(19) DANMARK

Patent- og Varemærkestyrelsen

(10) **DK/EP 3403031 T3**

(12) Oversættelse af europæisk patentskrift

(51) Int.Cl.: ***H 01 L 31/0232 (2014.01)*** ***F 24 S 23/79 (2018.01)*** ***G 02 B 19/00 (2006.01)***

(45) Oversættelsen bekendtgjort den: **2022-01-24**

(80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2021-11-10**

(86) Europæisk ansøgning nr.: **17738278.5**

(86) Europæisk indleveringsdag: **2017-01-09**

(87) Den europæiske ansøgnings publiceringsdag: **2018-11-21**

(86) International ansøgning nr.: **IL2017050024**

(87) Internationalt publikationsnr.: **WO2017122193**

(30) Prioritet: **2016-01-13 IL 24360116**

(84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**

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(54) Benævnelse: **OPTIMERET STATISK STRÅLINGSKOLLEKTOR**

(56) Fremdragne publikationer:
US-A- 3 923 381
US-A- 4 047 517
US-A- 4 309 079
US-A1- 2006 072 222
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US-A1- 2011 193 512
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DESCRIPTION

TECHNOLOGICAL FIELD

[0001] The present invention is generally in the field of radiation collectors designed to collect and concentrate incident electromagnetic radiation from a celestial radiation source.

BACKGROUND ART

[0002] Non-imaging optics relates to applications that do not require image formation (*i.e.,* no need to concentrate the collected rays to a single point), but rather efficient collection and concentration of electromagnetic radiation (*e.g.,* solar energy conversion, signal detection, illumination optics, and suchlike). Non-imaging optic solutions are developed nowadays for different applications requiring efficient collection of solar radiation, and attract considerable attention in attempts to reduce/replace use of fossil fuels. For example, and without being limiting, passive and active solar heating and/or lighting, hot water production, heat pumps and sorption cooling and refrigeration systems, industrial air and water systems for process heat, desalination, and/or solar chemical systems for thermal power systems.

[0003] International patent publication No. WO 2010/101644 describes a radiant energy trap with at least one refractor, reflector and receiver. The angle of acceptance of radiant energy can be flat panel equivalent with a relatively high concentration ratio (CR) of diffuse light. The refractor can be a composite of layers, solid or nested fluid layers. The fluid can be a transparent refractive component and can flow through the refractor as a thermal transfer medium. High solar energy utilization is achieved as a hybrid electric/thermal conversion, diffuse light concentrating solar collector PV cells can be displaced, proportional to the CR, with inexpensive optics. Overall orientation and relative angles of refractor surfaces can be changed to selectively reject a portion of diffuse light to increase CR. Radiant energy can be selectively directed to active PV area from PV cell contact area without reducing the angle of acceptance of ambient radiant energy. The refractor assembly can be arrayed and thermally isolated.

[0004] International patent publication No. WO 2007/026311 describes a solar collector comprising a tubular housing which is provided inside the space of the housing with an absorber for absorbing solar radiation across virtually the entire surface of the tubular housing; one or more surfaces reflecting solar radiation for indirectly irradiating the part of said absorber which is located on the shadow side of the tubular housing, at least one of the reflecting surfaces extending up to at least the horizontal tangent on the outermost point of the absorber which is located on the side of the housing on which direct solar radiation impinges; in which the solar collector is characterized in that the surfaces reflecting the solar radiation and the absorber are designed such that all solar radiation incident at right angles impinges on the absorber, on the one hand directly and on the other hand by reflection on the reflecting surfaces, in such a manner that the sine of the angle of incidence of said radiation on the absorber is substantially equal to 1.

[0005] US patent publication 2001/006066 describes a solar collection system and method having means for receiving solar radiation through a main refractive interface and means for internally reflecting at least once, at least a portion of the received solar radiation. The refractive medium may be liquid, gel or solid. The device may be integrated with a photovoltaic device, photohydrolytic device, a heat engine, a light pipe or a photothermal receptor.

[0006] US patent No. 4,815,444 describes a solar concentrator trough of wide-angle capability disposed east-west lengthwise in an inverted V shape. The legs of the inverter V include an angle of less than 180 degrees as measured on the underside of the trough. The trough leans at an appropriate angle toward a path of solar traverse so as to function for any desired fraction of the year without adjustment. Heated liquid rises to the high point in the concentrator's absorber conduit and flows by conduit to a reservoir. Higher temperature performance is achieved in part by making minimal adjustments to the angle of lean.

