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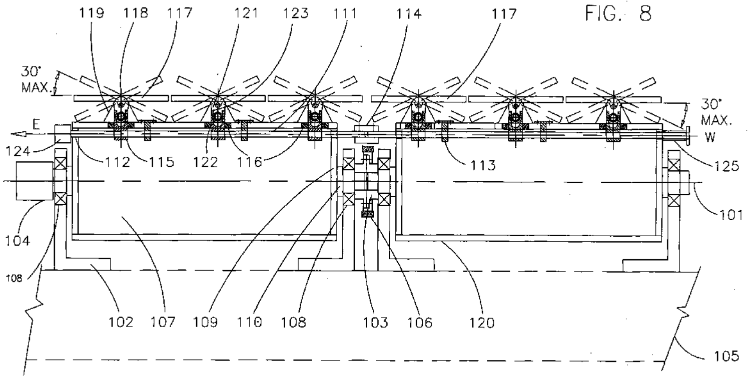
(54) **Title**: A SOLAR CENTRAL RECEIVER SYSTEM EMPLOYING COMMON POSITIONING MECHANISM FOR HELIOSTATS

FIG. 8



(57) **Abstract**: A solar central receiver system employing common positioning mechanism for heliostats relates to a system of concentrating and harvesting solar energy. The heliostats of said system are positioned like facets of a Fresnel type of reflector. The heliostats are placed in arrays, wherein each array has a common positioning mechanism. The common positioning mechanism synchronously maneuvers the arrays of heliostats in altitudinal and/or azimuthal axis for tracking an apparent movement of the sun. The common positioning mechanism is employed for synchronously orienting said heliostats with respect to a stationary object and the sun such that incident solar radiation upon said heliostats is focused upon said stationary object from dawn to dusk. Subsequent to each said orientation of said heliostats, collective disposition of said heliostats always forms an arrangement that is capable of reflecting and thereby focusing incident solar radiation upon said stationary object.

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A solar central receiver system employing common positioning mechanism for heliostats.

RELATED APPLICATIONS:

Priority is claimed for the provisional Indian patent application 1545/MUM/2009 filed on 1st July 2009, an Indian nonprovisional Patent application 1545/MUM/2009 filed on 10th August 2009, and a patent of addition 951/MUM/2010 filed on 30th March 2010. The aforementioned patent applications are incorporated herein in their entirety by reference.

BACKGROUND OF THE INVENTION:

Field of the Invention:

A solar central receiver system of the present invention employs a common positioning mechanism for heliostats for orienting the heliostats with respect to a stationary object and the sun such that incident solar radiation upon the heliostats is focused upon the stationary object from dawn to dusk. The system consists of light reflecting heliostats grouped in either horizontal east west directional or horizontal north south directional linear and parallel arrays that are positioned about the stationary object. Heliostats are precisely positioned as per their location in a heliostat field like facets of a Fresnel type of reflector and the positioned heliostats are synchronously maneuverable. For tracking an apparent movement of the sun in the sky, the common positioning mechanism brings about synchronized altitudinal and/or azimuthal orientation of heliostats. Subsequent to each such orientation, collective disposition of heliostats always forms an arrangement that is capable of reflecting and thereby focusing incident solar radiation upon said stationary object.

Description of the Related Art:

A solar central receiver system (a solar furnace) is a dependable efficient producer of large commercial quantities of power. Conventionally, a solar furnace has a tower-mounted central receiver for collection of sunlight and conversion thereof into electricity. The solar radiation is concentrated on to the central receiver by reflection from heliostats spaced about the tower. A solar tracking system aims the heliostats by continually predicting the location of the sun in the sky. Predictions are based on the date, time, longitude and latitude. Configuring each heliostat to be individually movable typically requires a large amount of expensive motorized equipment and dedicated motors. A need therefore exists to have a low cost and efficient common positioning mechanism for heliostats for tracking the diurnal movement of the sun. An objective of the present invention is to install arrays of heliostats that are synchronously rotatable about altitudinal as well as azimuthal axis by common positioning mechanism such that the heliostats continue to reflect the sunlight towards a stationary object from dawn to dusk.

Conventionally it is essential to individually control rotation of mirrors of heliostats with respect to a fixed target and the moving sun. This necessitates expensive individual sensing, aiming and alignment devices for heliostats, a state of the art computer for predicting and controlling the required altitudinal and azimuthal rotation of each heliostat, and protecting the computer from heat and dust. This results in an increased cost. Hence the objective of the present invention is to have synchronously maneuverable heliostats that are positioned as per their location in a heliostat field like facets of a Fresnel type of reflector. With such disposition of synchronously maneuverable heliostats, calculation of required altitudinal and/or azimuthal rotation of any single heliostat would suffice to predict the altitudinal and or azimuthal rotation of the entire respective array of heliostats or all the heliostats of the heliostat field. Moreover, conventionally, each heliostat has to be independently supported by a sturdy pedestal for providing the structural strength. A reflector mirror of a heliostat assembled on a conventional pedestal is like a sail ready to fly off when the wind gets underneath it. Hence it is also an objective of the present invention to utilize low-level arrays of heliostats. The position of heliostats close to the ground has an advantage of reduced wind velocity. Packing the heliostats in horizontal plane helps to attenuate the wind force from row to row. The present invention either eliminates or reduces the required number of motors, gearboxes, hydraulic pistons, hoses, other activators and massive supports for the heliostats as are required for the operation of conventional solar furnace. This advantageously reduces the cost and complexity. Thus, the rationale of the present invention is to provide many novel features that are not anticipated or implied by any of the prior art.

BRIEF SUMMARY OF THE INVENTION:

A solar central receiver system employing common positioning mechanism for heliostats relates to a system of concentrating and harvesting solar energy. Heliostats are precisely positioned as per their location in a heliostat field like facets of a Fresnel type of reflector and the positioned heliostats are synchronously maneuverable. A heliostat field of the present invention consists of arrays of flat or curved light reflecting heliostats that are located with respect to a stationary object. Pluralities of rotatable shafts are provided for mounting the arrays of heliostats. Rotatable shafts are positioned horizontally either in east west direction or in north-south direction, at same height and rotatable about a first rotation axis that is either horizontal and in east west direction or horizontal and in north-south direction. Rotation of a rotatable shaft synchronously rotates an array of heliostats mounted on said rotatable shaft about said first rotation axis. A plurality of drive means provides synchronous rotation of rotatable shafts such that arrays of heliostats mounted on said rotatable shafts synchronously rotate about said first rotation axis. An array of mounting means is provided for mounting an array of heliostats over each rotatable shaft. Each said mounting means is provided in a manner which permits individual pivotal movement of the mounted heliostat with respect to the rotatable shaft about a second rotation axis that is perpendicular to said first rotation axis. Heliostats of said array of heliostats are linked mechanically so as to be pivotably rotatable in synchronism. Each rotatable shaft supports a rotation mechanism to drive the mounted array of heliostats to rotate about said second rotation axis. The common positioning mechanism of the present invention is used for orienting the heliostats with respect to a stationary object and the sun such that incident solar radiation upon heliostats is continually focused upon the stationary object from dawn to dusk. Subsequent to each said orientation of heliostats, collective disposition of the heliostats always forms an arrangement that is capable of reflecting and thereby focusing incident solar radiation upon the stationary object.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS:

1) FIG. 1 depicts an embodiment of the solar central receiver system where focused solar radiation from heliostats falls upon a central receiver.
2) FIG. 2 schematically depicts a top view of a huge paraboloid concentrator that is hypothetically cut into numerous small reflective segments.
3) FIG. 3 depicts the formation of juxtaposed reflective segments.
4) FIG. 4 depicts the changed reflection pattern in said juxtaposed segments.
5) FIG. 5 depicts the requisite attunement of juxtaposed reflective segments.
6) FIG. 6 schematically illustrates a top view showing layout of arrays of heliostats in a circular heliostat field.
7) FIG. 7 schematically shows a top view of the heliostat field depicting the characteristic positioning of the H shaped brackets.
8) FIG. 8 depicts a slotted link and pusher mechanism for driving an array of pivotally rotatable heliostats to synchronously rotate for tracking the apparent motion of the sun in the sky.
9) FIG. 9 depicts a chain sprocket and gear wheel transmission mechanism.
10) FIG. 10 depicts a rack and pinion and gear transmission mechanism.
11) FIG. 11 depicts a composite link mechanism.
12) FIG. 12 shows a plan view of the fixing arrangement of a heliostat on an H shaped bracket.
13) FIG. 13 is a cross section along line x-y of said plan view of FIG. 12.
14) FIG. 14 depicts a scheme for determining the angle for positioning of an H shaped bracket over respective support.
15) FIG. 15 depicts a scheme for determining the angle of inclination of a heliostat for positioning over respective H shaped bracket.

16) FIG. 16 to 19 schematically depict the pattern of rotation of heliostats about the first rotation axis and the second rotation axis for tracking the apparent azimuthal and altitudinal movement of the sun.
17) FIG. 20 schematically depicts another embodiment, wherein the heliostats move around their centers such that there is no radius of rotation.
18) FIG. 21 schematically depicts a sectional view of construction of the embodiment as depicted in FIG. 20.
19) FIG. 22 depicts another embodiment having a collecting reflector as a stationary object for further concentrating the focused solar radiation.
20) FIG. 23 depicts another embodiment having collecting reflectors as a stationary object for further concentrating the focused solar radiation.
21) FIG. 24 depicts another embodiment having a tower mounted collecting reflector as a stationary object for further concentrating the focused solar radiation.
22) FIG. 25 depicts yet another embodiment having a collimating reflector as a stationary object for collimating the focused solar radiation.

DETAILED DESCRIPTION OF THE INVENTION:

A lot of attempts have been made to reduce the cost of solar furnaces by introducing ganged heliostats. However in the known art, common positioning mechanism is employed for rotation of ganged heliostats either for altitude axis rotation or azimuth axis rotation. The present invention discloses a novel common positioning mechanism for heliostats for both altitude and azimuth axis rotation! To elucidate the functionality of such an innovative common positioning mechanism, a concept of a 'dynamic flattened manifestation of a paraboloid concentrator' is put forward.

A paraboloid (parabolic) concentrator is a reflective device that concentrates electromagnetic radiation to a common focal point. Since the solar radiation can be focused, a paraboloid concentrators is regarded as most appropriate to collect and concentrate the solar energy. As the size of a parabolic concentrator increases, it becomes increasingly difficult to build it with the requisite precision and to track it for altitudinal and azimuthal motion of the sun. Nevertheless, even for a huge (humongous) paraboloid concentrator, a concentrating flattened manifestation is possible that can track the altitudinal and azimuthal motion of the sun!

To elaborate the concept of a 'dynamic flattened manifestation of a paraboloid concentrator', consider a huge paraboloid concentrator having a circular aperture of 250 meters. For the description purpose, it is assumed that such a huge paraboloid concentrator is positioned on a flat horizontal ground, wherein said ground is tangential to the center of the paraboloid concentrator and the solar radiation is vertically and paraxially incident. Suppose the continuous surface of the huge paraboloid concentrator is hypothetically cut into numerous small segments. Then such hypothetical segments would evidently have the same orientation, inclination and disposition but would have discontinuities between them. FIG. 2 schematically depicts a top circular view 21 of a huge paraboloid concentrator 22 that is cut into numerous small segments (as denoted by numerals 23, 24, 25 aligned in east west directional array 26) surrounding the center 27.

FIG. 3 schematically depicts such hypothetically cut discrete segments 35, 36, and 37. Perpendicular lines are drawn from said segments on the ground 34. From points where perpendicular lines from medial aspect of said segments meet the ground, parallel lines 38, 39 and 40 are drawn parallel to respective said segments 35, 36 and 37. The parallel lines represent juxtaposed reflective segments, juxtaposed to the ground 34. The juxtaposed reflective segments have the same angle of inclination as that of the segments 35, 36 and 37. Such juxtaposed reflective segments form the first step of creating a 'flattened manifestation of the huge paraboloid concentrator'.

To form a flattened manifestation of the huge paraboloid concentrator, the solar radiation reflected off the juxtapoased segments 38, 39, and 40 needs to fall on a fixed target positioned at a desired height and preferably in the axial region. Therefore, the angle of inclination of each juxtaposed reflective segment would have to be attuned. For example as depicted in FIG. 4, a hypothetically cut segment 42 has its juxtaposed reflective segment 46 located near the ground. When a light beam 41 is incident on the segment 42, it would be reflected and would fall on the focal point 44 on the axis 50. If that light beam 41 falls on the juxtaposed reflective segment 46 instead of the hypothetically cut segment 42, it would be reflected (reflected beam 47) towards point 48 located on the axis 50. Now, all the juxtaposed reflective segments are needed to be attuned such that the reflected solar radiation would fall on a fixed target placed in the axial region at a desired height. FIG. 5 depicts a juxtaposed reflective segment 51 and a respective attuned juxtaposed reflective segment 52. The incident solar radiation 53 incident on the juxtaposed reflective segment 51 would be reflected at a point 55 located on the axis 56. The fixed target like a central receiver may be positioned at a different location as indicated by numeral 57. Consequently, the inclination of said juxtaposed reflective segment would have to be attuned such that the reflected light should fall on said fixed target 57. The segment 52 is such an attuned juxtaposed reflective segment, which reflects the incident light on the position of the fixed target depicted by numeral 57.

It is already assumed that the solar radiation is vertically and paraxially incident. When the entire juxtaposed reflective segments pertinent to the huge paraboloid concentrator are attuned, said huge paraboloid concentrator can be said to be transformed into its 'flattened manifestation related to the location of the sun at zenith'. Such a flattened manifestation may be considered as an analogue of a Fresnel type reflector. In a Fresnel type reflector, optically flat cuts are made at desired angles so as to direct the incident light at a specific locus. Similar to the facets of a Fresnel type reflector, the attuned juxtaposed reflective segments of the present invention are precisely oriented and inclined. The inclination and orientation of an attuned juxtaposed reflective segment depends on its location with respect to a stationary object, the height and the position of the stationary object on which the incident solar radiation is to be focused, and the location of the sun in the sky.

To enable such a flattened manifestation of the humongous paraboloid concentrator to track the apparent altitudinal and azimuthal motion of the sun, a 'dynamic flattened manifestation of the humongous paraboloid concentrator' would have to be created.

Now the inclination and orientation of an attuned juxtaposed reflective segment in a heliostat field depends on its location with regard to a stationary object, the height and the position of the stationary object on which the incident solar radiation is to be focused, and the location of the sun in the sky. Here, except for the location of the sun in the sky, the rest of the criteria, which define the inclination and orientation for each attuned juxtaposed reflective segment are unchanging. The position of the sun in the sky is the only variable factor. Hence, once the attuned juxtaposed reflective segments are positioned with respect to the location of the sun at the zenith, for any other location of the sun in the sky, only the angle of incidence of solar radiation on such segments would be changed. The changed angle of incident solar radiation would be exactly the same for all the attuned juxtaposed reflective segments. Therefore, for any changed location of the sun in the sky, the extent of the changed inclination and orientation in each attuned juxtaposed reflective segment would be the same. Consequently, for a changed location of the sun in the sky, when related change is made by a synchronous re-orientation of the inclination and orientation of attuned juxtaposed reflective segments, a 'flattened manifestation of said huge paraboloid concentrator is formed related to said changed location of the sun in the sky'.

In a 'dynamic flattened manifestation of a huge paraboloid concentrator', the attuned juxtaposed reflective segments are synchronously maneuverable in altitudinal and/or azimuthal axis for tracking a changed position of the sun in the sky. Subsequent to each such synchronous maneuver for the changed position of the sun in the sky, collective disposition of the attuned juxtaposed reflective segments always forms an arrangement that is capable of reflecting and thereby focusing incident solar radiation upon the stationary object. Said attuned juxtaposed reflective segments when solar tracked is such a way so as to reflect and concentrate the incident solar radiation on a fixed target (stationary object) from dawn to dusk, in that case said attuned juxtaposed reflective segments fulfill the criteria of heliostats and hence hereafter are referred to as heliostats in the present text.

Thus, the present invention puts forward the scheme of synchronous rotation of precisely positioned heliostats to the same extent about altitude and/or azimuth axis for tracking the sun so that the reflected solar radiation would continue to fall on a fixed target. The heliostat field of the present invention consists of flat or curved light reflecting heliostats grouped in horizontal east west directional or horizontal north south directional linear and parallel arrays positioned about the stationary object. Pluralities of rotatable shafts are provided for mounting arrays of heliostats about the stationary object. The rotatable shafts are positioned horizontally and either in east west direction or in north south direction, at same height, and rotatable about a first rotation axis that is horizontal and east west directional or horizontal and north south directional. A plurality of drive means is provided for synchronous rotation of rotatable shafts such that arrays of heliostats mounted on the rotatable shafts synchronously rotate about the first rotation axis so as to track the apparent motion of the sun from dawn to dusk. When rotatable shafts are positioned horizontally in north south direction, the rotation of rotatable shafts would track the apparent altitudinal movement of the sun. And when rotatable shafts are positioned horizontally in east west direction, the rotation of rotatable shafts would track the apparent azimuthal movement of the sun. In the detailed description of the invention that follows, for convenience, it is assumed that the rotatable shafts are positioned horizontally, in east west direction, at about the same height, and rotatable about a first rotation axis that is horizontal and in east west direction.

