiting. Other embodiments will readily suggest themselves to such skilled persons having the benefit of this disclosure. Reference will now be made in detail to implementations as illustrated in the accompanying drawings. The same reference indicators will be used throughout the drawings and the following detailed description to refer to the same or like parts.

[0021] In the interest of clarity, not all of the routine features of the implementations described herein are shown and described. It will, of course, be appreciated that in the development of any such actual implementation, numerous implementation-specific decisions must be made in order to achieve the developer's specific goals, such as compliance with application- and business-related constraints, and that these specific goals will vary from one implementation to another and from one developer to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking of engineering for those of ordinary skill in the art having the benefit of this disclosure.

[0022] In accordance with the present invention, the components, process steps, and/or data structures may be implemented using various types of operating systems, computing platforms, computer programs, and/or general purpose machines. In addition, those of ordinary skill in the art will recognize that devices of a less general purpose nature, such as hardwired devices, field programmable gate arrays (FPGAs), application specific integrated circuits (ASICs), or the like, may also be used without departing from the scope and spirit of the inventive concepts disclosed herein.

[0023] A solar energy collection system is described. FIGS. **1**A-**1**F illustrate an embodiment of a single trough solar energy concentrator or collector suitable for use with various embodiments discussed herein. FIG. **1**A is a perspective view of the single trough solar energy collector, FIG. **1**B is a top perspective view of the single trough solar energy collector, FIG. **1**C is a side view of the single trough solar energy collector, and FIG. **1**D is a bottom perspective view of the single trough solar energy collector. The collector **100** has an optical aperture **101** designed to admit incident sunlight onto reflector panels **106**. The support structure **102** is arranged to support at least two reflector panels **106**. Reflector panels **106** are attached to the support structure **102**. The collector **100** may have a base **124** and a pair of reflective side walls formed from the reflector panels **106**. The collector **100** may be configured so as to direct incident sunlight entering collector **100** through the optical aperture **101** toward a region slightly above a top edge of the opposing reflector panel **106**. The support structure **102** is composed of a plurality of shaping ribs **216** (FIG. **1**A) and other components as further described in detail below. The collector **100** also has a plurality of receivers or solar receivers **104** coupled near the top edges of the collector **100**. Example solar receivers will not be discussed herein to prevent obfuscation of the invention, but are disclosed in co-pending application Ser. No. 12/124,121, entitled "Photovoltaic Receiver", filed May 20, 2008, which is incorporated herein by reference for all purposes. The solar receivers may be passively cooled (such as with air using a finned heat sink) or actively cooled (such as with cooling fluids in a pipe).

[0024] FIG. **1**E illustrates a cross-sectional diagram of a trough. FIG. **1**F illustrates a cross-sectional diagram of a collector. Each collector **100** has a longitudinal axis **162** (FIG. **1**A) and an optical aperture **101** (FIG. **1**F). For the purposes of this explanation, we utilize the term aperture to refer to the effective trough opening that exists when the collector is directly facing the sun. We also use the term normal axis **160** (or aperture axis or lateral axis as illustrated in FIG. **1**A) to refer to a geometric axis that is perpendicular to the longitudinal axis and parallel to incident solar radiation when the collector is facing directly towards the sun. However, for collection of sunlight by the collector, the sun does not need to be directly overhead. In one embodiment, the collector trough **120** has a curvature resembling that of a quarter section of a parabola **132**. In other words, the curvature of the trough may approximate an arc of a circle or any other geometries that provide suitable concentration of the sunlight at the targeted receivers. In the quarter section embodiment, the trough **120** may be composed of two quarter section of a "full" or traditional parabola having the same focus. Although described as a quarter section of a parabola this description is not intended to be limiting as the troughs **120** are approximately similar to a quarter section of a parabola shape and not an exactly mathematically perfect parabola shape.

[0025] FIG. **1**E illustrates a traditional center-focusing full parabola configuration **130**, with a focus at **135**, superimposed and compared to the use of two quarter sections of a parabola **132**. As compared to the full parabola configuration **130**, use of a substantially quarter of a parabola **132** configuration provides for a deeper or V-shaped trough and each side of the trough has less curvature. A quarter section of a parabola **132** is a section of a parabola such that when two opposing quarter sections are positioned adjacent to each other the focus of one section is near the top edge of the opposing section. For example, the focus for section **132***a* is at **133***a* and the focus for section **132***b* is at **133***b*. The quarter parabolic trough **132** achieves the same geometric concentration as a full parabola concentrator, but has a lower curvature and may also be stiffer. The reduced curvature also reduces the stress in a bent reflector panel **106** and allows reflector panel **106** to be formed from a generally planar panel. The increased stiffness results from the shape having a higher area moment of inertia. Having a deeper trough and/or truss (as discussed below) also generally provides for a stiffer collector than a shallower one. Additionally, for a fixed axial load, a straighter beam may be stiffer than a curved beam. The increased intrinsic stiffness of this design allows collector **100** to be fabricated using lighter and less expensive materials such as aluminum, sheet metal, and the like.

[0026] Referring back to FIGS. **1**A-**1**C, the support structure **102** may support or hold a plurality of reflector panels **106**. The reflector panels **106** may be shaped by elastic deformation against shaping ribs **216** (FIGS. **2**A and **2**B) of the support structure **102**. In one embodiment, the reflector panels **106** may be plastically formed with a curvature. Thus, the reflector panels **106** may be supported and held by the structure **102** with a curvature resembling a quarter parabolic configuration, as further discussed in detail below with reference to FIGS. **2**A and **2**B.