[0007] WO 2010/107921 describes a solar energy collector system including a base, and a parabolic trough collector carried by the base for reflecting sunlight to a longitudinal focal line. The parabolic trough collector includes a center section horizontally positioned with respect to ground, and opposing end sections adjacent the center section. Each end section is angled towards the ground. A conduit is positioned along the longitudinal focal line to receive the reflected sunlight. The conduit circulates a heat transfer liquid therethrough to be heated by the reflected sunlight.

[0008] US Patent Publication No. 8,546,686 describes a solar collector utilizes multiple reflections of light passing down a tapered, pyramidal-type structure made of highly-reflective mirrored surfaces. A right-angled truncated reflective pyramidal structures have been discovered to have many properties which make them superior to existing concentrator geometries. The use of a tapered, pyramidal-type structure creates multiple reflections which appear at the collector output in the form of a Buckminster-Fullerene display, providing improved collector efficiency and amplification when compared to prior art "concentrators" of the Fresnel lens or parabola type.

[0009] US Patent Publication No. 8,350,145 describes a generator for photovoltaic conversion of concentrated sunlight into electricity, the generator incorporates a plurality of photovoltaic cells and is intended for operation near the focus of a large paraboloidal reflector pointed at the sun. Within the generator, the entering concentrated light is relayed by secondary optics to the cells arranged in a compact, concave array. The light is delivered to the cells at high concentration, consistent with high photovoltaic conversion efficiency and low cell cost per unit power output. Light enters the generator, preferably first through a sealing window, and passes through a field lens, preferably in the form of a full sphere or ball lens centered on the paraboloid focus. This lens forms a concentric, concave and wide-angle image of the primary reflector, where the intensity of the concentrated light is stabilized against changes in the position of concentrated light entering the generator. Receiving the stabilized light are flat photovoltaic cells made in different shapes and sizes and configured in a concave array corresponding to the concave image of a given primary reflector. Photovoltaic cells in a generator are also sized and interconnected so as to provide a single electrical output that remains high and stable, despite aberrations in the light delivered to the generator caused by, for example, mispointing or bending of the primary reflector. In some embodiments, the cells are set back from the image formed by the ball lens, and part of the light is reflected onto each cell small secondary reflectors in the form of mirrors set around its perimeter.

[0010] US Patent Publication No. 4,047,517 describes a method and apparatus for receiving solar energy reflected from a heliostat configuration in which the apparatus is formed of converging vanes defining cavities therebetween, and preferably converging towards a cavity. The vanes may partially or completely define an enclosed volume. Surfaces of the vanes are provided with reflective surfaces near the outer portions of the receiver, selective surfaces at the intermediate portions and, optionally, absorbing surfaces at the interior portions. Cooling means are provided within the vanes of the receiver adjacent the selective and absorbing surfaces. In a preferred embodiment, a transparent barrier is provided transverse to the vanes substantially at the change from the reflective to the selective surfaces, and an infrared absorbing heat transfer fluid is flowed inwardly from the transparent barrier to the cavity to cool the receiver and absorb energy irradiated from the vanes and cavity.

[0011] US Patent Publication No. 3,923,381 non-imaging systems and devices for collection and concentration of electromagnetic energy and particularly solar energy including one or more longitudinally-extending, generally trough-shaped bodies having curving inner reflective walls for concentration of energy from a relatively large entrance aperture toward a relatively small exit aperture. Solar energy concentrators of this patent include energy traps and collect and concentrate substantial amounts of direct solar energy, even at solstice, without substantial diurnal tracking.

[0012] US Patent Publication No. 2010/269816 describes solar energy collector system including a base, and a parabolic trough collector carried by the base for reflecting sunlight to a longitudinal focal line. The parabolic trough collector includes a center section horizontally positioned with respect to ground, and opposing end sections adjacent the center section. Each end section is angled towards the ground. A conduit is positioned along the longitudinal focal line to receive the reflected sunlight. The conduit circulates a heat transfer liquid therethrough to be heated by the reflected sunlight.

[0013] US Patent Publication No. 4,309,079 describes a solar radiation concentrator wherein an array of solar collectors is disposed in a semicircle and rotatable 180 degrees about an axis in the plane of the semicircle to achieve seasonal adjustment. Each said collector is slightly tilted out of the plane of said semicircle, whereby seasonal adjustment of said array may be achieved by rotating said array through 180 degrees twice a year.