If the stationary object is a central receiver, a tower is erected in the center of the heliostat field for mounting the central receiver. FIG. 6 schematically illustrates a top view of a circular heliostat field 60. The parallel east west oriented rows of rotatable shafts (as denoted by numerals 61, 62, 63 as an exemplification) extend across the entire heliostat field 60. On each said rotatable shaft a plurality of heliostats (as denoted by numerals 64, 65, 66 as an exemplification) are fixedly positioned. For said heliostat field 60, area 68 represents the central area where a tower is erected for mounting a fixed target (for example, a central receiver). Reference numeral 67 indicates the central point of said field 60. Said parallel rows of east west oriented rotatable shafts are placed horizontal to the ground plane. The term 'horizontal to the ground plane' is to be understood as designating a notional horizontal plane, which is perpendicular to the vertical solar radiation. If the ground area is not planar and has topographic variations, it may be evened out or made usable by structural and positional adjustments of support structures like pedestal supports and supporting frames such that said rotatable shafts remain horizontal and at the same level. Each row of heliostats (for example, row 61) mounted on a respective rotatable shaft is supported on a pedestal or a linear supporting frame (as depicted in FIG. 8, numeral 105). Bottom chords of the supporting frames are fixed to the ground by anchor penetration. Each two adjacent rows (twins), for example row 61 and 62, are interconnected and are configured to be mounted on a shared support structure for rigidity. An access way 69 is located between each such twin for the movement of people and equipment for maintenance and inspection purposes. The parallel east west directional rotatable shafts extend across the entire heliostat field and are placed horizontal to the ground plane. An array of mounting means is provided for mounting an array of heliostats over each rotatable shaft. Each said mounting means is designed in a manner which permits individual pivotal movement of the mounted heliostat with respect to the rotatable shaft such that each mounted heliostat is rotatable about a second rotation axis that is perpendicular to said first rotation axis. Heliostats of heliostat arrays mounted on respective rotatable shafts are linked mechanically so as to be pivotably rotatable in synchronism. Each rotatable shaft supports a rotation mechanism to drive the mounted heliostats to rotate about said second rotation axis to track the altitudinal movement of the sun. A linear actuator, coupled with the rotation mechanism, causes synchronous rotation of the linear array of heliostats positioned over each rotatable shaft about said second rotation axis.

Various figures, which depict schematic representations of certain embodiments, are exemplary and numerous variations are possible without departing from the main theme. An embodiment of a solar central receiving system 11 (solar furnace) of the present invention, as depicted in FIG. 1, comprises of a heliostat field 12 enclosing pluralities of linear arrays of heliostats surrounding a centrally located tower 14. The expanse of land enclosing the solar central receiver system is referred to as a heliostat field. Conventionally, heliostats are arranged in concentric arcs around a centrally located tower. The present invention does not need nor characterize a solar furnace with arc-shaped layouts. In the present invention, a heliostat field may be of any size and shape like rectangular, circular, oval or polygonal. A stationary object like a central receiver can be located anywhere in the heliostat field. But a central location of a central receiver is appropriate, as it would achieve maximum collection of the incident solar radiation. The central location of the central receiver would optimize the positioning of the heliostats such that it would maximize the number of heliostats that are in the vicinity of the central receiver. And nearer the placement of heliostats, superior is the percentage of delivery of reflected sunlight on the central receiver. As depicted in FIG. 1, the stationary object is a central receiver 15, which is mounted at a pre-defined height above the ground level on a substantially centrally located tower 14. Said central receiver 15 is meant for absorbing the reflected solar radiation from heliostats 13 located around said central receiver 15. Horizontal parallel arrays of rotatable shafts 16 are located about said centrally located tower 14 and positioned in east west direction, at about same height, and rotatable about a first rotation axis that is horizontal and in east west direction. Linear arrays of heliostats are mounted on parallel rotatable shafts 16. Each rotatable shaft 16 has an array of mounting means for mounting an array of heliostats. The rotatable shafts 16 are positioned horizontal, parallel and in east west direction and are preferably placed at the same height. Each rotatable shaft 16 provides a linear array of mounting means for mounting a linear array of heliostats. Flat or curved light reflecting heliostats 13 direct the incident solar radiation 17 onto the central receiver 15. The central receiver 15 of the system 11, supported by vertical masts of the tower 14, form a centrally located fixed target. The heliostats 13, positioned low with regard to ground level, are arrayed over the entire area of said heliostat field 12 that is selected to provide reflection of the solar radiation towards said central receiver 15. In order to prevent damage of heliostats by wind force, the positioning of the heliostats is kept as low as possible. In addition, the placement of heliostats in the horizontal plane helps to attenuate the wind from row to row, thereby reducing wind loading on heliostats 13. Furthermore, a wall around the heliosat field is advisably erected to reduce the wind load.

In a solar furnace, the heliostats have a fixed target and are required to reflect the incident solar radiation continually on said fixed target from dawn to dusk. Hence at any given instant, each heliostat would have a different disposition. To simplify the solar tracking mechanism for heliostats in a solar furnace, numerous attempts were made to achieve a common positioning for ganged heliostats. But it was accomplished for either altitude or azimuth axis rotation. However, in the present invention, based on the novel concept of ‘a dynamic flattened manifestation of a paraboloid concentrator’, a common positioning mechanism for heliostats is employed for both altitude and/or azimuth axis rotation.

The heliostats may be square-shaped or circular or rectangular or hexagonal or octagonal or polygonal. Heliostats having a square or rectangular perimeter are cheaper. Circular shaped heliostats have the largest area of non-interfering shape but are costly to manufacture. The heliostats may be flat or concave or paraboloid shaped and have a conventional supporting frame for rigidly holding their shape and contour and for preventing damage or bending. Heliostats may be fabricated from a plastic and clad with a reflective film like Mylar or Reflectech. Heliostats may be fabricated with metals such as polished aluminum, or steel with nickel/chromium plating, or glass with/without a silvered coating as in a mirror, or ceramics or other composites such as fiberglass or graphite or polymers or plastics having a reflective coating, or any other material that meets the structural and reflective properties required of a flat or curved or parabolic reflector. High reflectivity of heliostats could be availed from the use of vacuum deposited aluminum or silver.

The heliostat field of the present invention comprises a plurality of heliostats and may include tens or hundreds or thousands of heliostats. The number, size, shape and disposition of heliostats may differ in different embodiments as per the size of said heliostat field, the intended scale of power system (small or large), and the intended use of the solar central receiving system. For example, in a huge heliostat field like 4 acres land area, the heliostats would preferably be one square meter. Said heliostats would have a positioning height of approximately one to four feet above the ground level. For this size, the rows of said heliostats can be spaced apart laterally by a gap of 4 to 5 feet.

Figures 8 to 18 schematically depict certain embodiments of common positioning mechanism. The elucidated embodiments are exemplary and those experts in the art can very well recognize that numerous variations are possible without departing from the main theme.

The rotatable shafts are rigid, preferably tubular in type and rotate for simultaneously orienting a plurality of heliostats positioned over them. The east west directional rotatable shafts are rotated to track the diurnal azimuthal motion of the sun. The distance between the parallel shafts is kept minimum but sufficient so that fouling of heliostats mounted on these shafts is avoided in their any position. Referring to FIG. 8, pluralities of shaft segments 107 are interconnected to form a rotatable shaft 101. Each shaft segment 107 preferably consists of a sturdy rotatable structure like a pipe having a tubular cross-section and long enough to mount preferably 2 to 4 heliostats. At each end of the shaft segment 107, end flanges 109 are fitted. Said flanges 109 support circular projections 110 of the shaft segment 107. Each circular projection 110 is supported on bearing 108 mounted in a pedestal 102. Each half portion of flexible brake drum coupling 103 is supported on adjoining circular projection 110 so that all shaft segments 107 are coupled together. Or the adjoining shaft segments 107 are connected by flexible couplings and a brake is connected at the nondriving end of the shaft 101. An actuating rod 111 is supported in end flanges 109 via bushes 112 such that the said actuating rod 111 can move to and fro in a direction parallel to the axis of the shaft segment 107. Additionally, the actuating rod 111 is supported on supporting bushes 113 such that the deflection of actuating rod 111 is kept minimum. Actuating rod 111 of each shaft segment 107 is joined with another actuating rod 111 of the adjoining shaft segment 107 by means like coupling 114. In other embodiments, the actuating rod 111 can also be supported on the outside surface of shaft segment 107. Here, the actuating rods 111 can be supported on the flanges 109 that are projected above the outer surface of the shaft segment 107.

An actuator 124 is fitted at one end of the actuating rod 111. At the other end of the actuating rod 111, tension is exerted by means like spring 125 so that the actuating rod 111 is always subjected to tension. Actuator 124 is always subjected to the tensile force exerted by spring 125. Hence, positive locking of the input shaft of the actuator 124 is required. The said input shaft is positively locked by a failsafe brake along with means like roller type bi-directional fold back device or irreversible drive like a worm reducer having a large reduction ratio. Said actuator, developing force and motion in a linear manner, may be a pneumatic actuator or an electric actuator or a motor or a hydraulic cylinder or a linear actuator etc. A plurality of links 115 are rigidly fitted on actuating rod 111 such that each link 115 is very close to a supporting bush 113. Supporting bush 113 and link 115 project out of the circular pipe 120 through slot 116 provided in said pipe 120. A plurality of supports 117 for the heliostats are pivoted by pivot pins 118 on brackets 119. Said brackets 119 are rigidly fitted on pipe 120. Support 117 can freely oscillate about said pin 118. A heliostat is to be mounted on each said support 117. Hence oscillation of said support 117 about pin 118 rotates respective heliostat (not shown in the figure) positioned over it. An arm 121 is rigidly fixed on support 117 such that it also oscillates along support 117 about pivot pin 118. Pin 122 is permanently fitted on arm 121 and the said pin 122 is engageable in a slot 123 formed in the body of link 115.

When the actuating rod 111 is linearly moved in the eastern direction by the actuator 124, said link 115 moves said pin 122 towards eastern direction and this results in the clockwise rotation of the arm 121 along support 117 about pin 118. Said clockwise rotation is preferably up to 30^0 or more depending on the movement of the actuating rod 111. Initially when the movement is zero, the said clockwise rotation is zero and the support 117 is in the horizontal plane. And said clockwise rotation increases as the said movement of actuating rod 111 in eastern direction increases. However, the ratio of the said clockwise rotation and the said linear motion may or may not be constant. Similarly, when the actuating rod 111 is linearly moved in the western direction, the arm 121 along with the support 117 rotate in anticlockwise direction. And said anticlockwise movement is preferably up to 30^0 (or more than 30^0 if needed) depending on the movement of said actuating rod 111.

FIG. 9 is another embodiment, wherein the assembly of the rotatable shaft 101 is practically identical with the embodiment described with reference to FIG. 8. However, instead of a slotted link and pusher mechanism, a chain sprocket and gear wheel transmission mechanism is assembled for generating a rotational motion of said support 117 when said actuating rod 111 is moved in eastern or western direction. A plurality of chain segments 151 are rigidly fitted on actuating rod 111. A plurality of chain sprockets 152 are engageable with said plurality of chain segments 151 such that a to and from motion of the actuating rod 111 results in a rotational movement of the chain sprockets 152 about sprocket pins 153. Said sprocket pins 153 are fitted on the brackets 119. Said brackets 119 are rigidly fitted on pipe 120. Supporting bushes 113 are close to said chain sprockets 152. Each sprocket 152 and said supporting bush 113 are freely movable through the slot 116 provided in said pipe 120. A plurality of supports 117 are pivoted by pivot pins 118 on brackets 119. Said supports 117 can have controlled oscillatory motion about said pins 118. A heliostat is to be mounted on each said support 117. Hence oscillation of said support 117 about pin 118 rotates respective heliostat (not shown in the figure) positioned over it. A gear sector 155 is rigidly fixed on each said support 117 such that it also oscillates along said support 117 about said pivot pin 118. Each said gear sector 155 is rotationally engageable with a gear wheel 154 coaxially fitted on the chain sprocket 152. Hence, the gear wheel 154 is subjected to a rotational motion of the chain sprocket 152 obtained by a to and fro motion of the actuating rod 111. Hence, said to and fro motion of the actuating rod 111 results in the rotational movement of the gear sector 155 along with the support 117.

When the actuating rod 111 is linearly moved in the eastern direction by the actuator 124, chain sprocket 152 rotates in clockwise direction. This results in the rotation of the gear wheel 154 in the clockwise direction by the same magnitude. Gear sector 155 is engaged with the gear wheel 154. Hence, the gear sector 155 is rotated in anticlockwise direction. Hence, the support 117 rotates in anticlockwise direction. Said anticlockwise rotation is preferably up to 30^0 (or more than 30^0 if needed) depending on the movement of the actuating rod 111. Initially, when the movement is zero, said anticlockwise rotation is zero and the support 117 is in the horizontal plane. And said anticlockwise rotation increases as said movement of the actuating rod 111 in the eastern direction increases. Said anticlockwise rotation is practically proportional to said movement of the actuating rod 111 in the eastern direction. Similarly, when the actuating rod 111 is linearly moved in the western direction, said gear sectors 155 along with the supports 117 rotate in the clockwise direction. Said clockwise rotation is practically proportional to said movement of the actuating rod 111 in the western direction.

FIG. 10 depicts yet another embodiment to obtain the rotation of the heliostats about the altitudinal axis. This embodiment is practically identical to the embodiment described with reference to FIG. 9 except that a rack 161 is rigidly fitted on the actuating rod 111 instead of said chain segments 151. And said rack 161 is engageable with said gear wheel 154. Numerous variations are possible to rotate said supports. For example, in embodiments depicted in FIG. 9 and 10, a gear sector can be made directly engageable with chain segments or rack. Depicted in FIG. 11 is yet another embodiment, wherein the rotatable shafts are positioned horizontal and in north south direction and are rotatable to obtain rotation of the heliostats for tracking the apparent altitudinal movement of the sun. Here, the assembly of the rotatable shaft 101 is also practically identical to the embodiment described with reference to FIG. 8. However, instead of a slotted link and pusher mechanism, a composite link mechanism is assembled for generating a rotational motion of said support. This embodiment is usable in colder zones that are beyond the tropic of Cancer or Capricorn. A plurality of links 174 are rigidly fitted on actuating rod 111 such that each link 174 is very close to a supporting bush 113. Supporting bush 113 and link 174 project out of the circular pipe 120 through slot 116 provided in said pipe 120. A plurality of supports 117 for the heliostats are pivoted by pivot pins 118 on brackets 119. Said brackets 119 are rigidly fitted on pipe 120. Support 117 can freely oscillate about said pin 118. A swiveling link 171 is pivoted at its one end on link 174 via a pivot pin 172. The other end of the swiveling link 171 is connected to support 117 via a connecting pin 173. The support 117, swiveling link 171 and link 174 on actuating rod 111 along with pivot pins 118, 172 and 173 form a mechanism such that when link 174 is moved towards southern direction by actuator 124, the swiveling link 171 swivels in downward direction and hence support 117 swivels in downward direction. The extreme position of support 117 will be horizontal, that is, parallel to the axis of the shaft segment 107. When the actuator 124 moves the link 174 via actuating rod 111 towards northern direction, the swiveling link 171 swivels upwards and hence support 117 swivels upwards in anticlockwise direction. In topmost position, support 117 would be inclined to the horizontal plane preferably by 50 degrees.

The disposition and orientation of a heliostat positioned on a rotatable shaft would depend on the location of the heliostat in the heliostat field and would be similar to the related attuned juxtaposed reflective segment. An elongated support is a topmost component of the mounting means and is provided for mounting a heliostat. Said supports are positioned parallelly and lengthwise over each rotatable shaft. An H shaped bracket is positioned over each said support for realizing the distinct orientation, defined angle of inclination and balanced positioning of a heliostat fixed over said support. The placement and fixation of each said H shaped bracket is critical. Midpoint of said central member of said H shaped bracket is fixed over midpoint of respective said support such that said central member is collinear to the line joining the center of said heliostat field and the medial end of said central member. As depicted in FIG. 7, dotted lines 92, 93 and 94 denote such collinear lines for the H shaped brackets 75, 76 and 77 respectively. When fixed on a support, the central member of the fixed H shaped bracket forms an angle (angle ‘a’ as depicted in FIG. 12) with respect to said support. Said angle a varies for an H shaped bracket on respective support as per the location of the support in the heliostat field. FIG. 7 diagrammatically depicts the scheme of disposition (orientation) of H shaped brackets. Three H shaped brackets 75, 76 and 77 are depicted for illustration of said scheme. The heliostat field 71 has a central circular space 78 for the central tower and numeric 79 represents the center of said circular space 78. The east west oriented shaft 72 shows the supports 81, 82 and 83. A central member of each H shaped bracket is fixed over midpoint of respective support. Each H shaped bracket has a medial member (numerals 84, 85 and 86 depict medial members of the H shaped brackets 75, 76 and 77 respectively), a lateral member parallel to said medial member (numerals 87, 88 and 89 depict lateral members of the H shaped brackets 75, 76 and 77 respectively), and a central member (numerals 90, 74 and 91 depict central members of the H shaped brackets 75, 76 and 77 respectively) joining them. The length of medial and lateral members would remain the same for all H shaped brackets, while the length of the central member of said H shaped bracket would decrease, as the angle of inclination of a heliostat would increase.

FIG. 12 and 13 schematically illustrate the orientation angle 'a' for fixedly positioning of an H shaped bracket on a support, wherein said angle 'a' varies as per the location of a support in the heliostat field, and the angle of inclination 'b' formed by a heliostat on an H shaped bracket, wherein said angle of inclination 'b' varies as per the location of a heliostat in the heliostat field. FIG. 12 shows a top of view (a view seen from C) of the fixing arrangement of a heliostat 131 on an H shaped bracket 132. Besides, as depicted in FIG. 12, each H shaped bracket is fixed on respective support with the requisite angle 'a' as described hereinbefore and elsewhere. The midpoint of the central member of the H shaped bracket 132 is fixed on respective support 117 at its center such that centerline of said H shaped bracket lies at a specific angle 'a' with centerline of said support.