[0027] Although a single quarter parabolic trough provides higher bending stiffness than the equivalent full parabolic trough, it is an open shape and may thus have low torsional stiffness. As illustrated in FIG. 1F, the quarter parabola trough configuration or shape is configured to direct the focus of the trough **120** to a location just above the far edge of the opposing trough segment. This allows the solar receivers **104** to be located where they will not shade the reflector panels **106**. Additionally, the solar receivers **104** may be attached to the trough **120** edges **103** without the use of struts that extend over the faces of the reflector panels. Traditionally, installing struts over the trough opening creates a closed shaped truss. The struts cast shadows over the reflector panels, which results in a less efficient photovoltaic design. As described above, use of the quarter parabola trough configuration of FIG. 1F permits the use of the closed shaped truss under the trough pair **107** and under the reflector panels **106**. Furthermore, the quarter parabola trough configuration allows for the solar receivers **104** to be located at the edges of each trough in the trough pair **107**, as further described below with reference to FIG. 2A. The solar receivers **104** and all structural elements such as the stand, support structure and frame thus do not cast a shadow over the reflector panels **106**, which results in a more efficient solar energy collector **100**.

[0028] Referring back to FIGS. 1B-1D, the dimensions of the collector units **100** may be widely varied to meet the needs of particular applications. By way of example, collector lengths $L_{collector}$ on the order of between about 5-40 meters (m) having at least three solar receivers **104** mounted near each top edge of the support structure **102** works well for many applications. In such systems, the optical aperture width (W1) may be between about 800-1200 millimeters (mm) and the width of receiver (W2) may be between about 5-150 mm. The height (H1) of each trough from bottom **124** to top edges **103** of the support structure **102** may be between about 300-400 mm. The top edges **103** may also lie in a longitudinal plane **140** of the collector. In one specific example, $L_{collector}$ may be 20 m, W1 may be 1010 mm, W2 may be 100 mm, the total width of the trough pair **107** may be 2.10 m, and H1 may be 360 mm. To achieve the approximate quarter parabola curvature a generally planar panel may be elastically deformed to deviate from planarity from between about 10 to 40 mm. Although some specific dimensions are mentioned herein, it should be appreciated that the dimension of the collectors are in no way limited to these ranges. Rather, they can be widely varied to meet the needs of a particular application.

[0029] FIGS. 2A-2C illustrate an expanded perspective view of a pair of collectors using the collector illustrated in FIG. 1A. As seen therein, the trough pair **107** has a plurality of shaping ribs **216** spaced along the longitudinal axis **162** (FIG. 1A). The shaping ribs **216** may provide both the correct optical shape and the structural stiffness for the reflector panels **106**. The surface of the shaping ribs **216** adjacent to reflector panels **106** is formed to resemble the quarter parabolic configuration or shape. The shaping ribs **216** may approximately resemble a quarter parabolic shape to achieve an adequate focus of sunlight on solar receivers **104**. For example, in one embodiment the surface of the shaping ribs **216** adjacent to reflector panels **106** may be formed to approximate an arc of a circle or other shape that provides suitable concentration at the receiver. Although the shaping ribs **216** are illustrated below the edge of the reflector panels **106**, the location or positioning of the shaping ribs **216** is not meant to be limiting as the shaping ribs **216** may be located at any longitudinal position to support the reflector panels **106**.

[0030] The shaping ribs **216** may be formed as a single, dual, or multiple trough structure from a sheet stock by water jet cutting, laser cutting, stamping, or any other suitable means. The sheet stock may be of any form. For example, the sheet stock may be a planar, rectangular sheet stock. In another example, the sheet stock may be formed into a “T” shape, “D” shape, “L” shape, “C” shape, or any other similar shape that provides for a higher stiffness and stronger shaping rib. In another embodiment, shaping ribs **216** may be assembled from multiple pieces and coupled together via any means such as the use of structural adhesives, welding, bolts, and the like. Furthermore, the shape of the shaping ribs **216** may minimize scrap during production as most of the material in a rectangular piece of sheet stock is used to form the shaping ribs **216**.

[0031] The quarter parabolic configuration of the shaping ribs **216** allows for the shaping ribs **216** to be made from lighter, lower-cost structural material. Additionally, in one assembly procedure, flat reflector sheets are bent to conform to the quarter parabolic configuration of the shaping ribs **216**. As described above, one advantage of the quarter parabolic configuration is that it does not generate large stresses within the reflector when the reflector sheets are bent during assembly to form the reflector panels **106**. Furthermore, the support structure **102** allows a single reflector panel **106** to be fabricated from a single, continuous reflector sheet for each half trough that extends along the entire length $L_{collector}$ of the collector **100**. Of course it should be appreciated that in alternative embodiments, each half trough can be formed from multiple reflector panels arranged side-to-side, end-to-end or in any configuration that completely covers the half trough.

[0032] In one embodiment, each reflector panel **106** may be made of Miro-Sun® 4270 KKSP, made by Alanod of Ennepatal, Germany. The Miro-Sun® KKSP is a 0.5 mm thick aluminum strip that may have a specialty surface providing over 90% specular reflection over the band in which silicon photovoltaic cells operate. A protective lacquer coating may be applied to the top of the reflector panels **106** to increase abrasion and weather resistance. In another embodiment, the reflector panels **106** may be made of any high reflection material, produced by Alanod or a plurality of other vendors. In still another embodiment, the reflector panel **106** may have a silver coated polymer-based laminate over the aluminum strip. Once the reflective properties of the silver coated laminate are degraded from weather and/or the sunlight, the silver coated laminate may be removed to thereby expose a new reflective layer. This allows the collector **100** to be used for longer periods of time without having to be replaced, easily maintained, and less costly. A reflector panel may have between about 1-5 layers of silver coated laminate.

[0033] The reflector panels **106** may be made in a continuous roll-to-roll process having a width of 1250 mm. Each reflector panel **106** may be formed by using an entire roll width, or one-half or one-third of the width of the roll, thereby reducing any waste as the entire roll may be used to form the reflector panels. In one example, the reflector panels **106** may be a half-width slit roll having a width of 625 mm, which forms a reflector panel having a length substantially equal to $L_{collector}$ and a height substantially equal to H1. In another example, the length may be 2.0 m and the height may be 360 mm. In one embodiment, each reflector panel may be formed from a plurality of reflector sheets, each sheet being fabricated from a roll of reflector material in such a way to substantially utilize all the reflector material on the roll with minimal waste.

[0034] In another embodiment, the reflector panels **106** may be made of a tempered thin glass minor bonded to a suitable backing. The mirror may have a thickness of between about 0.10 mm to 1 mm. The quarter parabolic configuration curvature of the reflector panels **106**, when elastically deformed to conform on the shaping ribs **216**, is less than the curvature of a traditional full parabola configuration allowing use of the tempered thin glass minor. In one embodiment, the reflector panels **106** may have a silver coated laminate over the mirror as discussed above.

[0035] In yet another embodiment, the reflector panel **106** may have a backing panel attached to the reflective surface (not shown) to stiffen the panel assembly. In one example, the backing panel may be a sheet of aluminum or similar material. In another example, the backing panel may have a complex structure, such as a honeycomb, X-shape, V-shape, or the like. The backing panel may have a thickness of between about 0.5 mm to 5 mm.

[0036] In yet still another embodiment, the reflector panels **106**, support structure **102**, and frame **108** may all be made of the same material, such as aluminum. Use of the same material may ensure a similar coefficient of thermal expansion (CTE) that allows for the use of large area reflector panels without deleterious mechanical deformation. As illustrated and described above with reference to FIG. **1**B, each collector **100** may have multiple reflector panels **106** that each run the full length $L_{collector}$ of the collector **100**. This provides for easier assembly of the collector **100** and for a stiffer overall structure compared to current solar energy collectors. Current collectors must install shorter reflector panels or strips to accommodate for the CTE mismatch between the frame and the reflector because the CTE mismatch may cause deformation and potential permanent mechanical damage as discussed above.

[0037] As described above and below in detail, in some existing designs, strips of the reflector panels may cast a shadow on the solar cells. Any shadow on the solar cell may reduce the overall concentrator efficiency disproportionately due to the nature of the electrical connection among the solar cells as the solar cells may be connected electrically in series. The efficiency may decrease by the ratio of shadow width to cell width and not by the ratio of shadow width to aperture length. For example, a 5 mm wide gap or non-reflective section between the strips of reflectors may cast a shadow at least 5 mm wide on a cell 78 mm wide, leading to an overall efficiency decrease of 5/78 or 6.4%.

[0038] In the illustrated embodiment, the frame **108** has a plurality of cross beams **212** and at least a pair of parallel support bars **214**. The parallel support bars **214** may be elongated, longitudinal structures formed from an extrusion. In another embodiment, the parallel support bars **214** may have a plurality of elements, such as additional parallel support bars, coupled together such as with the use of structural adhesives, welding, soldering, brazing, and the like to form the single parallel support bar for the frame **108**. Alternatively, the parallel support bars **214** may be made stronger with other structural devices such as angled brackets, elongated rods positioned within the center of the parallel support bars **214**, and the like. The cross beams **212** may be any member joining the support bars **214** to provide structural support and bracing between the support bars **214**.

[0039] The frame **108** may be coupled to the bottoms **124***a* and **124***b* of the support structure **102** and shaping ribs **216** to provide structural support and/or additional torsional stiffness for the collector **100**. This forms a closed truss **136**, as illustrated below in FIG. **3**B, in a region between the troughs below the reflector panels **106**. The closed collector support truss framework forms a triangular or trapezoidal-shaped torque tube. Although described as a triangular or trapezoidal shape, the truss is approximately similar to a triangular or trapezoidal shape and not an exactly mathematically perfect trapezoidal shape. Given the large apertures **101** and the light weight of the collector **100**, the trapezoidal torque tube provides for a stiff structure.

[0040] In one embodiment, the cross beams **212** are T-sections as illustrated in FIGS. **2**A and **2**B and may be substantially equal to the number of shaping ribs **216**. The cross beams **212** may be formed from an extrusion. In another embodiment, the cross beams **212** may be positioned to form various geometric shapes, such as joining the support bars **214** at an angle thereby forming a triangle. Thus, the placement of the cross beams **212** is not meant to be limiting as the cross beams **212** may be placed in any position along the support bars **214** such as an X-shape, and the like.

[0041] The frame **108** may connect to the trough pair **107** via the bottoms **124***a*, **124***b* to form the closed trapezoidal torque tube structure **136** as described above. In one embodiment, frame **108** may be coupled to the support structure **102** via opening **350** (FIG. **2**C) with a bolt, screw, mating tabs and slots, or any other similar known means. Additional hardware, such as lugs, may be used to couple the frame **108** to the trough pair **107** as further discussed below. In another embodiment, frame **108** may be coupled to the trough pair **107** by being welded together, or by any other means. The frame **108** may have a length substantially equal to or slightly less than $L_{collector}$. The frame **108** may also extend the entire length across all adjacent collectors in the array of collectors.