As depicted in FIG. 12, an H shaped bracket 132 consists of a central member fixed on support 117, a medial member at right angle to the central member and located medially towards the center of heliostat field, and a lateral member parallel to the medial member and at right angle to the central member and located towards the periphery of said heliostat field. At the medial end, on the medial member, a plurality of hinge support 133 are fixed. Pivot pin 134 is located in the hinge support 133 such that it is free to rotate about its own axis, and the pivot pin 134 is at right angle to said central member. Said heliostat 131 is fitted on the pivot pin 134 via pivot pin attachment 135 such that said heliostat 131 is free to oscillate along with pivot pin 134.

Now referring to FIG. 13, the heliostat 131 is inclined with the H shaped bracket 132 at an angle of inclination 'b'. FIG. 13 is a cross section along line x-y shown in FIG. 12. Referring to FIG. 13, the inclination of the heliostat 131 with respect to the H shaped bracket 132, that is angle 'b', is mathematically determined, and accordingly the length of each leg assembly 136 supporting lateral aspect of respective heliostat 131, and the length of the central member of related H shaped bracket is determined. Inclination angle 'b' is minimal for heliostats 131 located near the stationary object and slowly increases in heliostats located towards the periphery of said heliostat field. The inclination angle 'b' of any heliostat is influenced by the position of said heliostat on a rotatable shaft, the location of said rotatable shaft in said heliostat field, and the height of the fixed target. Referring to FIG. 12 and 13, the leg assembly 136 comprises spherical joint 137 and 138 fitted on the bottom face of the lateral aspect of each heliostat, and spherical joint 139 and 140 fitted on the lateral member of an H shaped bracket. Spherical joints 137 and 139 are connected with each other via link means like a turn buckle, slotted link etc. Similarly, spherical joint 138 is connected with spherical joint 140 via link means like a turn buckle, slotted link etc. Angle of inclination 'b' can be precisely adjusted and fine tuned by adjusting the length of leg assembly 136.

At a specific location in the heliostat field, an H shaped bracket is positioned over a support at a precise angle of orientation (angle 'a'). Said angle 'a' can be mathematically determined. Similarly, at a specific location in the heliostat field, a heliostat is fixedly positioned over an H shaped bracket at a precise angle of inclination (angle of inclination 'b'). Said angle of inclination 'b' can be mathematically determined. For the said mathematical determinations of an angle 'a' and an angle 'b', it is assumed that the sun is at the zenith and directly overhead of the heliostat field and the incident solar radiation is vertical. Furthermore, since the mounting means are mounted on the rotatable shafts and the supports are the uppermost members of the mounting means, it is further assumed that said supports are topmost in their horizontal position with respect to the rotatable shafts. Referring to FIG. 14, B is the center of a heliostat field, C is the center of a central member of an H shaped bracket installed on a support. Hence BC is the distance from said center of said heliostat field to center of central member of said H shaped bracket. MN is a line (line MN is either in east west direction or in north south direction) along which a rotatable shaft is positioned on which an array of heliostats is to be installed. Said line MN is at a distance BA from the said center B, such that BA is perpendicular to said line MN. Hence AB is the minimal distance from said center B of said heliostat field to said line MN. The center of the central member of said H shaped bracket is fixedly positioned on the said support at point C such that said central member is oriented collinear to BC, and said central member makes an angle 'a' with respect to said support, which support is parallel to said shaft MN.

Now, Sin of angle a = AB/BC, where AB is the measured minimal distance from said center B of said heliostat field to said line MN (AB is the length of the side opposite the angle a), and where BC is the measured distance from said center B of said heliostat field to said point C where said central member of said H shaped bracket is fixed (BC is the hypotenuse).

Hence the angle 'a' is calculated by the expression Sin a = AB/BC.

In other words, said angle 'a' depends on a minimal distance between a center of said heliostat field and a hypothetical chord or a line whereupon a rotatable shaft is located on which a heliostat is positioned. Said minimal distance is a length of a side opposite said angle 'a'. Similarly said angle 'a' depends on distance between said center of said heliostat field to a position of a midpoint of said heliostat on said rotatable shaft. Said distance is a length of hypotenuse. Said angle 'a' is calculated by finding sine of said angle 'a', wherein said sine of said angle 'a' is equal to said length of said side opposite said angle 'a' divided by said length of said hypotenuse.

As shown in FIG. 15, each heliostat is inclined with respect to the respective H shaped bracket at an angle 'b'. The angle of inclination of a heliostat with respect to an H shaped bracket, that is angle 'b', is also mathematically determined. Now as schematically depicted in FIG. 15, B is the center of a heliostat field where a fixed target is perpendicularly erected and R is the location of the fixed target, wherein said R is at a height H from the ground plane G, such that RB = H = height of said fixed target.
The distance from the heliostat EF to B = BC, where C is the location of the center of said heliostat EF positioned just above the ground level.
Considering the enormity of the heliostat field and the height H, the negligible height of said EF above said ground level is ignored.
Now it is assumed that the incident sun rays are perpendicular to ground level. Hence, the reflected sunray CR makes an angle θ with respect to the height of the fixed target RB such that $\tan \theta = BC/RB$, where the terms BC and RB are defined hereinabove. And hence angle θ is defined by the above expression $\tan \theta = BC/RB$.
Angle SCR = angle CRB = angle θ, because RB is parallel to the incident

vertical sunray SC.
EF is the position of the heliostat. And CD is normal to EF. The normal CD divides the angle SCR. Hence angle SCD = angle θ/2 = angle DCR.
Now angle RCB = angle α = angle 90 degrees – angle θ.
And normal DC is perpendicular to EF.
Hence angle DCE = angle 90 degrees = angle DCR + angle α + angle BCE = angle DCR + (angle 90 degrees – angle θ) + angle BCE.
Therefore angle 90 degrees = angle DCR + angle 90 degrees – angle θ + angle BCE. Therefore angle θ = angle DCR + angle BCE.
But angle DCR = angle θ/2. Therefore angle θ = angle θ/2 + angle BCE.
Hence angle BCE = angle θ/2.
Since EF is seen crossing the ground plane, angle 'b' = BCE = θ/2 degrees.

Even with said mathematical determinations of angle 'a' and angle 'b', for fixedly positioning each H shaped bracket on a support and for fixedly positioning each heliostat on H shaped bracket, an alignment system is preferably used onsite. Here, the alignment and installation of heliostats is done with the vertically incident light and the supports in their topmost horizontal position, wherein the positioned heliostats properly focus the incident vertical light on to the fixed target.

FIG. 16 to 19 schematically depict the pattern of rotation of said heliostats about said first and said second rotation axis for tracking the apparent azimuthal and altitudinal movement of the sun respectively. FIG. 16 schematically depicts a heliostat 181 located on a support 182 wherein the incident vertical solar radiation 184 is reflected (reflected beam 185) to fall upon a fixed target 186. The support 182 is mounted on rotatable tubular shaft 183. Said rotatable shaft 183 is rotatable about a first rotation axis that is horizontal and east west directional. Now, it is assumed that there is no altitudinal movement and the apparent azimuthal movement of the sun is 20 degrees towards south. To track this azimuthal movement, as shown in FIG. 17, said rotatable shaft 183 is rotated (clockwise) southward by 10 degrees about said first rotational axis thereby rotating the heliostat 181 by 10 degrees. The incident solar radiation 187 falling on heliostat 181 is seen to be reflected (reflected beam 188) towards the fixed target 186. FIG. 18 depicts a diagrammatic representation of fixedly positioned heliostat 181 on a support 182 with a distinct orientation and angle of inclination such that the incident vertical solar radiation 189 is reflected (reflected beam is shown by numeral 190) to fall on the fixed target 186. FIG. 18 depicts the pivotally rotatable support 182 mounted on a rotatable shaft 183. Said support 182 is the mounting means for mounting the heliostat 181. Suppose it is assumed that there is no azimuthal movement and the altitudinal movement of the sun towards west is 50 degrees. As shown in FIG. 19, to track this apparent westward 50 degrees altitudinal movement of the sun, as per the law of reflection, the heliostat 181 is rotated by 25 degrees towards west (clockwise) about said second rotational axis. The incident solar radiation 191 falling on heliostat 181 is seen to be reflected (reflected beam 192) towards the fixed target 186.

The heliostats are fitted on rotatable shafts. Though insignificant, the rotation of heliostats around said rotatable shafts has a play due to the required proper fitment. Said heliostats rotate along a circular path having a radius that is comparable to a radius of said rotatable shafts. The rotatable shafts are rotated for tracking the sun, wherein reflected solar radiation also travels to a certain distance, which is proportional to said radius when said rotatable shafts are rotated. A central processing unit (CPU) generates controlling commands for a compensatory controlled lag or lead in movement of each rotatable shaft to compensate said travel of reflected solar radiation. Or the rotatable shafts are synchronously rotated about said first rotation axis for tracking the azimuthal movement of the sun, and subsequently each rotatable shaft is fine tuned to compensate said travel of reflected solar radiation such that a collective disposition of said heliostats always forms an arrangement that is capable of reflecting and thereby focusing incident solar radiation upon said stationary object. Here, said travel of reflected solar radiation would differ between the heliostats mounted on the medial (near center of heliostat field) and lateral (near periphery of heliostat field) aspect of a rotatable shaft and position of said rotatable shaft in a heliostat field. Preferably a mean (average) is taken for medial-most and lateral-most heliostat for calculating said lag or lead for each rotatable shaft and each rotatable shaft is fine tuned accordingly. Furthermore, diurnal azimuthal movement of the sun is usually minimal and hence said travel of reflected solar radiation would be minimal. Or a compensatory controlled movement of the fixed target in a required direction is realized to trace said reflected solar radiation. Here, in this embodiment, which is optional, the tower/mount for supporting the fixed target supports a rectangular platform. A straight or curved slide is fitted on said platform for movement of said fixed target in a required direction from dawn to dusk to trace said reflected solar radiation, wherein said fixed target is slid in the same direction and proportional to said travel of reflected solar radiation from dawn to dusk. A numerically controlled drive is fitted on said slide for said compensatory controlled movement of said fixed target in said required direction.

Yet another embodiment is described hereinbelow with reference to FIG. 20 and 21, wherein heliostats rotate around their centers. FIG. 21 is a schematic cross sectional view of the FIG. 20. The heliostats have central holes and the east west directional rotatable shafts pass through said holes. When said shafts are rotated for tracking the azimuthal movement of the sun, the heliostats move around their centers about a first rotation axis that is horizontal east west directional. The assembly of the rotatable shaft and the actuating mechanism are practically identical to the embodiment described with reference to FIG. 8. As depicted in FIG. 20 and 21, a plurality of slotted links 208 is permanently fixed on the actuating rod 204. A plurality of stub shafts 209 pass through the shaft segments 201 and are supported in the shaft segments 201 via bushes. A pair of trapezoidal flanges 210 are permanently fixed on said stub shafts 209 such that each said trapezoidal flange 210 is on either side of the shaft segment 201. A pusher rod 211 is permenently fitted in the pair of the trapezoidal flanges 210 such that the said pusher rod 211 is engageable in the slot 212 in the slotted link 208. When the actuating rod 204 is moved by the actuator 207 in eastern/western direction, the slotted link 208 pushes the pusher rod 211, which results in the rotation of the pair of the trapezoidal flanges 210 about the axis of said stub shaft 209. The said pair of the trapezoidal flanges 210 are permenently fitted with each other via a pair of member 213 situated at the two ends of the said pair of the trapezoidal flanges 210. Each said pair of members 213 has a hole 215 at their central aspect through which a heliostat is engageable via a pin or a projection for installation purposes. Each heliostat is rotatable about an axis of said pin or said projection 216, and each heliostat is rotated about said axis of said pin or said projection while fixedly installing. The heliostat 214 are rotated about said axis of said pin or said projection and are rigidly fixed at any desired angle via clamping means. For example, in one of the embodiments, one circular flanged male pivotal projection 216 having its circular projection suitable for said hole 215 is fitted around said hole 215 on each said member 213 via screws (screws not shown in the figure). Each heliostat 214 is having an eleptical shaped opening at its center through which the shaft segment 201 passes through. The size of the eleptical opening and the size of the major axis of the said eleptical opening is large enough to accommodate the movement of the said trapezoidal flanges 210 and said members 213. Two circular female projections 217 are fitted at the end of the major axis of the said eleptical opening in the heliostat 214. The bore of the said circular female projection 217 matches with the diameter of the male pivotal projection 216 such that the heliostat 214 is rotatable on the axis of male pivotal projection 216. The male pivotal projection 216 forms a pivot for heliostat 214. The heliostat 214 can be rotated with respect to said pivot and can be rigidly fixed on the said pivot at any 'desired angular position' via clamping means (clamping means not shown in the figure). The linear motion of the actuating rod 204 results in the movement of the heliostat 214 about the axis of the stub shaft 209. To and fro movement of said actuating rod 204 increases or decreases the angle 'c' of the trapezoidal flanges with respect to the axis of the shaft segment 207. As described hereinbefore, at a specific location in a heliostat field, the angle of inclination of a heliostat with respect to ground level is equal to angle $\theta/2$ degrees, wherein said angle θ can be mathematically calculated. Hence said heliostat is rotated about said axis of stub shaft and about said pin or said projection such that the whole plane of said heliostat makes said angle $\theta/2$ with respect to the ground level, wherein a line joining the center of the heliostat field and midpoint of medial border of said heliostat is perpendicular with respect to medial border of said heliostat. Once such a position is achieved, then said heliostat is rigidly fixed at that formed angle of rotation about said axis of said pin or said projection via clamping means. Similarly said heliostat is set in the same angle of inclination with respect to said shaft. All the heliostats of said heliostat field are positioned in a similar way as described hereinabove. From this attained position, said heliostats are synchronously rotated to the required current position. The said rotatable shaft or shafts are rotated about the axis of said rotatable shaft or shafts, which is first rotation axis for tracking the apparent movement of the sun. Likewise, linear actuators, coupled with actuating rods, achieve to and fro movement of the actuating rods resulting in rotation of said heliostats about the axis of said stub shafts, which is a second rotation axis that is perpendicular to said first rotation axis.

To compensate for said radius of rotation of the heliostats as described hereinbefore, and to compensate for mechanical error in precision while rotating the heliostats, and to widen the stationary target to accommodate near about entire delivered solar radiation for better results, certain embodiments are schematically depicted in FIG. 22 to 25. In the embodiment depicted in FIG. 22, a large single curved collecting reflector 233 (a convex or concave reflector mirror) is installed at one side of the heliostat field similar to one installed in the solar furnace at Pyrenees-Orientales in France for refocusing the delivered solar radiation by heliostats on to a receiver. As depicted in Fig. 22, said heliostats 231 of the heliostat field reflect the incident solar radiation 235 and thereby deliver the reflected solar radiation 236 on said collecting reflector 233. The delivered solar radiation is further refocused by said collecting reflector 233 on a receiver

234, which receiver 234 is mounted at the focal points of said collecting reflector 233. Another embodiment is schematically depicted in FIG. 23, wherein instead of a single collecting reflector, a plurality of collecting reflectors 276 to 279 are installed in the central area of said heliostat field and are used for refocusing the delivered solar radiation from heliostats 268 to 275 on respective receivers 280 to 283. The heliostats (depicted by numerals 268 to 275 as an exemplification) mounted on rotatable shafts (depicted by numerals 260 to267 as an exemplification) reflect and thereby focus the incident solar radiation on said large curved mirrors 276 to 279. The delivered focused solar radiation is further refocused on receivers 280 to 283, which receivers 280 to 283 are mounted at the focal points of said curved mirrors 276 to 279 respectively. Alternatively, in another embodiment as depicted in FIG. 24, a stationary object is a curved mirror 303 mounted on vertical supports such that the axis of said curved mirror 303 coincides with the axis of the solar central receiver system. Said optic axis of the solar central receiver system passing through the center of said curved mirror 303 lies perpendicular to a plane tangent to the center of said curved mirror. The heliostats 300 positioned low over the ground plane 302 in a heliostat field 301 focus the incident solar radiation 305 and thereby deliver it on said stationary object 303. The delivered solar radiation concentrate is further refocused (refocused solar radiation is depicted by numeral 306) by said large curved mirror 303 (collecting reflector 303) on a receiver 304, which receiver 304 is mounted above ground level 302 underneath said curved mirror and at the focal point of said curved mirror 303.

The said single collecting reflector or said said large curved mirror or each said collecting reflectors are capable of withstanding high temperatures and may have an area of about 0.1 % to 1.5 % of heliostats field. Preferably, a cooling mechanism like a heat sink is provided on nonreflecting backside of said single collecting reflector or said collecting reflectors. A dielectric mirror, in which absorption of the radiation is negligible, may be used.

One of the embodiments of the solar central receiver system has a tower top configuration, wherein heliostats reflects sunlight upon a central receiver. In other embodiments, a collecting reflector or collecting reflectors are used to further concentrate the reflected solar radiation, which is made incident on a receiver or receivers respectively. Said central receiver or said receiver or said receivers are capable of withstanding high temperatures like 1200 to 1800 degrees Fahrenheit, and enclose heat transfer fluid like molten salts or synthetic oil or liquid metals or water, and absorb delivered solar energy and convert the solar energy to thermal energy. The absorbed solar energy heats up the enclosed heat transfer fluid, and the heated said heat transfer fluid is transferred into a hot thermal storage tank, wherein said hot thermal storage tank permits electrical power production that is not concurrent with availability of sunlight. The energy conversion system for said electrical power production can be a Rankine cycle conversion system, wherein heated said heat transfer fluid from said hot thermal storage tank is transferred to a boiler/heat-exchanger to generate high quality steam. Said steam powers a steam turbine to produce electricity. Or the energy conversion system can a Brayton cycle conversion system. Once the heat from the heat transfer fluid is removed, the heat transfer fluid is transported back to the cold storage tank for reuse. Or when said receiver or said receivers absorb incident concentrated solar radiation, wherein a very high temperature is achieved, then such a high temperature can be used for separation of water molecules in to hydrogen and oxygen. Or instead of said receiver or receivers, a thermal cycle engine like a Stirling engine coupled to an electric generator may be placed. Or said solar radiation concentrate could be aimed at mechanical/thermo-voltaic generator or thermopile or photovoltaic conversion.