[0042] As illustrated in FIG. **2**A, the support structure **102** may have receiver support rails **202**, **204**. The receiver support rails **202**, **204** may be oriented perpendicular to the shaping ribs **216** and attached to the top ends of each support rib **216**. Each receiver support rail **202**, **204** may be configured to receive solar receivers **104**. In one example, each receiver **202**, **204** may be configured to slideably receive a solar receiver **104** in a longitudinal direction as illustrated by arrow A. In another example, solar receivers **104** may be coupled to each receiver **202**, **204** by any means that allows for differential thermal expansion between the solar receivers **104** and each receiver **202**, **204**. Solar receivers **102** may be coupled to trough pair **107** in such a manner to allow removal or installation of a middle receiver without removal of adjacent receivers.

[0043] FIG. **2**C illustrates a detailed view of section **222** of FIG. **2**B. In the illustrated embodiment, each shaping rib **216** has a groove **220** to receive a bottom edge protector **224**. The bottom edge protector **224** extends longitudinally substantially near the bottom **124** of the entire length of support structure **102**. The bottom edge protector **224** may have a slit, grove, notch, or any other type of groove **220** to receive and support the bottom edge of the reflector panel **106**. Reflector panel **106** may be press fit into the edge protector **224** or be attached to the edge protector **224** by any suitable means including use of structural adhesives, welding, or brazing, or similar means. As further illustrated in FIG. **2**C, a drainage gap **110** may be formed between the lower edges of each reflection panel to allow any moisture or water to drain through the collector **100**. The width (W**5**) of the drainage gap **110** may be between about 5-20 mm. In one embodiment, W**5** may be about 10 mm or 1 centimeter (cm).

[0044] In one embodiment, the reflector panels **106** may be affixed to the support structure **102** by any known means such as the use of structural adhesives, welding, soldering, brazing, bolts, screws, or the like. This allows for the reflector panels **106** to resist shear and the stiffness of the collector **100** increases. Unlike traditional full parabola collectors, the quarter parabolic configuration may be able to withstand higher shear loads before buckling due to its lower curvature. Additionally, for the same system design load, a wider spacing between each shaping rib **216** may be possible.

[0045] When reflector panels **106** are held and supported by support structure **102** between a top attachment member on the support structure (not shown), bottom edge protector **224**, and against shaping ribs **216**, the reflector panels **106** are bent with a curvature having a substantially quarter parabolic configuration. This quarter parabolic configuration enables incident sunlight **135** to be directed towards the solar receiver **104** using a single reflection as illustrated in FIG. **1**F. Use of only a single reflection improves the collector optical efficiency compared to multi-reflection systems.

[0046] FIGS. **3**A-**3**C illustrate one embodiment of an array of solar collectors. FIG. **3**A illustrates a top view of the array of solar collectors **300** in a circular configuration. The following terms, definitions, and equations will be used:

Ground Cover Ratio=area of all array of collectors/total area of collector field

Collector Area Efficiency=area of array of array of apertures capturing sunlight in one array of collectors/area of the one array of collectors

Composite Area Efficiency=Ground Cover Ratio×Collector Area Efficiency

[0047] The array of collectors **300** has a plurality of collectors **100***a, b, c, n* (where n is an integer), each collector is similar to the collector described above with reference to FIGS. **1**A-**1**F. Each collector **100***a-n* may be of varying length to form a desired configuration, such as a circular or carousel configuration as illustrated in FIG. **3**A. The collectors **100***a-n* are positioned side-by-side such that the longitudinal axes of each collector are parallel and lie in longitudinal plane **140** (FIG. **1**C). Each adjacent collector **100***a-n* is positioned as close together as possible in a direction perpendicular to the trough longitudinal axis to maximize the collector area efficiency of the array of collectors. In other words, the ratio of the solar capture area to the total carousel area (illustrated in dotted lines in FIG. **3**A) is maximized. In one embodiment, each collector **100***a-n* may be positioned with a gap of about approximately 10 mm to about 300 mm between the reflective side walls of adjacent collectors. In another embodiment, the gap between the reflective side walls is between about 10 mm to about 100 mm and in a specific embodiment, the gap is about 10 mm.

[0048] Solar collectors using actively cooled solar receivers may be positioned with a gap of about 10 mm between the reflective side walls. Waste energy removed by the cooling fluid may then be reused, such as to pre-heat water as part of a hot or industrial process water system.

[0049] In one example, the carousel **300** diameter, d, may be between about 5 m to about 40 m. In a specific example, the diameter may be about 20 m. The width of each collector may be about 1 meter and the array of collectors **300** may have about 18 collectors total. As discussed above, the width of each receiver and the drainage gap may be about 1 cm. With these dimensions, the collector area efficiency of each array of collectors is about 90%. In other words, when the sun is directly overhead, 90% of the sunlight incident in the circular area defined by the carousel strikes a reflector and is available to produce useful energy. This collector area efficiency results in efficient utilization of available real estate or land.

[0050] FIG. **3**B illustrates a side view of one embodiment of the array of collectors. FIG. **3**C is an example block diagram of the solar collector system. The array of collectors **300** has a plurality of collectors **100***a-n* positioned side-by-side in transverse direction perpendicular to the collector longitudinal axis. As discussed above, each collector **100***a-n* may have a frame **108***a-n*, and plurality of solar receivers (not shown). The collectors **100***a-n* are supported by the frames **108***a-n* and the common platform **302**. Alternatively, the array of collectors **300** may be mounted directly on the common platform **302** without use of the frames **108***a-n*.