In another embodiment as depicted in FIG. 25, a curved concave mirror 310 (a convex mirror can also be used) is mounted behind the focal point 311 of the solar central receiver system such that the focused solar radiation 312 delivered by the heliostats 313 is 'collimated and reflected' (collimated and reflected radiation is depicted by numeral 316) towards the central area of the heliostat field. The 'center of said heliostat field' 314, said focal point 311 and the center of said curved concave mirror lie on the optic axis 315. The said curved concave mirror 310 is positioned such that the said optic axis 315 passing through its center lies substantially perpendicular to a plane tangent to the center of said curved mirror. Said focal point 311 of the solar central receiver system lying on said optical axis 315 is at the focus of said curved concave mirror 310. Said collimated solar concentrate is made incident on a receiver light pipe 317 and is used for lighting the inside of buildings. Said receiver light pipe 317 is positioned underneath said collimating reflector 310 such that the axes of said receiver light pipe and said collimating reflector coincide with the optic axis 315 of said solar central receiver system. Concentrated and collimated light entering in said receiver light pipe 317 is routed and circulated for lighting inside of buildings or for hybrid solar lighting. Or said collimated solar radiation concentrate can be used to heat water or to heat swimming pools. Or said collimated solar radiation concentrate could be aimed at mechanical/thermo-voltaic generator or thermopile or photovoltaic conversion with great advantage.

Pertaining to various embodiments as described with reference to figures 1- 25, for the convenience of the description purposes, the rotatable shafts were assumed to be positioned horizontal and in east west direction. Alternatively, rotatable shafts can be positioned horizontally and in north south direction instead of east west direction, at same height, and rotatable about a first rotation axis that is horizontal and in north south direction. Here, the heliostat field would consist of flat or curved light reflecting heliostats grouped in horizontal north south directional linear and parallel arrays instead of east west directional linear and parallel arrays. The positioning of the arrays of heliostats on rotatable shafts and configuring common positioning mechanism would be as described hereinbefore in the text with reference to figures 1- 25.

The position of a celestial object like the sun can be defined by specifying its altitude and azimuth. An altitude of an object is equal to its elevation angle in degrees above the horizon and an azimuth of an object is equal to its angle in the horizontal direction. A solar tracking system of the present invention, as in prior art, comprises a central processing unit (CPU), a memory, and logic-based application software including CPU-executable code loaded in said memory. Predictions of the location of the Sun in the sky are based on the date, time, longitude and latitude related to the heliostat field. The CPU receives inputs from sensory means as in prior art, such as optical sensors, radiofrequency sensors, magnetic sensors, position-sensing detectors, optoelectric sensors, radiofrequency identifier tag or magnetic strip. Position-sensing or positional error detection by an aiming device enables fine scale pointing and tracking. Extensive references are available in literature, which richly describe the sun tracking and target alignment processes for heliostats of a solar furnace, their mechanism and various applications. An alignment apparatus or a positional error detection instrument may be used to assist said computer based alignment system. Such positional error detection instrument is described by Litwin, Robert Z.; et al in US patent application 20050274376, and said patent application is incorporated herein with reference. A sun tracking system for a central receiver solar power plant, by Reznik; Dan S.; et al in US patent application 20090107485, describes a system that uses cameras for acquiring pointing samples by setting the direction of reflection of the heliostats and detecting concurrent sunlight reflections into the cameras. Said system can also be included for solar tracking and proper pointing of mirrors of heliostats of present invention. Said application 20090107485 is also incorporated herein with reference. To align the mirrors of heliostats to their fixed target while fixedly installing on respective supports or to align the mirrors of heliostats for tracking the apparent motion of the sun from dawn to dusk, a computer based alignment system of prior art is used. Using the predicted location of the sun, inputs from sensors, height and position of said central receiver, and elevation of heliostats, the CPU periodically calculates an azimuth and elevation angle for heliostats, and said heliostats are positioned accordingly such that the reflected solar radiation falls upon the desired target. In solar furnace of the present invention, it is not essential to individually sense, align and control rotations of mirrors of each of pluralities of heliostats in accordance with the diurnal movement of the sun. In the present invention, predicting the required altitudinal and/or azimuthal rotation of even a single heliostat would suffice. Due to peculiar disposition of heliostats as explained in a dynamic flattened manifestation of a paraboloid concentrator, for any changed location of the sun in the sky, the extent of the changed inclination and orientation in each heliostat would be the same. Hence for a changed location of the sun, the present invention puts forward the method of synchronous rotation of an array of heliostats or all the arrays of heliostats to the same extent about altitude and/or azimuth axis. The CPU generates controlling commands such that a geared electric motor drive unit/units synchronously rotate the rotatable shaft/shafts to same extent about said first rotation axis. The CPU also generates controlling commands such that the linear actuator/actuators synchronously rotate the array/arrays of heliostats to same extent about said second rotation axis. Said motor drive units or said linear actuators can be driven with the same drive signal or each said motor drive unit or each said linear actuator could be driven with an individual drive signal. Once the entire heliostats are synchronously rotated to the same extent for the apparent altitudinal and/or azimuthal movement of the sun, a single heliostat from each array of heliostats can be used for fine-tuning the related array of heliostats. A single heliostat from each array of heliostat can have an independent sensing, tracking and alignment system. For fine tuning purpose, each motor drive unit could be driven with an individual drive signal, wherein respective rotatable shaft is rotated about said first rotation axis, and each linear actuator could be driven with an individual drive signal, wherein respective array of heliostats is rotated about said second rotation axis.

The above description thus indicates certain embodiments of the present invention, and it is apparent to those expert and skilled in the art that numerous versions and modifications and variations may be made without departing from the theme and the scope of the present invention. The present invention may, of course, be carried out in other specific ways than those herein set forth without departing from the spirit and essential characteristics of the invention. The detailed description of the invention with reference to drawings should therefore be considered in all respects as illustrative and not restrictive, and all changes coming within the meaning and equivalency range of the detailed description are intended to be embraced therein.

We claim:

Claim 1. A solar central receiver system employing common positioning mechanism for heliostats for synchronously orienting said heliostats for altitude and/or azimuth axis orientation with respect to a stationary object and the sun such that incident solar radiation upon said heliostats is focused upon said stationary object from dawn to dusk.

Claim 2. A common positioning mechanism for synchronously maneuvering ganged heliostats for altitude and/or azimuth axis orientation with respect to a stationary object and a celestial object such that incident electromagnetic radiation emitted from said celestial object upon said heliostats is continually focused upon said stationary object.

Claim 3. A solar central receiver system employing common positioning mechanism for heliostats, wherein said heliostats are positioned like facets of a Fresnel type of reflector, and wherein said heliostats are synchronously maneuverable in altitudinal and/or azimuthal axis for tracking an apparent movement of the sun.

Claim 4. A solar central receiver system employing common positioning mechanism for heliostats for orienting said heliostats with respect to a stationary object and the sun such that incident solar radiation upon said heliostats is focused upon said stationary object and thereby deliver concentrated solar radiation upon said stationary object from dawn to dusk;
wherein each heliostat is precisely positioned according to its location in a heliostat field;
wherein for tracking an apparent movement of the sun in the sky, said

common positioning mechanism is employed for orienting said heliostats for altitude and/or azimuth axis orientation;
wherein subsequent to each said orientation of said heliostats, collective disposition of said heliostats always forms an arrangement that is capable of reflecting and thereby focusing incident solar radiation upon said stationary object.

Claim 5. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 4, wherein said precisely positioning of said heliostats is like facets of a Fresnel type of reflector, wherein said heliostats are synchronously maneuverable by said common positioning mechanism in altitude and/or azimuth axis orientation such that subsequent to each said orientation for an apparent movement of the sun in the sky, a collective disposition of said heliostats always forms an arrangement that is capable of reflecting and thereby focusing incident solar radiation onto said stationary object.

Claim 6. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 1 to 5, wherein said stationary object is a central receiver or a collecting reflector or collecting reflectors or a collimating reflector or a thermal cycle engine or a mechanical/thermo-voltaic generator or a thermopile or a photovoltaic conversion system.

Claim 7. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 1 to 6, wherein said solar central receiver system comprising:
a heliostat field consisting of flat or curved light reflecting heliostats mounted on rotatable shafts and grouped in horizontal east west directional

linear parallel arrays that are positioned with respect to said stationary object;

said stationary object is mounted at a pre-defined height above ground level;

pluralities of rotatable shafts, provided for mounting arrays of heliostats, are positioned with respect to said stationary object, wherein an array of heliostats is mounted on each rotatable shaft, and wherein each said rotatable shaft is positioned horizontally and in east west direction, at same height, and rotatable about a first rotation axis that is horizontal and in east west direction;

wherein each said rotatable shaft is coupled with a drive means to drive said rotatable shaft to rotate about said first rotation axis such that each heliostat mounted on each said rotatable shaft rotates about said first rotation axis for tracking an apparent azimuthal motion of the sun from dawn to dusk;

wherein each said rotatable shaft provides a linear array of mounting means for mounting a linear array of heliostats, wherein said mounting means of said linear array of heliostats are linked mechanically, and wherein each mounting means is designed in a manner which permits individual pivotal movement of mounted heliostat with respect to related rotatable shaft about a second rotation axis that is perpendicular to said first rotation axis;

and wherein each said rotatable shaft supports a rotation mechanism for synchronously rotating said linear array of heliostats about said second rotation axis, wherein a linear drive means is provided to drive said rotation mechanism, and wherein said rotation mechanism synchronously rotates each heliostat of said array of heliostats about said second rotation axis so as to track changing altitudinal angle of incident solar radiation.

Claim 8. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 7, wherein each said rotatable shaft is positioned horizontally and in north south direction, at same height, and rotatable about a first rotation axis that is horizontal and in north south direction, and wherein each said rotatable shaft is coupled with a drive means to drive respective rotatable shaft to rotate about said first rotation axis such that each heliostat mounted on each said rotatable shaft rotates about said first rotation axis for tracking an apparent altitudinal motion of the sun from dawn to dusk;
and wherein said rotation mechanism supported by each said rotatable shaft synchronously rotates respective said linear array of heliostats about said second rotation axis so as to track changing azimuth angle of incident solar radiation.

Claim 9. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 1 to 8, wherein said common positioning mechanism for rotating said heliostats about said first rotation axis comprises:
pluralities of rotatable shafts positioned with respect to said stationary object, wherein an array of heliostats is mounted on each said rotatable shaft, and wherein each said rotatable shaft is coupled with a drive means to drive said rotatable shaft to rotate about said first rotation axis such that each heliostat mounted on each said rotatable shaft rotates about said first rotation axis;
wherein for tracking an apparent motion of the sun in the sky, a central processing unit (CPU), using predicted location of the sun in the sky as per date, time, longitude and latitude related to said heliostat field, feedbacks

from sensory means, height and position of said stationary object and elevation of heliostats above ground level generates controlling commands for pluralities of drive means for rotating related said pluralities of rotatable shafts to synchronously rotate about said first rotation axis for orientation of said heliostats with respect to said stationary object and the sun such that said heliostats focus incident solar radiation upon said stationary object.

Claim 10. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 9, wherein said common positioning mechanism for fine tuning said rotation of said heliostats about said first rotation axis comprises:
a single heliostat among each said array of heliostats has a sensing and alignment system for solar tracking, wherein said sensing and alignment system provides related sensory data to said CPU;
wherein said CPU, using feedbacks from said sensing and alignment system, generates controlling commands for drive means related to said single heliostat for rotating related rotatable shaft to rotate about said first rotation axis for fine tuning said orientation such that disposition of related said array of heliostats is improved for reflecting and thereby focusing incident solar radiation upon said stationary object.

Claim 11. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 9 and 10, wherein each rotatable shaft of said plurality of rotatable shafts comprising:
a plurality of shaft segments coupled with each other via couplings, wherein said shaft segments are supported on bearings;
wherein fail safe brakes are fitted on each said rotatable shaft so that unwanted reverse rotation of said rotatable shaft due to eccentric loading

pressure like wind pressure, if any, is avoided;
and wherein each said rotatable shaft is coupled with a drive means, preferably an irreversible type, to drive respective rotatable shaft to rotate about said first rotation axis.

Claim 12. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 1 to 8, wherein said common positioning mechanism for rotating said heliostats about said second rotation axis comprises:
each rotatable shaft of said pluralities of rotatable shafts provides a linear array of mounting means for mounting a linear array of heliostats, wherein mounting means of said linear array of mounting means mounted on each said rotatable shaft are mechanically connected, and wherein each mounting means is designed for individual pivotal movement of mounted heliostat about said second rotation axis, said mounting means comprising:
a support for fixedly positioning a heliostat, wherein said support is pivotably rotatable about said second rotation axis;
a rotation mechanism to drive said supports to rotate about said second rotation axis;
an actuating means for actuating said rotation mechanism, wherein an actuator, developing force and motion in a linear manner, effects a to and fro movement of an actuating rod in a direction parallel to axis of said shaft segment, wherein said actuating rod, supported in end flanges of said shaft segments and movable in to and fro direction parallel to axis of said shaft segments has a driving end connected to said actuator, and wherein said actuating means actuates said rotation mechanism to drive said supports to rotate about said second rotation axis.

Claim 13. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 12, wherein said rotation mechanism for driving said support to rotate about said second rotation axis comprises a slotted link and pusher mechanism, wherein each said support oscillates freely about a pivot pin located on a bracket, wherein said bracket is rigidly fitted on said rotatable shaft, and wherein an arm of said support is engageable in a slot formed in body of a slotted link and movable with movement of said slotted link, wherein said slotted link is rigidly fitted on said actuating rod, and wherein said actuating rod when moved backward or forward results in clockwise or anticlockwise rotation about said second rotation axis of said support about said pivot pin.

Claim 14. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 12, wherein said rotation mechanism for driving said support to rotate about said second rotation axis comprises a chain sprocket and gear wheel transmission method, wherein said support oscillates freely about a pivot pin located on a bracket, wherein said bracket is rigidly fitted on said rotatable shaft, wherein a gear sector is rigidly fixed on said support such that said gear sector oscillates along said support about said pivot pin, and wherein said gear sector is rotationally engageable with a gear wheel coaxially fitted on a chain sprocket, wherein said chain sprocket is engageable with chain segments, which chain segments are rigidly fitted on said actuating rod, wherein said chain sprocket is engageable with said chain segments such that a to and fro motion of said actuating rod results in rotational movement of said chain sprocket about a sprocket pin, and wherein when said actuating rod is moved backward or forward, said gear wheel is subjected to clockwise or anticlockwise rotational motion that results in anticlockwise or clockwise rotational movement of said gear sector along with said support.

Claim 15. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 14, wherein a rack is rigidly fitted on said actuating rod instead of said chain segments in said rotation mechanism, wherein said rack is engageable with said gear wheel, wherein when said actuating rod is moved backward or forward, said gear wheel is subjected to clockwise or anticlockwise rotational motion that results in anticlockwise or clockwise rotational movement of said gear sector along with said support.

Claim 16. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 14 and 15, wherein said gear sector is directly engageable with chain segments or said rack such that when said actuating rod is moved backward or forward said gear sector is subjected to clockwise or anticlockwise rotational movement along with said support.

Claim 17. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 4, wherein an H shaped bracket is provided for said precisely positioning of a heliostat at a precise angle of orientation, wherein said H shaped bracket is fixedly positioned on a support at said precise angle of orientation, wherein said fixedly positioning said H shaped bracket at said precise angle of orientation on said support comprising:
midpoint of central member of said H shaped bracket is fixed on a midpoint of said support, wherein said central member of said H shaped bracket is

fixedly positioned at said precise angle with said support such that said central member of said H shaped bracket is colinear with a line joining a center of heliostat field with said central member;
wherein said precise angle of orientation at which said H shaped bracket is fixedly positioned on said support varies according to a location of said support in said heliostat field;
wherein said precise angle of orientation for said H shaped bracket on said support depends on a minimal distance between said center of said heliostat field and a hypothetical chord or a line whereupon a rotatable shaft is located on which said H shaped bracket is mounted on said support, wherein said minimal distance is a length of a side opposite said precise angle;
wherein said precise angle also depends on a distance between said center of said heliostat field to a position of said midpoint of said central member of said H shaped bracket on said rotatable shaft, wherein said distance is a length of hypotenuse;
wherein said precise angle is calculated by finding sine of said precise angle, wherein said sine of said precise angle is equal to said length of said side opposite said precise angle divided by said length of said hypotenuse.

Claim 18. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 4, wherein while said precisely positioning of a heliostat, said heliostat makes a defined angle of inclination with respect to an H shaped bracket, wherein medial side of said heliostat is hingedly coupled with a medial member of said H shaped bracket, and wherein said heliostat is inclined at said defined angle with said H shaped bracket and accordingly length of link means like a turn buckle or a slotted link is selected and fixed between lateral member of said H shaped bracket

and lateral border of said heliostat for supporting lateral aspect of said heliostat, wherein said length of said link means can be fine tuned;
wherein said defined angle of inclination at which said heliostat is fixedly positioned with respect to said H shaped bracket varies according to a location of said H shaped bracket in said heliostat field;
wherein said defined angle of inclination at which said heliostat is fixedly positioned with respect to said H shaped bracket is angle $\theta/2$;
wherein angle θ depends on a distance between a center of heliostat field to a midpoint of said heliostat in said heliostat field, which is a length of a side opposite said angle θ, and a height of said stationary object from ground level, which is a length of an adjacent side of said angle θ;
wherein said angle θ is calculated by finding tan of said angle θ, wherein said tan of said angle θ is equal to said length of said side opposite said angle θ divided by said length of said adjacent side.