[0051] The common platform **302** may be made of any material desired. For example, the common platform **302** may be made of any strong material to form a stabilized base, such as steel, aluminum, engineered composite, and the like. Common platform **302** may be an open framework, which is lightweight, rigid, and readily allows fluids (such as rain) to be diverted away from the collectors **100***a-n* via the drainage gap **110** (FIG. **2**C) when positioned directly on the common platform **302**. In still another example, the common platform **302** may have a plurality of slits or grooves below the drainage gap **110** (FIG. **2**C) to collect and drain fluids.

[0052] A plurality of stands **304***a,b,c* may be positioned on the bottom surface **316** of the common platform **302** and mounted to a base (not shown). The base may or may not be parallel to the common platform. The base may be the ground, a roof, or any other real estate the solar collection system is positioned on. Each of the plurality of stands **304***a-c* may be designed to stabilize the common platform **302**. Although illustrated with three stands **304***a-c*, this number is not intended to be limiting as any number of stands may be used to stabilize the common platform **302**.

[0053] A rotation assembly **306***a-c* may be positioned between each stand **304***a-c* and the bottom surface **316** of the common platform **302**. The rotation assembly **306***a-c* may be ball bearings, wheels, or any other rotating element that facilitates rotation of the common platform **302**. In another example, the rotation assembly **306***a-c* may be any known hydraulic actuators, gears and levers, or any other rotation assembly configured or designed to rotate the common platform **302**. It should be understood that while the plurality of stands **304***a-c* are stationary and fixed to the base (not shown), the rotation assembly **306***a-c* is configured to rotate the common platform **302**, which in turn rotates the array of collectors **300**. In a specific example, the stands **304***a-c* may support a circular track (not shown). The rotation assembly **306***a-c* may be a plurality of wheels that engage the circular track to rotate the common platform **302** about an axis perpendicular to the longitudinal plane **140** (FIG. **1**C). Alternatively, common platform **302** may be supported by a single, centrally located stand and may be rotated about that stand.

[0054] The rotation assembly **306** may be rotated by a clock-like drive mechanism, such as a motor **320**, to track the daily east-west motion of the sun, thereby maintaining the alignment of incident solar radiation with the troughs. The motor **320** may be in communication with a controller **322**. In one embodiment, the controller **322** may by any known controller having memory **326** and any other desired device.

[0055] In another embodiment, the controller may be any known control box (not shown) mounted to the common platform, enclosed in a protective cabinet, and having appropriate access doors and the like. Within the cabinet, there may be switches, knobs, and the like to control the direction of rotation and speed of motor **320**. In one example, switch may be of a 5-position type, having a central "off" position, a standard reverse-speed position, a high reverse-speed position, a forward-speed position, and a high forward-speed position.

[0056] FIGS. **4**A-**4**D illustrate side views of other embodiments of an array of collectors. Referring to FIG. **4**A, the array of collectors **400** may have collector pairs **404***a-n* that are raised from the common platform **302** using risers **312***a-n* alternating with collector pairs **402***a-n* that are positioned directly on the common platform **302**. The troughs in each collector pair **404***a-n* may be mechanically coupled at or near the bottom of the frame **108***a-n*.

[0057] The offset **430** between frames **108** of alternating collector pairs **402***a-n* and **404***a-n* may be between about approximately 0.1 m to about 2 m. In a specific embodiment, the offset **430** between frames **108** of alternative collector pairs may be between about approximately 0.2 m to about 0.8 m.

[0058] FIG. **4**B illustrates a side view of two collector pairs illustrated in FIG. **4**A. Collector pair **418** is adjacent to collector pair **416** with line B denoting the transition between collector pair **418** and collector pair **416**. FIG. **4**B illustrates collector pairs **418**, **416** positioned such that the solar receivers **422** and **420** do not vertically overlap. FIG. **4**C illustrates the collectors pairs **418**, **416** positioned such that the solar receivers **422** and **420** vertically overlap. Overlapping the solar receivers **422**, **420**, allows the reflector panels of collector pairs **416**, **418** to be positioned closer to each other thereby increasing the collector area efficiency of the array of collectors.

[0059] Referring back to FIG. **4**A, staggering alternating collectors **402***a-n*, **404***a-n* in the array of collectors **400**, in the direction parallel to the aperture axis **160** (FIG. **1**A), forms unimpeded air flow channels between the upper and lower regions of the collectors as illustrated by arrows A. The unimpeded air channels reduce the wind load and stress on the collectors. Additionally, the unimpeded air channels allows for an increase of heat transfer from passively cooled heat sinks on the solar receivers. This results in cooler solar receivers, cooler solar cell operating temperatures, and increased solar cell efficiency. Staggering the collectors may also increase the torsional stiffness of the array of collectors since the structure's overall height is increased.

[0060] FIGS. **5**A and **5**B illustrate side views of still other embodiments of vertically staggered single collectors. Referring to FIG. **5**A, the solar receivers **506***a-n* of each single trough collector **502***a-n* do not vertically overlap. FIG. **5**B illustrates an array of single trough collector **504***a-n* with solar receivers **510***a-n* that vertically overlap.

[0061] Although FIGS. **4**A-**4**C show embodiments where a collector pair, (i.e. two collectors) are alternately staggered and FIGS. **5**A-B show embodiments where a single trough collector (i.e. one collector) is alternately staggered, the number of collectors in each adjacent vertically offset stagger is not limited by these embodiments. For example, the array of collectors may consist of groups of three or more collectors that are alternately staggered in either the upper or lower positions. Alternatively, the array of collectors may consist of varying numbers of staggered collectors. For example, a single trough collector may be in the upper position and groups of two collectors may be in the lower position.