Claim 19. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 1 to 10, wherein said heliostats rotate about their centers such that there is no radius of rotation, said common positioning mechanism comprises:
pluralities of rotatable shafts, provided for positioning arrays of heliostats, are located with respect to said stationary object, wherein an array of heliostats is positioned on each rotatable shaft;
wherein each heliostat of said array of heliostats has a central hole, and wherein respective rotatable shaft passes through said hole;
wherein each said rotatable shaft is positioned horizontally and positioned either in east west direction or in north south direction, at same height, and rotatable about a first rotation axis that is horizontal and either east west

directional or horizontal and north south directional respectively;
wherein each said rotatable shaft is coupled with a drive means to drive said rotatable shaft to rotate about said first rotation axis such that each heliostat positioned on each said rotatable shaft rotates about said first rotation axis for tracking an apparent motion of the sun;
a plurality of stub shafts are fitted such that said stub shafts pass through shaft segments of said rotatable shafts;
a pair of trapezoidal flanges are permanently fixed on each said stub shaft, wherein a trapezoidal flange is fitted on either side of said shaft segment;
a pusher rod is fitted in said pair of trapezoidal flanges such that said pusher rod is engageable in a slot in a slotted link, which slotted link is fitted with an actuating rod, wherein said actuating rod, supported in end flanges of said shaft segments and movable in to and fro direction parallel to axis of said shaft segments, has a driving end connected to an actuator, wherein when said actuator moves said actuating rod, each said slotted link pushes each said pusher rod, which results in rotation of each said pair of said trapezoidal flanges about axis of respective said stub shaft;
each said pair of trapezoidal flanges are permenently fitted with each other via a pair of members situated at two ends of said pair of trapezoidal flanges, wherein each said member has a hole through which a heliostat is engageable via a pin or a projection for installation purposes;
wherein each heliostat is rotatable about an axis of said pin or said projection, wherein each said heliostat is rotated about said axis of said pin or said projection while fixedly positioning;
wherein a heliostat is positioned such that said heliostat makes a distinct angle of inclination with respect to respective rotatable shaft that passes through said heliostat (or with respect to ground plane), wherein a line

joining center of said heliostat field and midpoint of medial border of said heliostat is perpendicular with respect to said medial border of said heliostat;
wherein said distinct angle of inclination at which said heliostat is fixedly positioned with respect to ground plane varies according to a location of said heliostat in said heliostat field;
wherein said distinct angle of inclination at which said heliostat is positioned with respect to ground plane is angle $\theta/2$, wherein angle θ depends on a distance between said center of said heliostat field to midpoint of said heliostat in said heliostat field, which is a length of a side opposite said angle θ, and a height of said stationary object from ground plane, which is a length of an adjacent side of said angle θ, and wherein said angle θ is calculated by finding tan of said angle θ, wherein said tan of said angle θ is equal to said length of said side opposite said angle θ divided by said length of said adjacent side;
wherein while said precisely positioning of a heliostat, said heliostat is rotated about said axis of said pin or said projection forming an angle of rotation with respect to said members of said trapezoidal flanges and rotated about said axis of said stub shaft forming an angle of inclination with respect to said shaft such that said heliostat is inclined at said distinct angle of inclination, wherein a line joining center of said heliostat field and midpoint of medial border of said heliostat is perpendicular with respect to medial border of said heliostat, wherein said heliostat is fixedly clamped via clamping means at said precisely positioned status so as to have a fixed formed angle of rotation about said axis of said pin or said projection, and wherein said heliostat is set in formed angle of inclination with respect to said shaft;
wherein rotation of said pair of said trapezoidal flanges results in rotation of

respective precisely positioned heliostat about respective stub shaft in a second rotation axis that is perpendicular to said first rotation axis, and wherein synchronous rotation of said array or arrays heliostats about said second rotation axis is for tracking an apparent movement of the sun in the sky;
wherein rotation of said rotatable shaft or shafts synchronously rotate said precisely positioned heliostats on said rotatable shaft or shafts about said first rotation axis for tracking an apparent movement of the sun in the sky.

Claim 20. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 1 to 19, wherein for said orientation of said heliostats, a central processing unit (CPU) under its control program executes or initiates execution of routines for solar tracking utilizing stored application software and/or various sensor inputs;
wherein said CPU, a memory, and an application software including CPU-executable code loaded in said memory predict location of the sun in the sky, wherein each said prediction is based on date, time, longitude and latitude related to location of said heliostat field;
wherein said CPU receives feedback from sensory means that comprise optical sensors and/or radiofrequency sensors and/or magnetic sensors and/or photodetectors and/or position-sensing detectors and/or optoelectric sensors and/or radiofrequency identifier tag and/or position-sensing detector and/or magnetic strip and/or feedbacks from drive motors;
wherein said CPU, said memory, and said application software including CPU-executable code loaded in said memory periodically calculate required azimuth and/or altitude axis rotation for heliostats using predicted location of the sun in the sky, feedbacks from sensory means, height and position of

said stationary object, and elevation of heliostats above ground level such that said heliostats reflect incident solar radiation on said stationary object; wherein said CPU generates controlling commands for a single geared motor drive unit for rotating related rotatable shaft to rotate about said first rotation axis for tracking an apparent motion of the sun in the sky and/or for fine tuning for said tracking, or said CPU generates controlling commands for a plurality of gear motors drive units for rotating related plurality of rotatable shafts to synchronously rotate about said first rotation axis for tracking an apparent motion of the sun in the sky;
wherein said CPU generates controlling commands for a single actuator for rotating respective array of said heliostats about said second rotation axis that is perpendicular to said first rotation axis for tracking an apparent motion of the sun in the sky and/or for fine tuning for said tracking, or said CPU generates controlling commands for a plurality of actuators for synchronously rotating said heliostats about said second rotation axis for tracking an apparent motion of the sun in the sky;
wherein said CPU includes a set of logic programs for converting commands into electronic drive signals.

Claim 21. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 1 to 11, wherein said heliostats, fitted on said rotatable shafts, rotate along a circular path having a radius that is comparable to a radius of said rotatable shafts, wherein reflected solar radiation also travels to a certain distance proportional to said radius, wherein a compensatory mechanism is employed to compensate said travel of reflected solar radiation.

Claim 22. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 21, wherein said compensatory mechanism comprising:
said CPU generates controlling commands for a compensatory controlled rotational movement, or lag or lead in rotational movement of each said drive means of each said rotatable shaft to compensate said travel of reflected solar radiation;
wherein said travel of reflected solar radiation would uniformly differ with heliostats mounted on medial to lateral aspect of each said rotatable shaft, wherein a mean is calculated for said travel of reflected solar radiation for each said rotatable shaft, and wherein said mean is used for calculating and executing said compensatory controlled rotational movement, or lag or lead in rotational movement of each related drive means for each related rotatable shaft.

Claim 23. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 21, wherein said compensatory mechanism comprising:
a mount, for mounting said stationary object, supports a rectangular platform, wherein a straight or curved slide is fitted on said platform for movement of said stationary object to trace said reflected solar radiation, wherein said stationary object is slid in same direction and proportional to said travel of reflected solar radiation to realize a compensatory controlled movement of said stationary object to trace said travel of reflected solar radiation from dawn to dusk;
a numerically controlled drive is fitted on said slide for said compensatory controlled movement of said stationary object.

Claim 24. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 1 to 23, wherein said stationary object is a central receiver;
wherein said central receiver is positioned at central aspect of said heliostat field at a pre-defined height above ground level;
wherein said central receiver is capable of withstanding high temperatures and encloses a heat transfer fluid like molten salts or synthetic oil or liquid metals or water;
wherein said central receiver absorbs focused solar radiation delivered by said heliostats and converts said solar radiation to thermal energy, wherein absorbed solar radiation heats up said heat transfer fluid.

Claim 25. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 1 to 23, wherein said stationary object is a single collecting reflector (curved reflecting mirror);
wherein said single collecting reflector is positioned on one side of said heliostat field at a pre-defined height above ground level;
wherein said single collecting reflector re-reflects and focuses delivered solar radiation by said heliostats upon a receiver, wherein said receiver is placed at a focal point of said single collecting reflector;
wherein said receiver is capable of withstanding high temperatures and encloses a heat transfer fluid like molten salts or synthetic oil or liquid metals or water;
wherein said receiver absorbs focused solar radiation delivered by said single collecting reflector and converts said solar radiation to thermal energy, wherein absorbed solar radiation heats up said heat transfer fluid.

Claim 26. A solar central receiver system employing common positioning mechanism as claimed in claim 1 to 23, wherein said stationary object is a plurality of collecting reflectors (curved reflecting mirrors);
wherein said plurality of collecting reflectors are positioned at central aspect of said heliostat field at a pre-defined height above ground level;
wherein delivered concentrated solar radiation by said heliostats is re-reflected by said collecting reflectors and thereby focused upon respective receivers, wherein respective receivers are placed at focal point of respective collecting reflectors;
wherein each said receiver is capable of withstanding high temperatures and encloses a heat transfer fluid like molten salts or synthetic oil or liquid metals or water;
wherein respective receiver absorbs focused solar radiation from respective collecting reflector and converts said solar radiation to thermal energy, wherein said absorbed solar radiation heats up said heat transfer fluid.

Claim 27. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 1 to 23, wherein said stationary object is a collimating reflector;
wherein said collimating reflector is mounted on a centrally located tower at a pre-defined height above ground level, wherein said collimating reflector is coaxially and perpendicularly positioned with respect to an optic axis of said solar central receiver system;
wherein said delivered focused solar radiation by said heliostats on said collimating reflector is collimated and reflected on a light pipe, wherein said light pipe is positioned underneath said collimating reflector such that axes of said light pipe and said collimating reflector coincide with optic axis of

said solar central receiver system, and wherein concentrated and collimated solar radiation entering in said light pipe is routed for lighting inside of buildings or for hybrid solar lighting or aimed/routed at or used for mechanical/thermo-voltaic generator or thermopile or photovoltaic conversion system or a thermal cycle engine like Stirling engine or heating water or heating a swimming pool.

Claim 28. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 25 to 27, wherein said collimating reflector or said single collecting reflector or said collecting reflectors are capable of withstanding high temperatures.

Claim 29. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 25 to 27, wherein a cooling mechanism like a heat sink is provided on nonreflecting backside of said collimating reflector or said single collecting reflector or said collecting reflectors.

Claim 30. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 24 to 26, wherein said heated said heat transfer fluid is transferred into a hot thermal storage tank, wherein said hot thermal storage tank permits said electrical power production that is not concurrent with availability of sunlight;
wherein energy conversion system for said electrical power production is a Rankine cycle conversion system, wherein heated said heat transfer fluid from said hot thermal storage tank is transferred to a boiler/heat-exchanger to produce steam, wherein said steam powers a steam turbine to produce electricity, or wherein said energy conversion system is a Brayton cycle

conversion system;
or wherein said absorbed incident concentrated solar radiation is used for separation of water molecules in to hydrogen and oxygen.

Claim 31. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 25 and 26, wherein said single collecting reflector or said collecting reflectors re-reflect and thereby focus said delivered concentrated solar radiation upon solar cells or a thermal cycle engine/engines or thermopile/ thermopiles respectively for harvesting solar energy, wherein said thermal cycle engine/engines or said solar cells or said thermopile/thermopiles are placed at or near-about said focal point/points of said single collecting reflector or said collecting reflectors respectively.

Claim 32. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 1 to 31, wherein said heliostats are square-shaped or circular or rectangular or hexagonal or octagonal or polygonal;
wherein said heliostats are flat or concave or paraboloid shaped and have a supporting frame for rigidly holding their shape and contour intact and for preventing damage or bending.

Claim 33. A solar central receiver system employing common positioning mechanism for heliostats as claimed in claim 32, wherein said heliostats are fabricated with metals such as polished aluminum or steel with/without nickel/chromium plating, or glass with/without a silvered coating as in a mirror, or ceramics or other composites such as fiberglass or graphite or polymers or plastics having a reflective coating like vacuum deposited aluminum or silver, or a plastic material coated or clad with a reflective film like Mylar or Reflectech, or said heliostats are fabricated of any other material that meets structural and reflective properties required of a flat or curved or parabolic reflector.

Claim 34. A dynamic flattened manifestation of a paraboloid concentrator for reflecting incident solar radiation upon a stationary object and thereby delivering concentrated solar radiation upon said stationary object from dawn to dusk;
wherein a flattened manifestation of a paraboloid concentrator comprises precisely positioned optical elements like facets of a Fresnel type of reflector, wherein for a fixed position of the sun in the sky incident solar radiation upon said optical elements is focused upon said stationary object;
and wherein said dynamic flattened manifestation of a paraboloid concentrator is a reorganizing variant of said flattened manifestation of a paraboloid concentrator, wherein said optical elements are synchronously maneuverable in altitudinal and/or azimuthal axis for tracking a changed position of the sun in the sky such that for said changed position of the sun in the sky collective disposition of said optical elements forms an arrangement that is capable of reflecting and thereby focusing incident solar radiation upon said stationary object;
and wherein said optical elements are periodically synchronously maneuvered in altitudinal and/or azimuthal axis for tracking changed positions of the sun in the sky, wherein subsequent to each said synchronous maneuver of said optical elements a collective disposition of said optical elements forms an arrangement that is capable of reflecting and thereby focusing incident solar radiation on to said stationary object.