[0062] FIGS. **6**A-**6**C illustrate an embodiment of a high ground cover ratio solar collection system. Ground cover ratio is the ratio of the area covered by the plurality of array of collectors to the total area of the solar field, i.e. the area of the land, such as a power plant, or rooftop where the plurality of array of collectors is situated. Ground cover ratio is equivalent to field area efficiency and the two terms may be used interchangeably.

[0063] FIG. **6**A illustrates a plurality of array of collectors **600***a-n* situated in a solar collection field **602**. The borders of the solar collection field **602**, as illustrated, are defined by the rectangular outline enclosing all the plurality of array of collectors **600***a-n*. Each array of collectors **600***a-n* are formed in a circular configuration and arranged close to an adjacent array of collectors in order to maximize the ground cover ratio. When the plurality of array of collectors **600***a-n* are positioned in close contact without any gaps between an adjacent array of collectors **600***a-n*, the field efficiency ratio is about 90%, that is approximately 90% of the available area in the field is occupied by the plurality of array of collectors. However, the array of collectors **600***a-n* may be positioned with a gap of between about 0.5 m to about 2.0 m between adjacent array of collectors **600***a-n* to allow for access to the array of collectors **600***a-n* for maintenance and/or servicing of the solar collection system. Having a gap between adjacent array of collectors **600***a-n* may decrease the field efficiency ratio to about 80%.

[0064] The amount of sunlight captured by a collector field is proportional to the composite area efficiency. The composite area efficiency is the product of the collector area efficiency for one array of collectors multiplied by the field area efficiency. It gives the ratio of sunlight available to produce energy compared to the available sunlight incident on the entire area of the solar field. As described here, the composite fill factor may have a value of approximately 74%, the product of the collector area efficiency for each array of collectors (90%) and the field area efficiency (82%). This is much higher than the composite area efficiency typically used for tilt tracking trough collectors.

[0065] Current tilt tracking solar systems pivot about a location above the base of the collector and each collector is tilted independently of other collectors. As such, each collector will shade other collectors as it tracks the sun, since adjacent edges of the collectors are vertically offset and the higher edge will shade adjacent collectors. Thus, current tilt tracking solar systems require low ground cover ratios and resultant low field efficiency ratios in order to avoid shading of adjacent collectors. The ground cover ratios for current tilt tracking trough collectors is typically less than 50% due to shading by adjacent collectors. Furthermore, current tilt tracking solar systems require complex framing and support structures and complex tracking mechanical systems.

[0066] Having an array of collectors **600***a-n* that are rotated and never tilted prevents shadowing from adjacent collectors within the array of collectors **600***a-n*. Shadowing an array of collectors by an adjacent array of collectors is possible, but may be minimized by increasing the diameter, d (FIG. **3**A), of the array of collectors, or decreasing the collector height, H**1** (FIG. **1**C). Furthermore, the staggering of collectors also does not result in any shadowing of adjacent collectors since the longitudinal axis **162** (FIG. **1**A) of the collector is always aligned with the incoming incident sunlight as the array of collectors is rotated to track movements of the sun. Thus, the ground cover ratio may be higher as compared to current tilt tracking systems.

[0067] The plurality of array of collectors **600***a-n* may be positioned in any desired location or site such as a solar collector field, rooftop, or the like. The desired location need not be substantially horizontal and in fact, may be tilted, such as on a tilted rooftop. For example, in the north hemisphere, the plurality of array of collectors may be mounted to a south facing tilted rooftop. This orientation will increase the collected solar insolation relative to a plurality of array of collectors positioned on a horizontal location.

[0068] Each array of collectors **600***a-n* may track movements of the sun by rotating in a direction as illustrated by arrow C. The axis of rotation may be about the center of each array of collectors **600***a-n* (e.g. of the circle) or may be rotated about any other position or axis. If the incident sunlight is directed in the direction of arrow D, each array of collectors **600***a-n* may be rotated in a direction such that the reflectors received full incoming sunlight. As illustrated in FIG. **6**B, the array of collectors **600***a-n* may be rotated in a direction such that the incoming solar insolation, illustrated by arrows E, is aligned along the longitudinal axis **162** (FIG. **1**A) of the trough. A common tracking mechanism may be used to rotate the plurality of array of collectors.

[0069] FIG. **6**C illustrates another embodiment of a high ground cover ratio solar collection system. The shape and size of each array of collectors may be adapted to increase the ground cover ratio. Such an arrangement is especially useful in sites with limited real estate, as it allows a maximum collection of useful solar energy. For example, array of collectors **600***a-n* may have a diameter of about 20 m and array of collectors **606***a,b* may have a diameter of about 10 m. The smaller array of collectors **606***a,b* may be positioned near the edge of the site and/or in positions where the larger array of collectors **600***a-n* would not fit. If desired, the smaller array of collectors may also be positioned between the larger array of collectors.

[0070] In another example, the configuration of the array of collectors **608** may be truncated. As illustrated in FIG. **6**C, the circular configuration of the array of collectors **608** may be truncated so that about ⅓ of a circle is present. If positioned on a rooftop, the edges of the array of collectors **608** may extend beyond the edge of the rooftop line when rotated to increase ground cover ratio.

[0071] FIGS. **7**A and **7**B illustrate top views of another embodiment of a high ground cover ratio solar collection system. As illustrated in FIGS. **7**A and **7**B, each array of collector **702***a-n* may be formed in a square configuration. Referring to FIG. **7**A, each of the array of collectors **702***a-n* in the solar collection system **700**, is configured similar to a square with a side length, L. Although illustrated with 9 identical array of collectors **702***a-n*, this is not intended to be limiting as any number of array of collectors may be used. Each adjacent array of collectors **702***a-n* may be spaced apart a distance r*L. To avoid interference between an adjacent array of collectors **702***a-n* while tracking, r must be greater than the square root of 2 or approximately 1.414. For sites with r values about 1.414, the ground cover ratio is about 0.5. For small sites or places with limited real estate, such as a rooftop, the ground cover ratio may exceed 0.5 if some portion of the array of collectors is allowed to extend past the rooftop edge.

[0072] As illustrated in FIG. **7**A, each array of collectors **702***a-n* may rotate in a direction indicated by arrows F to track the incoming sunlight, indicated by arrow I. In FIG. **7**B, each array of collectors **702***a-n* is rotated to track the incoming sunlight, indicated by arrows G. In this example, the solar azimuth angle, which is the deviation of the projection on a horizontal plane of the normal to the surface from the local meridian, with zero being due south in the northern hemisphere, east negative, and west negative, is approximately 45° and r is approximate 1.42. In this example, the corners of each array of collectors **702** *a-n* almost touches the corners of adjacent array of collectors **702***a-n*.

[0073] Having a solar collection system with a plurality of array of collectors that are nominally identical allows for the potential to lower manufacturing costs by simply increasing the volume of identical troughs that are manufactured. Additionally, each collector may have substantially the same electrical output thereby facilitating easy electrical connections between each collector in the array of collectors.

[0074] FIGS. **8**A and **8**B illustrate graphs comparing the energy collected at different times of the year. In the example shown in FIGS. **8**A and **8**B both the tilt tracked collector and rotation tracked collector carousels have a composite area efficiency of about 0.74. High composite area efficiency collector fields, such as the rotational track solar collectors, may collect a higher percentage of the incoming solar insolation than current tilt track solar collector systems and may thus generate more power. FIG. **8**A illustrates a graph comparing the collected solar energy for a tilt track system vs. a circular rotational track system on the summer solstice at latitude 33°. This day has the longest daylight hours and has the most available solar energy for capture. The latitude corresponds to good solar installation sites in the southwestern United States.

[0075] As illustrated in FIG. **8**A, during the central part of the day, both the tilt track solar system and the rotational track solar system produce essentially equivalent power. However, the tilt track solar system experiences some collector shading for most of the day. Only for about one hour before and one hour after noon (12 pm) are the tilt track system collectors completely illuminated by the incoming solar insolation. This contrasts with the rotation tracked collector carousels, where adjacent collectors in an array of collectors never shade each other. Integrating the collected powers over the entire day yields values of 7.72 kW*hr/m^2 for the rotation track system and 6.05 kW*hr/m^2 for the tilt track system. As such, the rotation track system collects 27% more power than the tilt track system.

[0076] FIG. **8**B illustrates a graph comparing the collected solar energy for a tilt track system vs. a circular rotational track system on the winter solstice at latitude 33°. This day has the shortest daylight hours and has the least available solar energy for capture. Similar to the summer solstice, during the central part of the day, both the tilt track system and the rotation track system produce essentially equivalent power. However, the tilt track system experiences some collector shading for most of the day. Only for about 1½ hours before and 1½ hours after noon (12 pm) are the tilt tracked system collectors completely illuminated by the incoming solar insolation. Integrating the collected powers over the entire day yields values of 4.23 kW*hr/m^2 for the rotation track system and 3.39 kW*hr/m^2 for the tilt track system. As such, the rotation track system collects approximately 25% more power.

[0077] The graphs illustrated in FIGS. **8**A and **8**B represent the extreme cases of solar insolation and collector performance. All other days have intermediate characteristics. Averaged over the entire year, the rotation track system collects about 25% more energy than the tilt track system. The ability to collect 25% more energy from the same collector, receiver, and real estate area is beneficial for the use of the rotation track system.

[0078] The rotation track solar energy collector system allows for a higher ground cover ratio, increases power generation per unit of area of land, and reduces wind load from its lower profile. Additionally, the rotation track system is more cost efficient as it has minimal framing and support structure requirements, a simplified tracking system, and may be made from less costly materials due to its lower profile. These are important, especially in small locations, such as rooftops, where the real estate to place the collectors is limited.

[0079] FIG. **9** illustrates an example computer system suitable for implementing the software applications used in one or more embodiments of a high ground cover solar collection system. FIG. **9** shows one possible form of the computer system **800**. Of course, the computer system may have many physical forms ranging from an integrated circuit, a printed circuit board, or the like.

[0080] Attached to system bus **820** is a wide variety of subsystems. Processor(s) **822** (also referred to as central processing units, controller, CPUs, or the like) are coupled to storage devices, including memory **824**. Memory **824** includes random access memory (RAM) and read-only memory (ROM). As is well known in the art, ROM acts to transfer data and instructions uni-directionally to the CPU and RAM is used typically to transfer data and instructions in a bi-directional manner. Both of these types of memories may include any suitable of the computer-readable media described below. A fixed disk **826** is also coupled bi-directionally to CPU **822**; it provides additional data storage capacity and may also include any of the computer-readable media described below. Fixed disk **826** may be used to store programs, data, and the like and is typically a secondary storage medium (such as a hard disk) that is slower than primary storage. It will be appreciated that the information retained within fixed disk **826** may, in appropriate cases, be incorporated in standard fashion as virtual memory in memory **824**.

[0081] CPU **822** is also coupled to a variety of input/output devices, such as display **804**, power adaptor **810**, rotation assembly **812**, and the like.