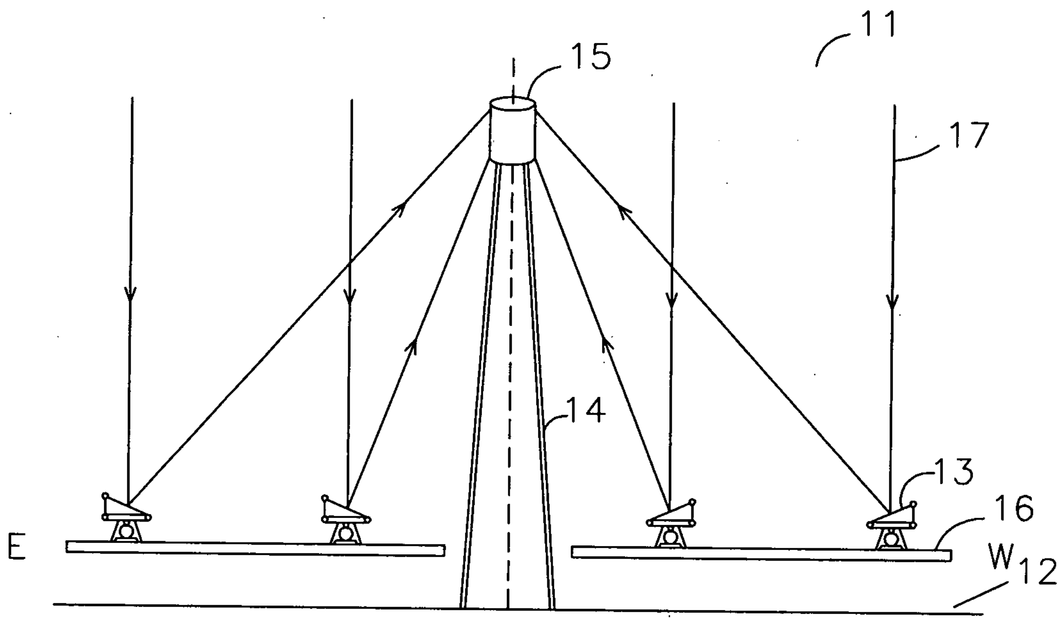

FIG. 1

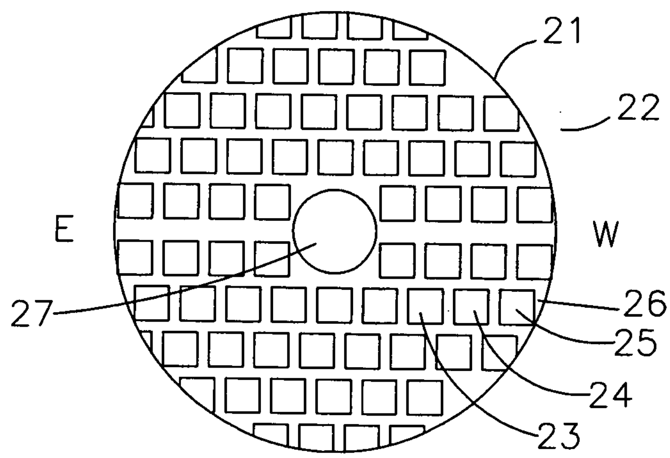

FIG. 2

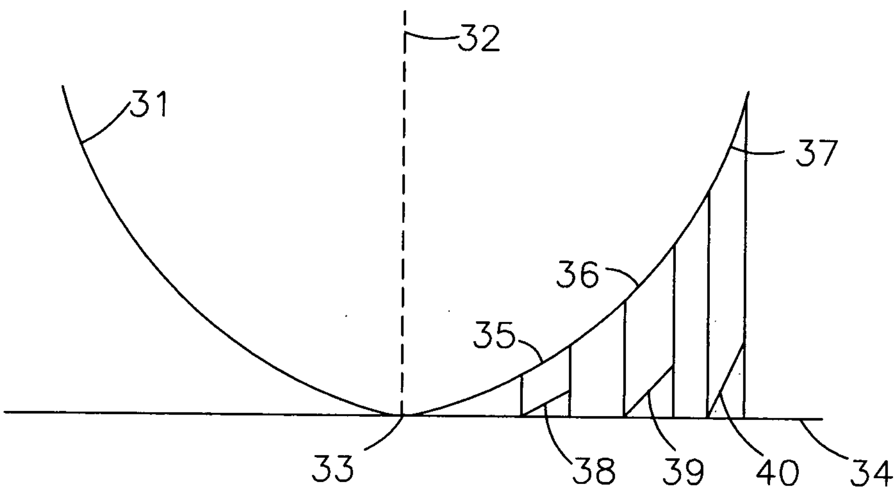

FIG. 3

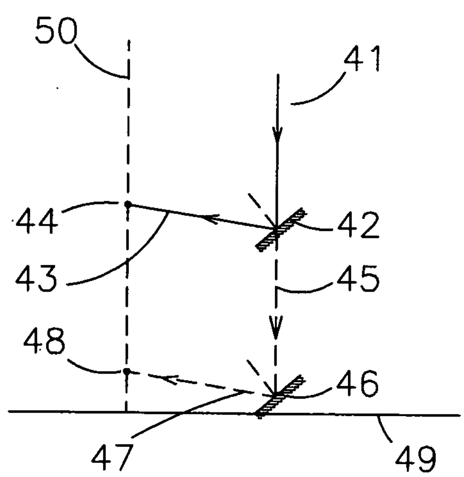

FIG. 4

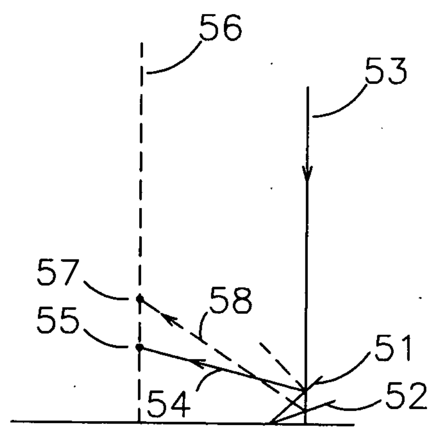

FIG. 5

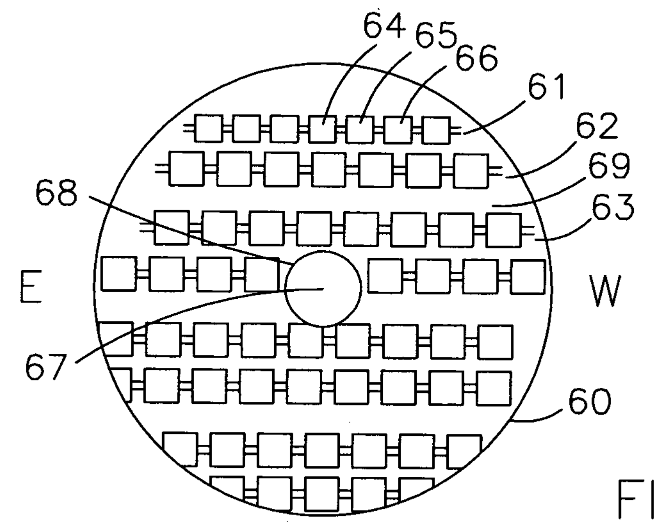
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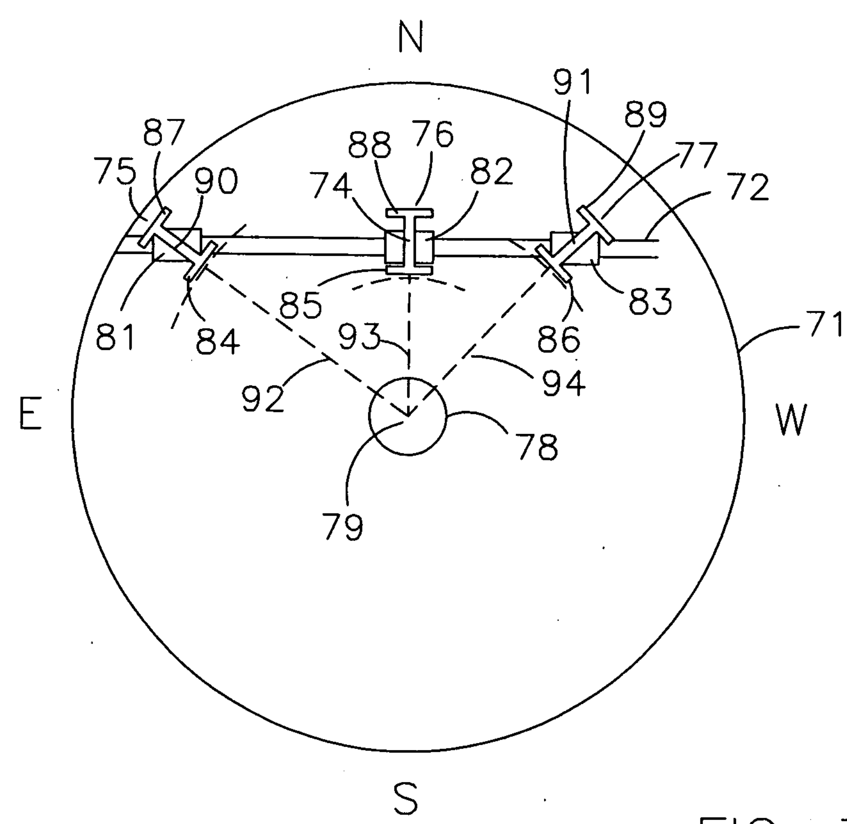
FIG. 6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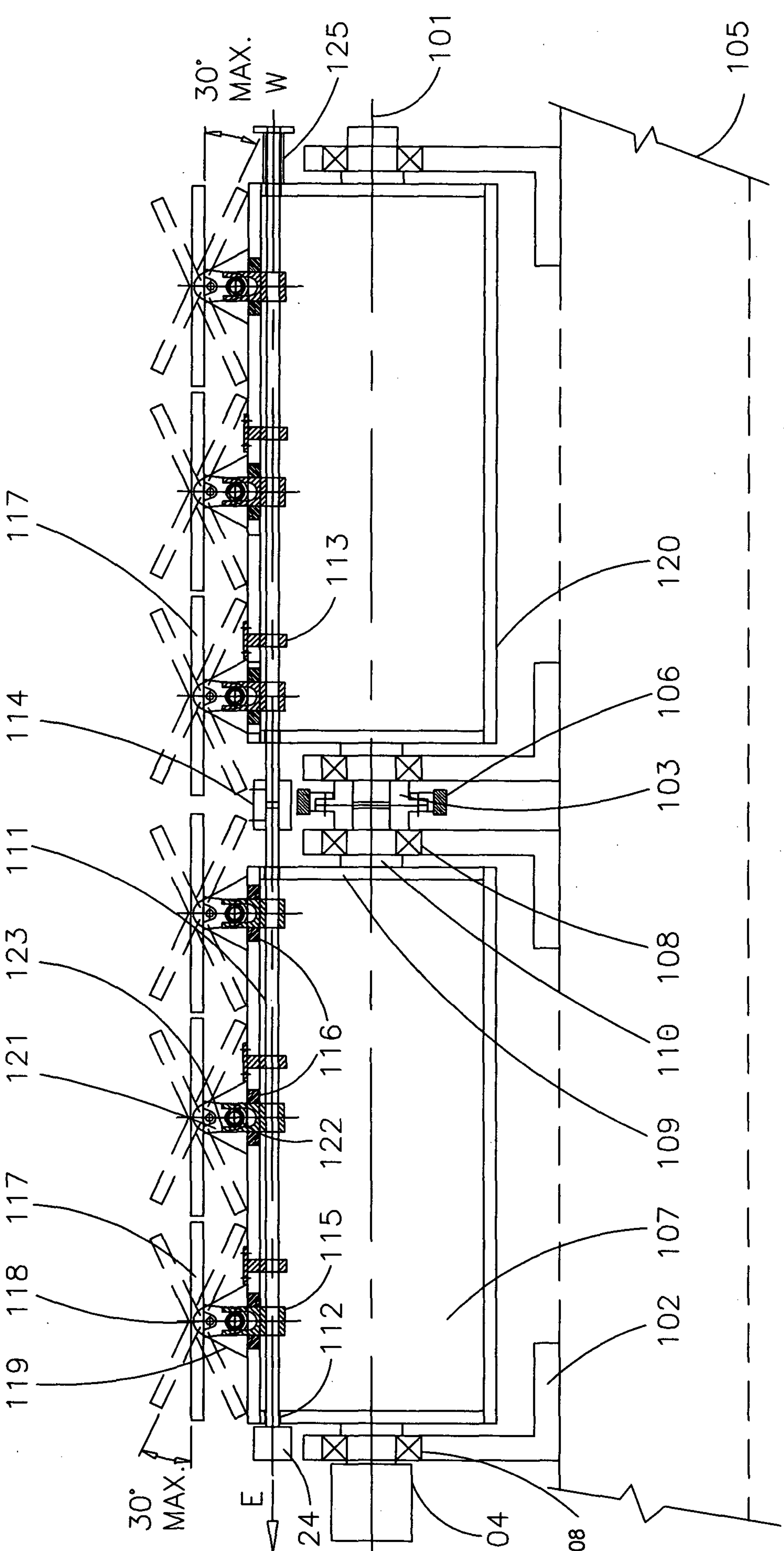
S

FIG. 7


30°
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30°
MAX.
E
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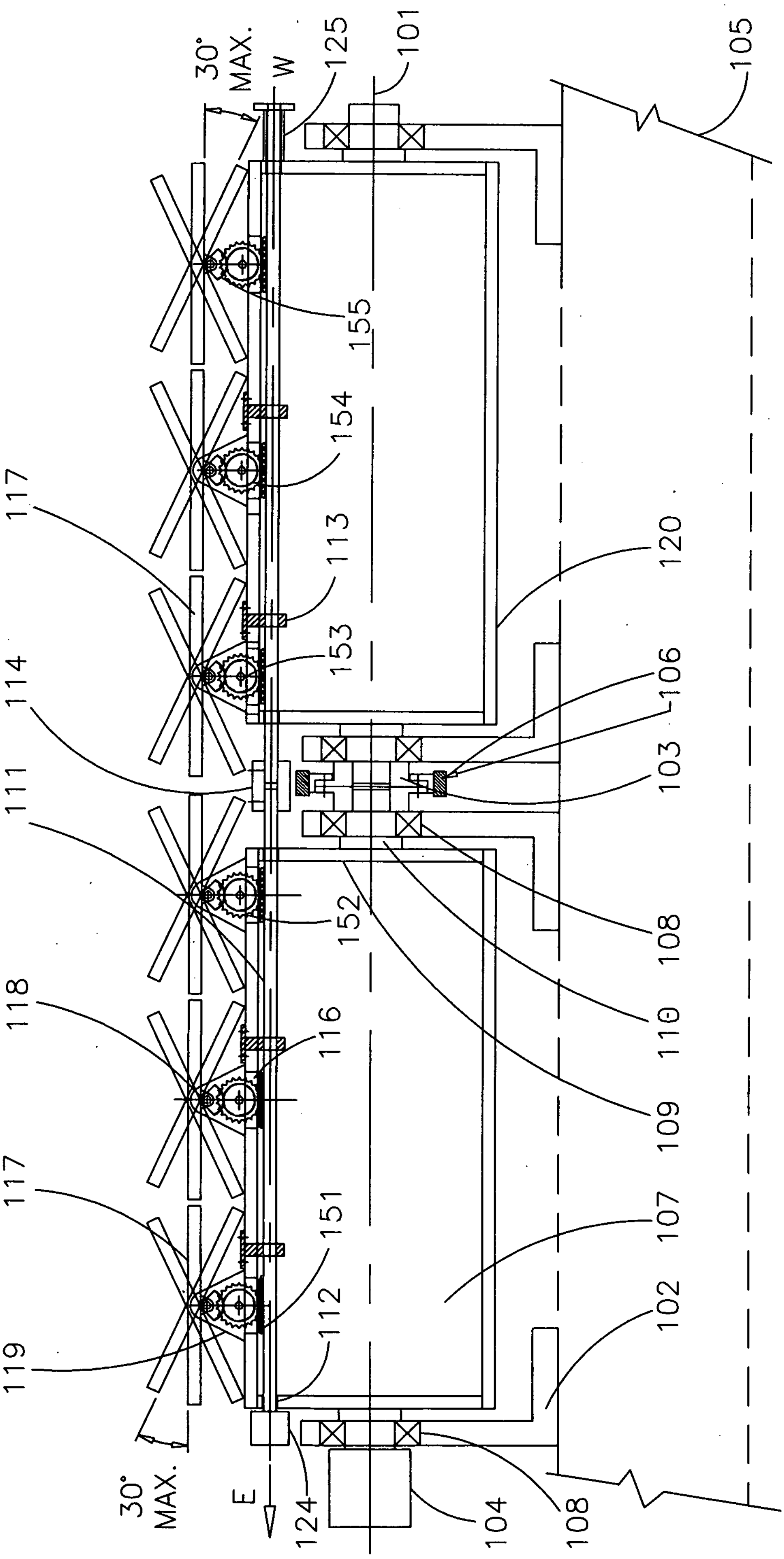
104
108

FIG. 8


30° MAX.
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30° MAX.
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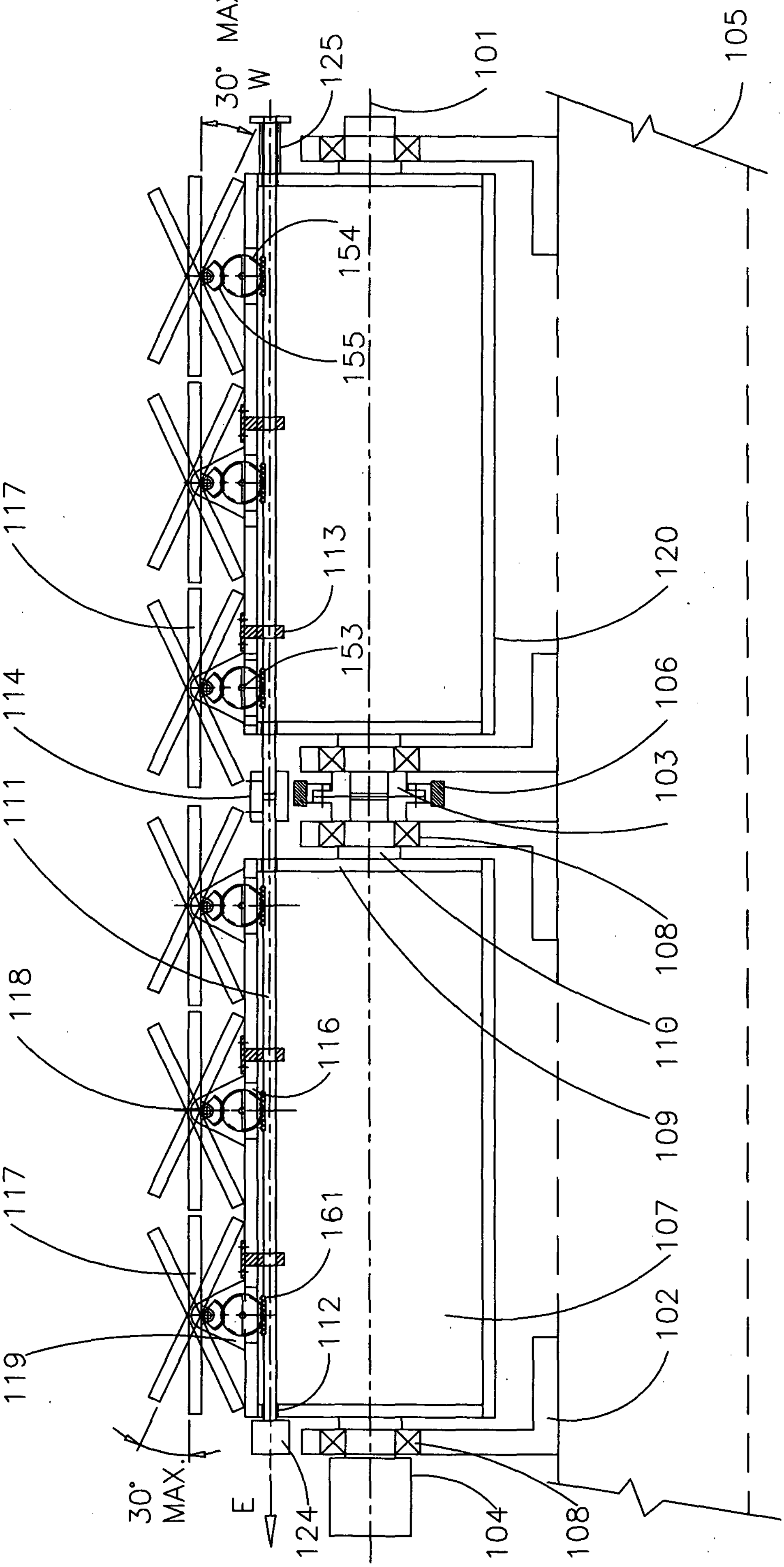
FIG. 9


30° MAX.
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30° MAX.
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FIG. 10