[0082] In addition, embodiments of the present invention further relate to computer storage products with a computer-readable medium that have computer code thereon for performing various computer-implemented operations. The media and computer code may be those specially designed and constructed for the purposes of the present invention, or they may be of the kind well known and available to those having skill in the computer software arts. Examples of computer-readable media include, but are not limited to: magnetic media such as hard disks, floppy disks, and magnetic tape; optical media such as CD-ROMs and holographic devices; magneto-optical media such as floptical disks; and hardware devices that are specially configured to store and execute program code, such as application-specific integrated circuits (ASICs), programmable logic devices (PLDs) and ROM and RAM devices. Examples of computer code include machine code, such as produced by a compiler, and files containing higher level of code that are executed by a computer using an interpreter. Computer readable media may also be computer code transmitted by a computer data signal embodied in a carrier wave and representing a sequence of instructions that are executable by a processor.

[0083] While embodiments and applications of this invention have been shown and described, it would be apparent to those skilled in the art having the benefit of this disclosure that many more modifications than mentioned above are possible without departing from the inventive concepts herein.

What is claimed is:

1. A solar energy collection system that includes an array of collectors to track movements of the sun along at least one axis, the collector comprising:

a plurality of reflector panels;

a support structure that supports the reflector panels, wherein the support structure supports the reflector panels in a manner that defines a trough, the trough having a longitudinal axis, a pair of reflective side walls and a trough aperture suitable for receiving incident sunlight during operation of the collector;

a plurality of solar receivers, each solar receiver being positioned generally adjacent an edge of an associated trough and including at least one photovoltaic cell, wherein the reflector panels are arranged to direct incident sunlight towards the solar receivers using a single reflection during operation of the collector; and

a tracking mechanism to rotate the collector about an axis perpendicular to the longitudinal axis to track movements of the sun and to direct incident sunlight along the longitudinal axis, the tracking mechanism including:

a common platform to support the collector; and

means for rotating the common platform.

2. The solar energy collector of claim **1**, further comprising:

a frame that is coupled to the support structure near the bases of the troughs to define a closed reflector support truss framework in cooperation with the support structure, wherein the reflector support truss framework is positioned behind the reflector troughs such that the reflector support truss framework does not shadow the reflector panels during operation of the collector.

3. The solar energy collector of claim **1**, wherein the means for rotating comprises:

a plurality of stands positioned on a bottom surface of the common platform and mounted to a base, each of the plurality of stands designed to stabilize the common platform;

a rotation assembly positioned between the plurality of stands and a bottom surface of the common platform designed to rotate the common platform;

a motor configured to rotate the common platform via the rotation assembly; and

a control box configured to communicate with the motor to control the rotation direction and speed of the common platform.

4. The solar energy collector of claim **1**, wherein the means for rotating comprises:

a plurality of stands positioned on a bottom surface of the common platform and mounted to a base, each of the plurality of stands designed to stabilize the common platform;

a hydraulic pump assembly positioned on a bottom surface of the common platform, the hydraulic pump configured to rotate the common platform; and

a control box configured to communicate with the hydraulic pump assembly to control the rotation direction and speed of the common platform.

5. The solar energy collector of claim **1**, wherein each reflective side wall has a curvature that approximates a quarter parabola segment to thereby concentrate incident solar radiation on the plurality of solar receivers.

6. The solar energy collector of claim **3**, wherein the stand further comprises:

a hydraulic pump assembly;

a control box configured to communicate with the hydraulic pump assembly to control the rotation of each collector about an axis perpendicular to the longitudinal axis.

7. The solar energy collector of claim **1**, wherein the array of collectors are positioned side-by-side in a transverse direction with a gap of no more than 20 millimeters between the reflective side walls of adjacent collectors.

8. The solar energy collector of claim **1**, wherein no component of the solar energy collection system shades the reflector panels during normal operation of the solar energy collection system.

9. The solar energy collector of claim **1**, wherein the adjacent collectors are vertically staggered.

10. The solar energy collector of claim **9**, wherein the solar receivers of adjacent collectors vertically overlap.

11. A solar energy collection system having an array of collector carousels that track movements of the sun along at least one axis, each collector carousel in the array comprising:

a plurality of adjacent collectors having reflector panels;

a support structure that supports the reflector panels, wherein the support structure supports the reflector panels in a manner that defines a reflector trough, each trough having a longitudinal axis, a pair of reflective side walls and a trough aperture suitable for receiving incident sunlight during operation of the collector;

a plurality of solar receivers, each solar receiver being positioned generally adjacent an edge of an associated trough and including at least one photovoltaic cell, wherein the reflector panels are arranged to direct incident sunlight towards the solar receivers using a single reflection during operation of the collector; and

a tracking mechanism to rotate the collector carousel about an axis perpendicular to the longitudinal axis to track movements of the sun and to direct incident sunlight at the trough aperture the tracking mechanism including:

a common platform to support the polarity of collectors; and

means for rotating the common platform.

12. A collector carousel to track movements of the sun along at least one axis, the collector carousel comprising:

a plurality of collectors having reflector panels;

a support structure that supports the reflector panels, wherein the support structure supports the reflector panels in a manner that defines a reflector trough, each trough having a longitudinal axis, a pair of reflective side walls and a trough aperture suitable for receiving incident sunlight during operation of the collector;

a plurality of solar receivers, each solar receiver being positioned generally adjacent an edge of an associated trough and including at least one photovoltaic cell, wherein the reflector panels are arranged to direct incident sunlight towards the solar receivers using a single reflection during operation of the collector; and

a tracking mechanism to rotate the collector to track movements of the sun and to direct incident sunlight at the trough aperture,

wherein no component of the collector carousel shades the reflector panels during normal operation of the collector carousel.

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