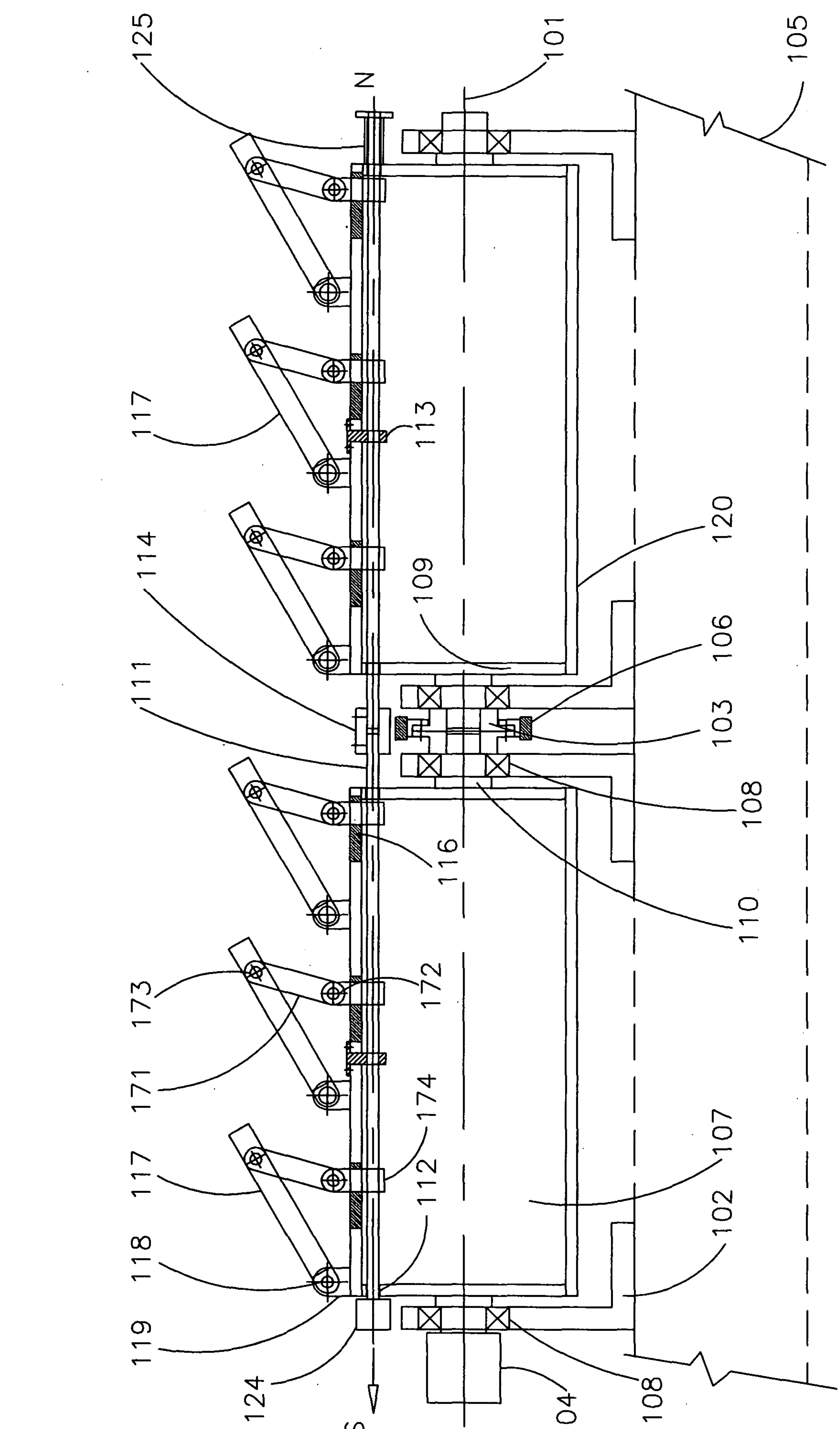
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FIG. 11

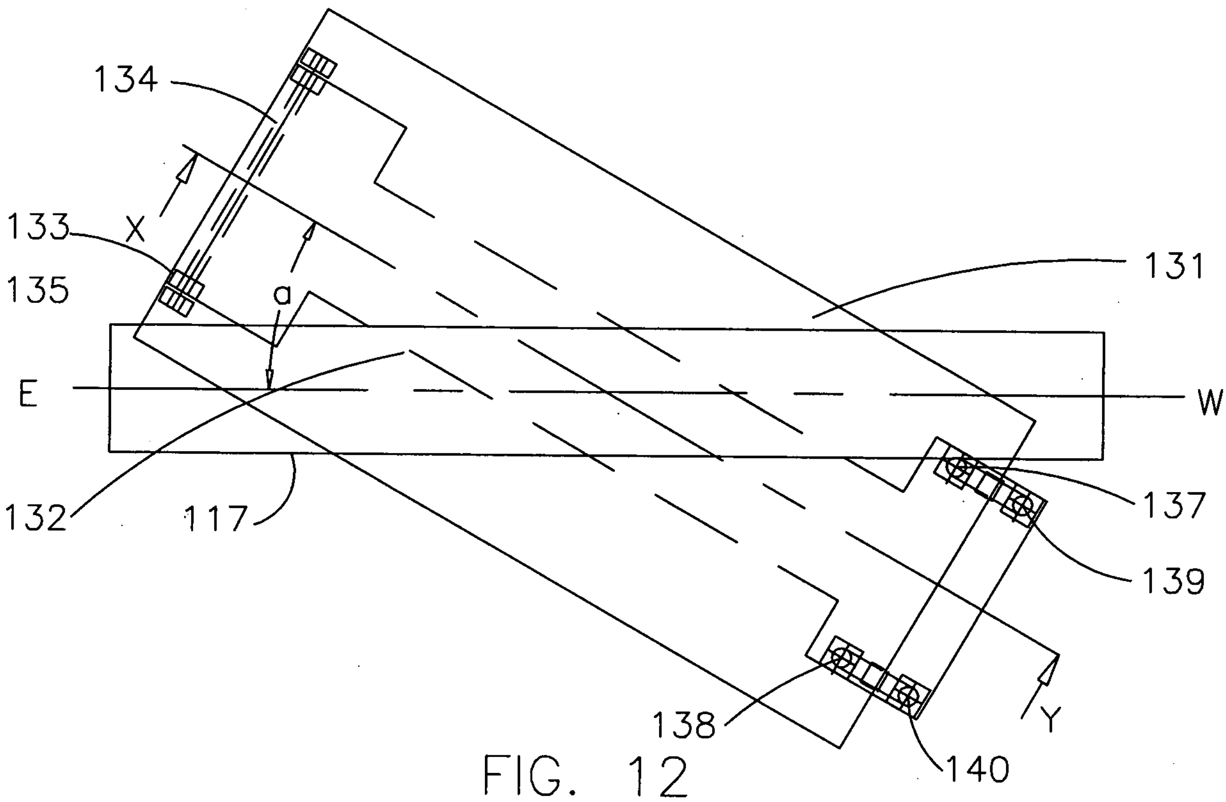

FIG. 12
(VIEW SEEN FROM C)

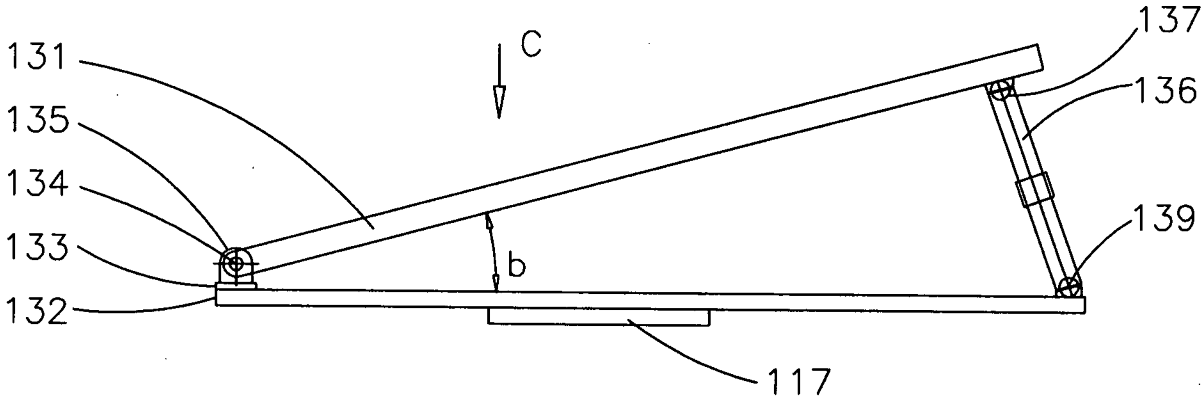

FIG. 13
(SECTION X–Y)

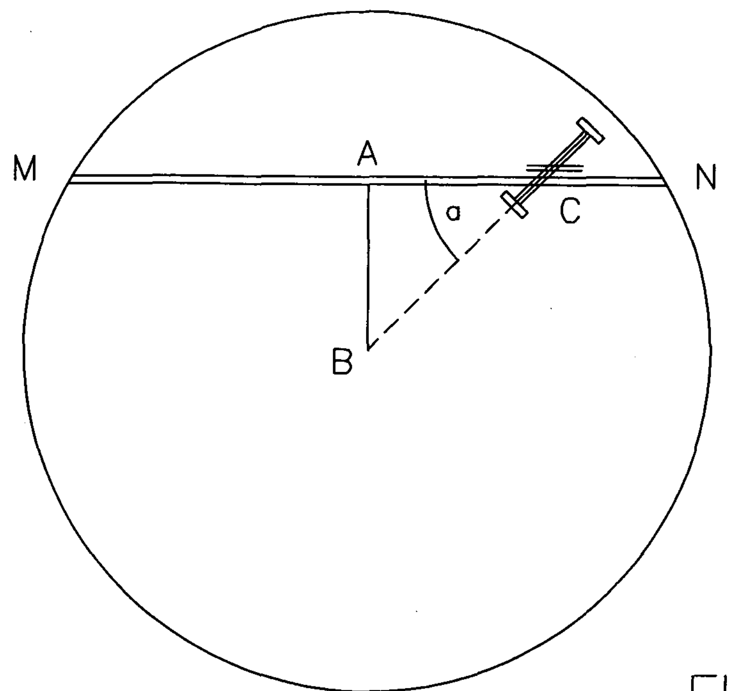

FIG. 14

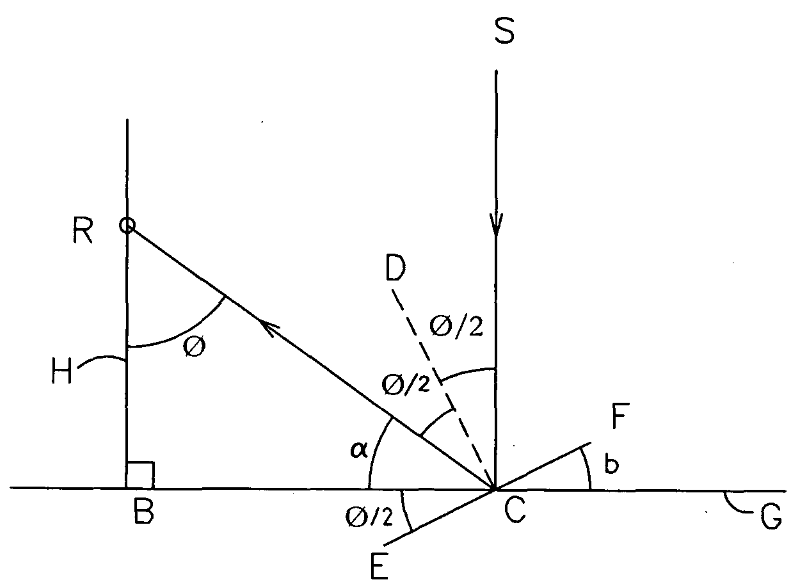

FIG. 15

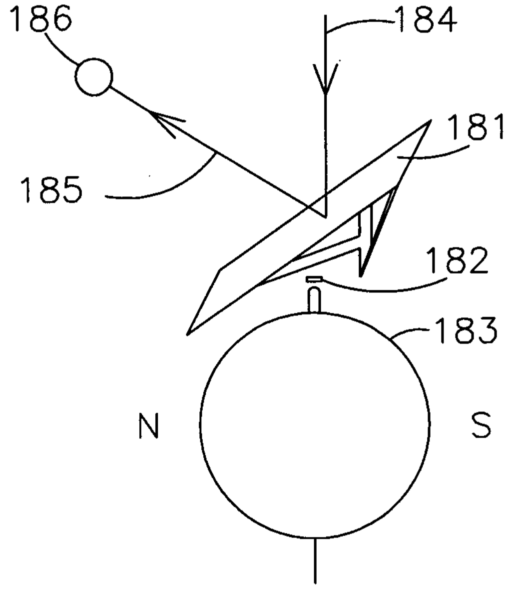

FIG.16

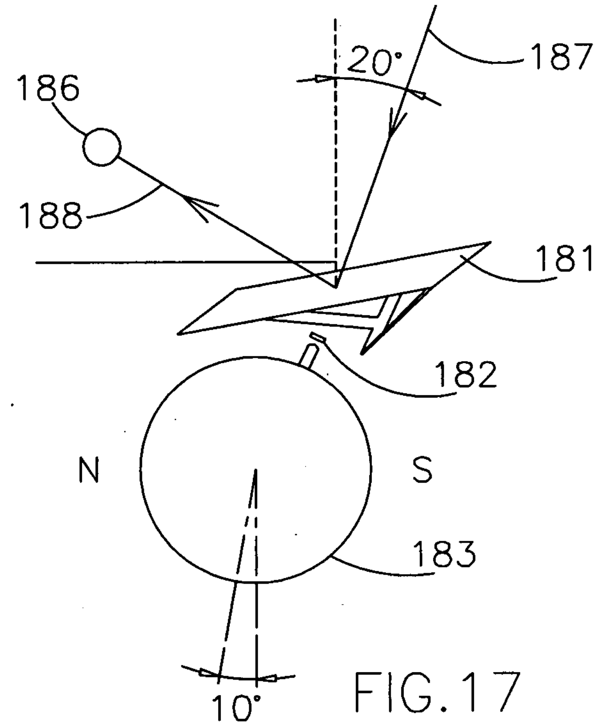

FIG.17

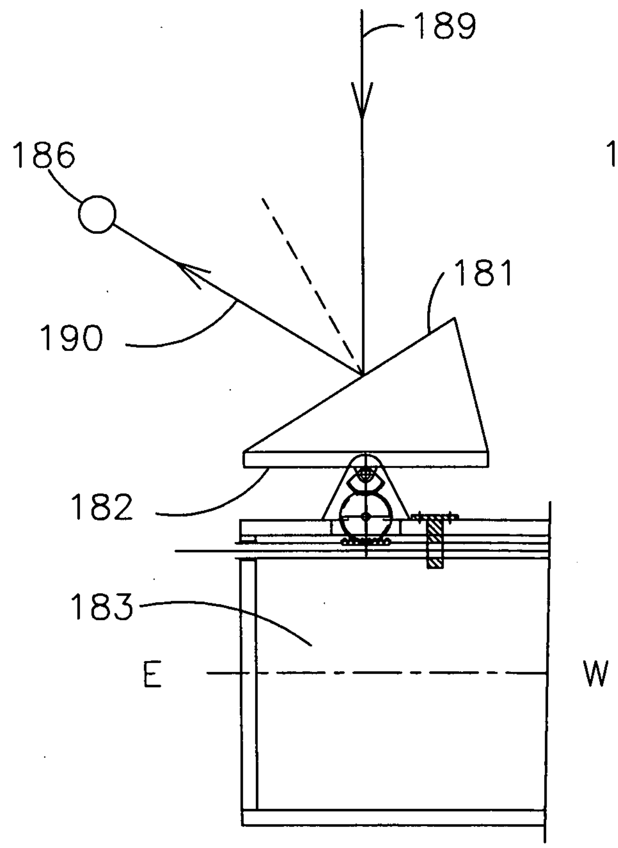

FIG.18

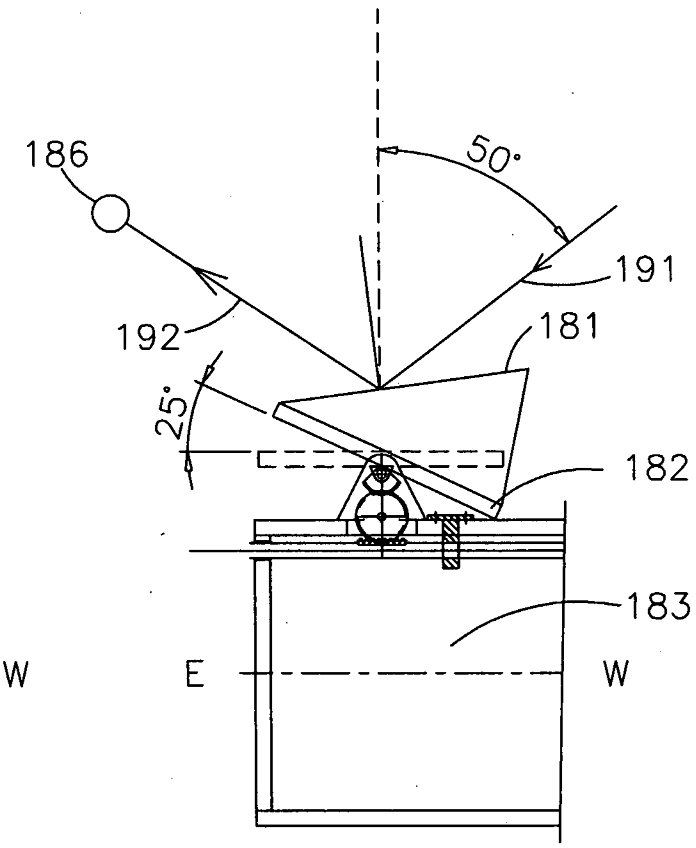

FIG.19

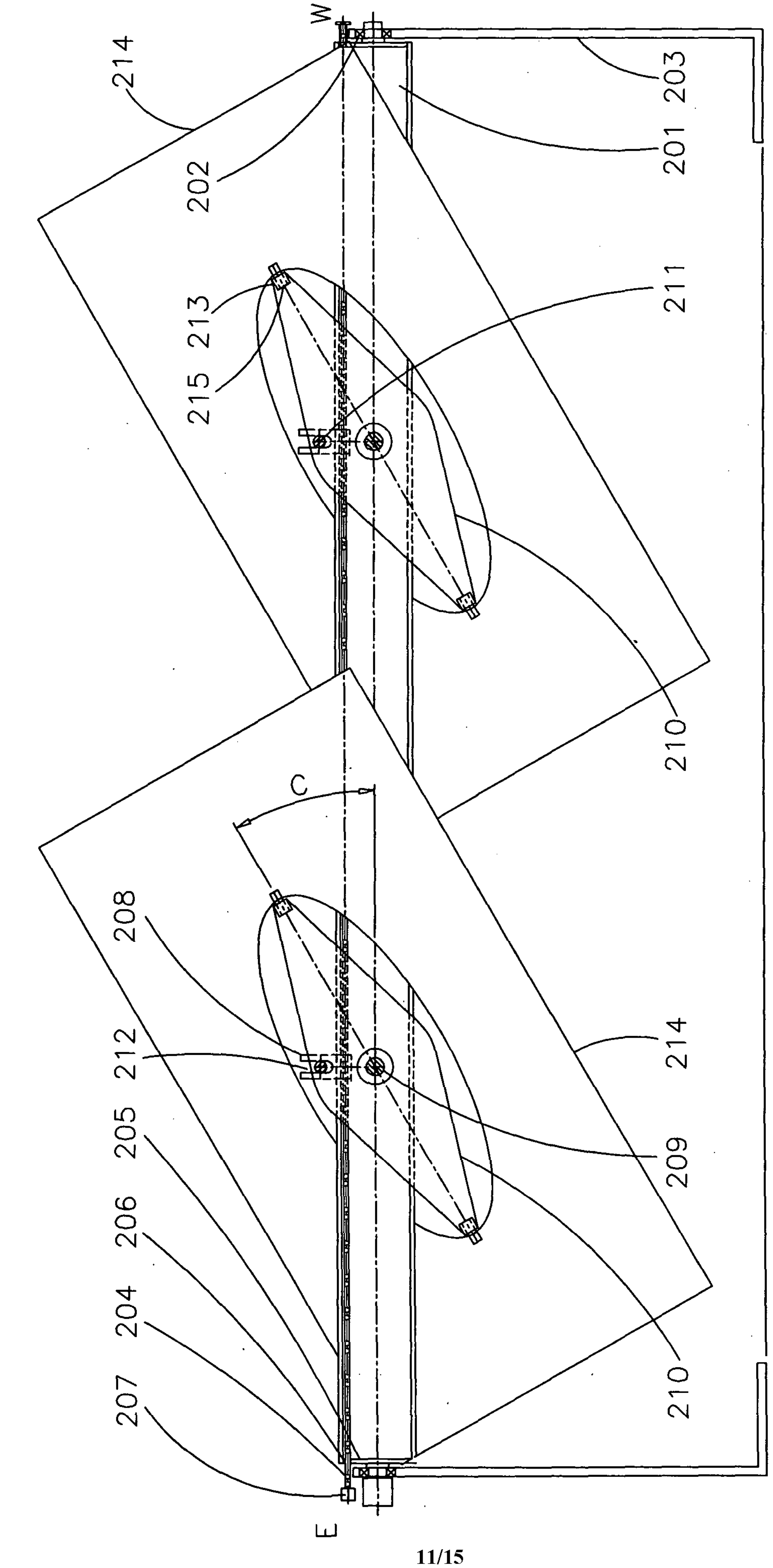
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FIG. 20

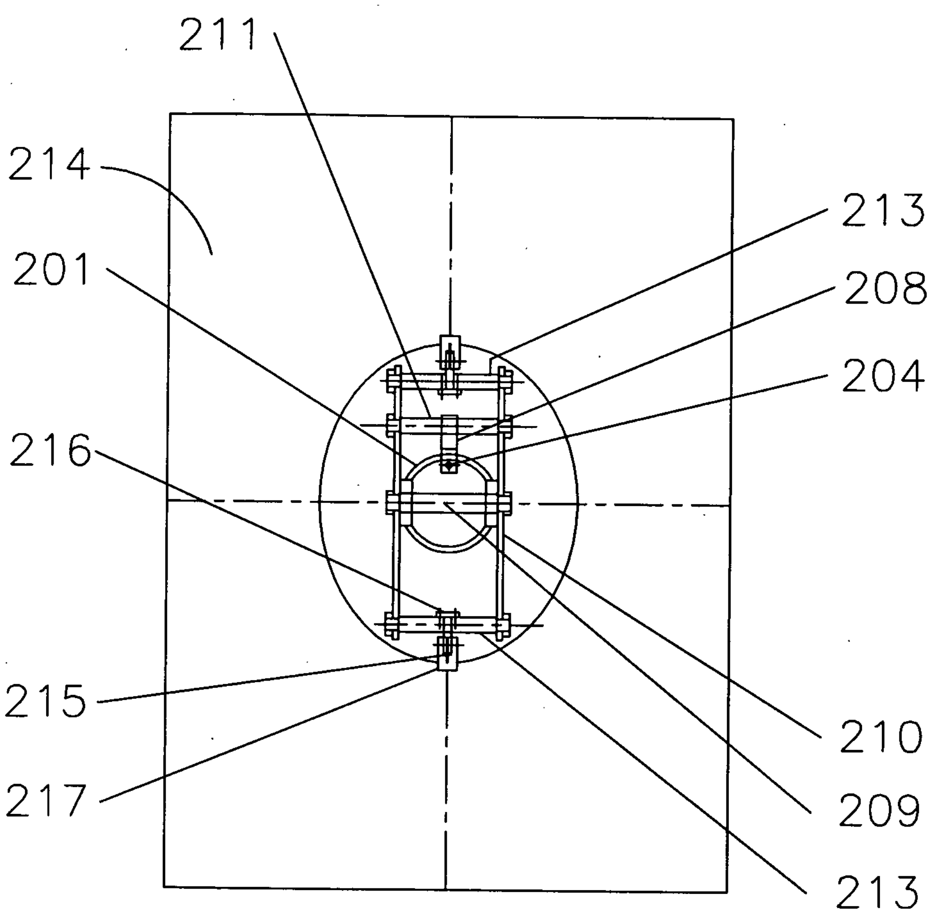

FIG. 21

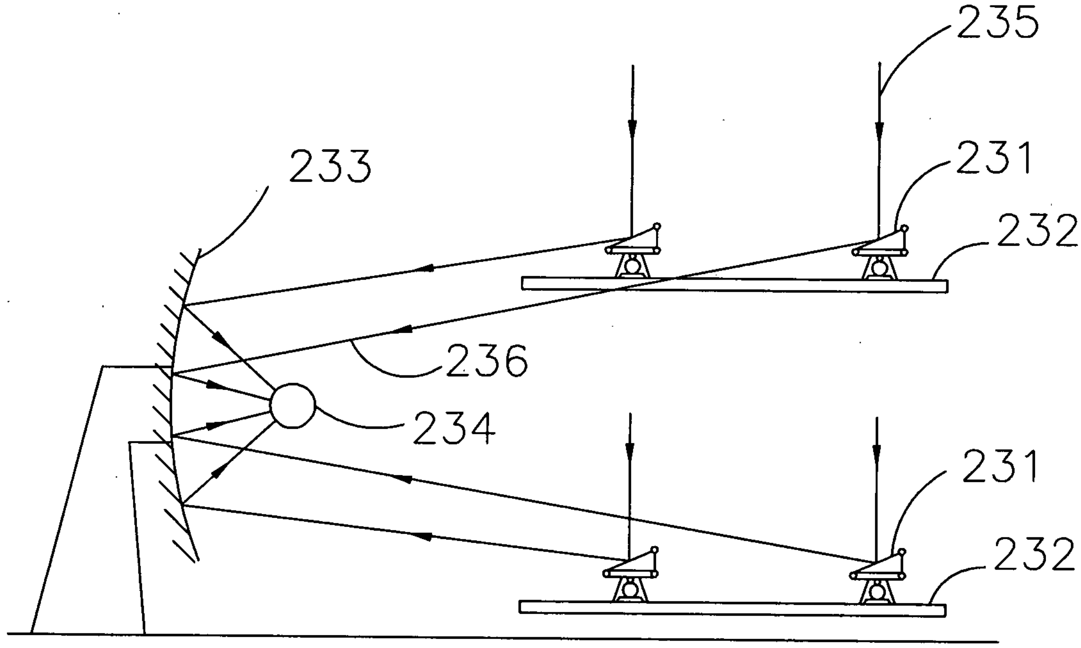

FIG. 22

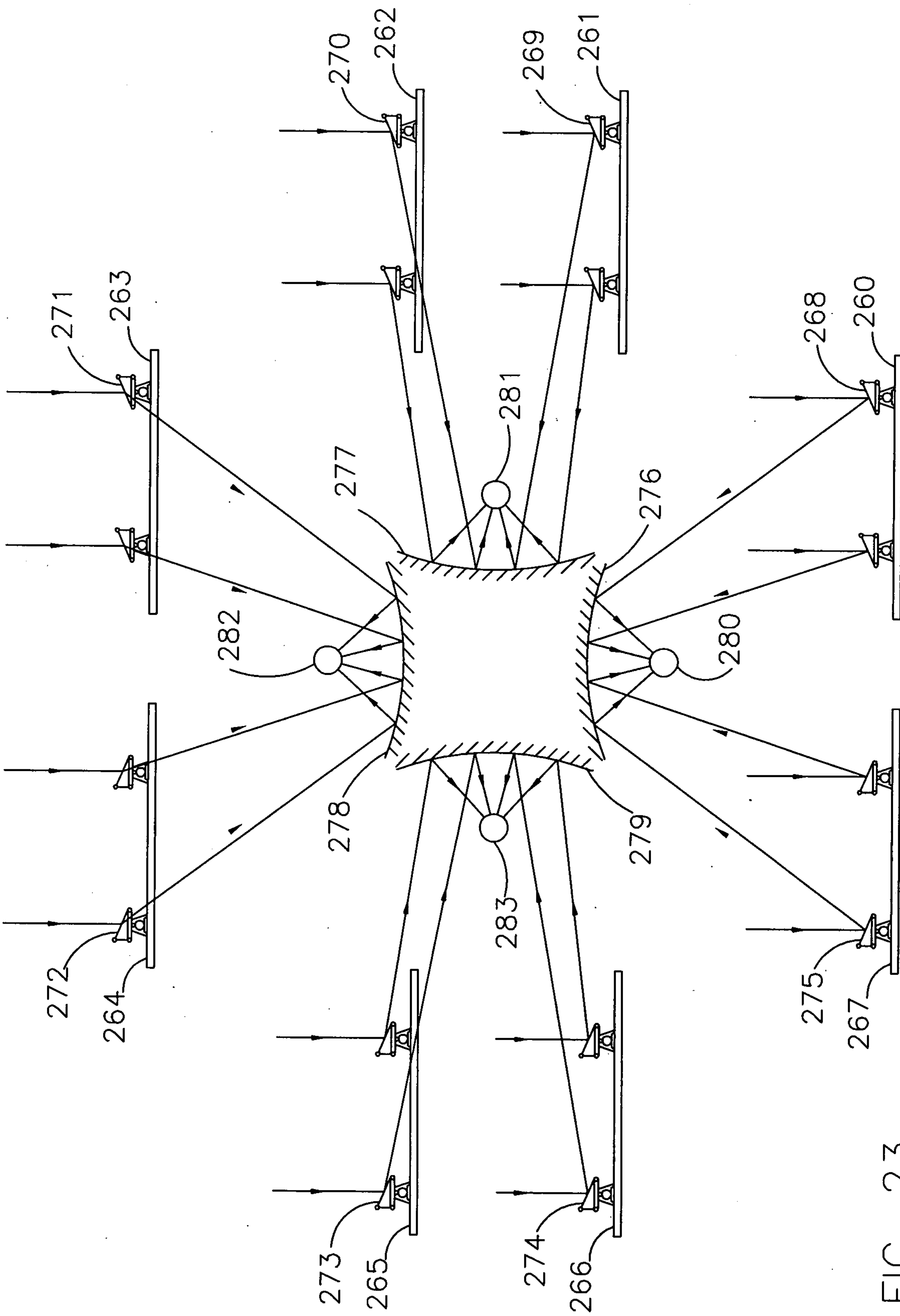

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FIG. 23

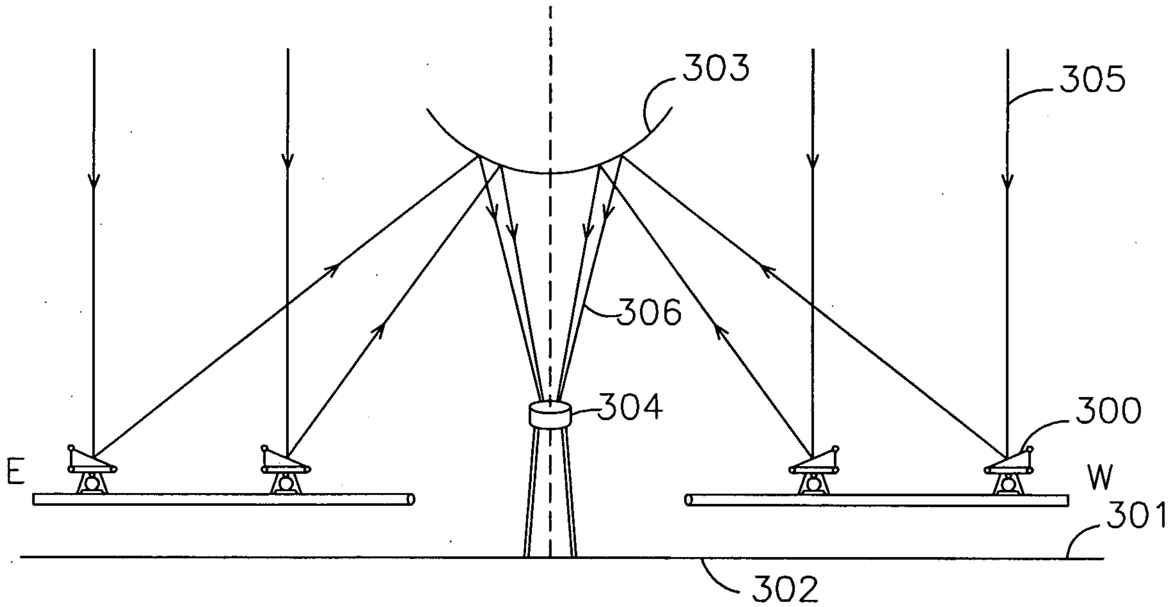

FIG. 24

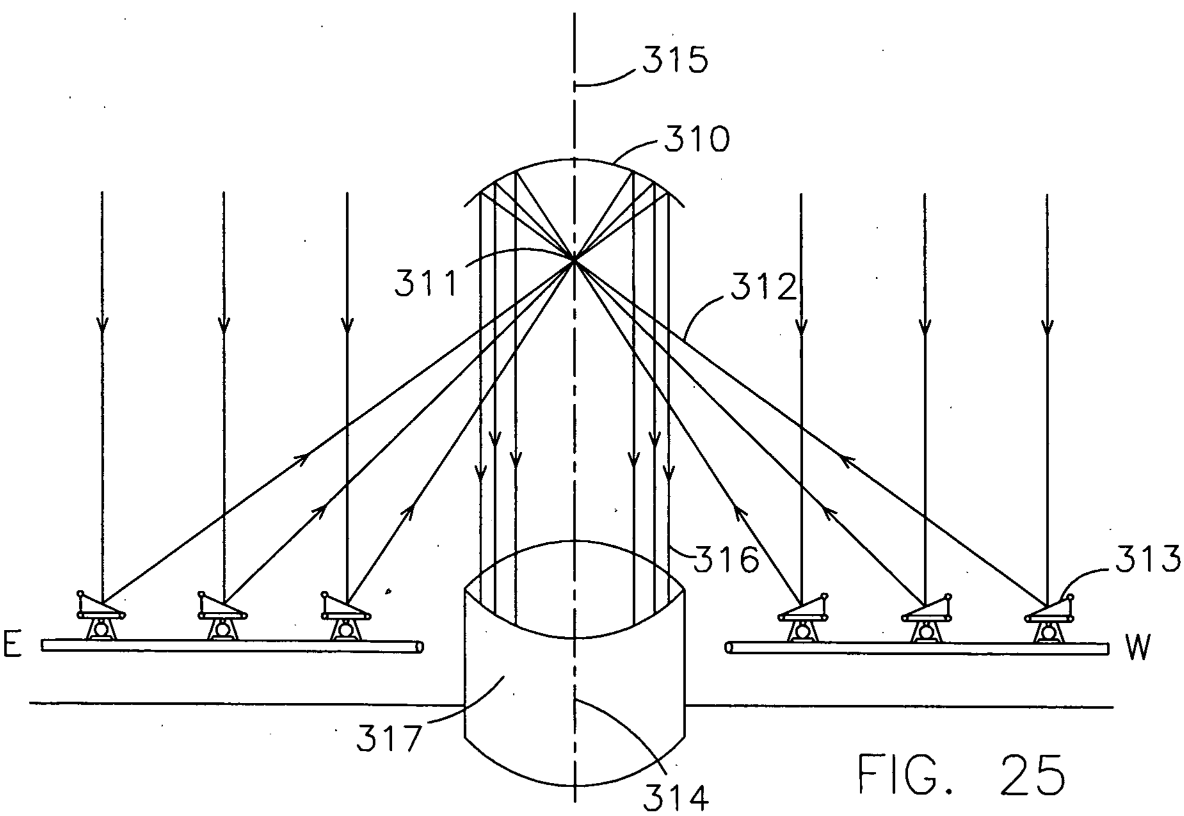

FIG. 25