GENERAL DESCRIPTION

[0014] Types of trough-shaped radiation (CPC - compound parabolic concentrator) collectors are commonly used in many applications to collect solar energy *e.g.,* for heating, lighting, and/or generating electricity. In certain conditions these types of collectors can maximize the solar energy collection, however, they cannot provide uniform collection profiles and thus cannot be effectively used in certain applications, such as solar illumination/lighting systems. The present invention provides apparatuses according to claim 1, and systems according to claim 13. These are configured to collect electromagnetic radiation emitted from a celestial radiation source and provide improved and substantially uniform radiation collection profiles throughout trajectories of movements of the radiation source in both the horizon-plane and seasonal-plane. Some of the embodiments disclosed herein further provide substantially improved concentration ratios.

[0015] In a broad aspect, there is provided an apparatus for collection of electromagnetic radiation emitted from a celestial radiation source and comprised of three trough-shaped radiation collectors. Each radiation collector being configured and oriented to optimize radiation collection of incident radiation arriving from the radiation source within a respective range of incident angles, as typically occurs during the morning, noon (midday) and afternoon, times of the day, and concentrate the collected radiation towards a common target surface of the apparatus. The radiation collectors are arranged such that one of the collectors is disposed between the two other collectors, such that the three collectors share the same plane of symmetry with the lateral collectors being tilted relative to the central collector.

[0016] The tilt angle of the lateral collectors defines a predetermined obtuse angle between elongated axes of symmetry their exit apertures and the elongated axis of symmetry of the exit aperture of the central collector. In this way, with the lateral collectors having substantially the same length, a substantially isosceles trapezoidal shape of the apparatus is obtained. In this configuration the exit apertures of the three collectors forms a continuous exit aperture also having a substantially isosceles trapezoidal shape/profile. A target surface for collecting the radiation outputted from the exit apertures of the apparatus may be centered between the free ends of the lateral collectors, substantially in parallel to the exit aperture of the central collector. Optionally, the target surface is vertically lowered to a position located below the apparatus.

[0017] Optionally, and in some embodiments preferably, the apparatus comprises two guiding panels extending from the exit apertures of the collectors towards the target surface and/or an exit aperture of the apparatus. The internal surfaces of the guiding surfaces are reflective and they are configured to enclose the radiation outputted from the exit apertures of the collectors and direct it towards the target surface and/or the exit aperture of the apparatus.

[0018] In some embodiments the apparatus is implemented by three two-dimensional trough-shaped radiation collectors *e.g.*, using parabolic reflectors, circular reflectors, elliptical reflectors, hyperbolic reflectors, or any combination thereof. In this case, a side reflector is mounted at the free end of each lateral collector substantially perpendicular to its reflectors and to its exit aperture.

[0019] Alternatively, the apparatus is implemented by three three-dimensional radiation collectors e.g., rectangular funnel-shaped collectors. For example, in possible embodiments the central collector is made of a pair of coaxial CPC collector, such that reflectors of one of the CPC collectors are substantially perpendicular to the reflectors of the other CPC collector, and the CPC collectors share the same exit aperture, and each lateral collector comprises a CPC collector having the side reflector at its free end and a trap reflector at its other end (*i.e.,* adjacent the central collector) configured to trap incident radiation arriving at angles parallel, or nearly parallel to the ground surface.

[0020] In order to prevent flux losses at northern or southern latitudes central reflective surfaces of the collectors are elevated relative to the horizon plane. In this way the coverage of the apparatus is adapted to encompass larger vertical movements of the radiation source in the seasonal-plane and maintain substantial uniform radiation collection profiles throughout the different seasons of the year. For example, if three-dimensional collectors are used in the apparatus, the central collector is tilted to provide the required elevation of the central reflective surfaces. Optionally, upper reflective surfaces of the lateral collectors are curved towards the reflective surfaces of the central collector, to preserve uniformity of the apparatus surfaces and of its radiation collection profiles.

[0021] In some embodiments the guiding panels comprise a plurality of parabolic ribs mounted between, and in parallel to, them. Each parabolic rib comprises reflective surfaces on both sides thereof, and one end thereof is located adjacent an exit aperture of one of the collectors and its other end extend towards the target surface and/or exit aperture of the apparatus. In this configuration a radiation guiding path is formed between each pair of adjacently located parabolic ribs, which forms a manifold of radiation guiding paths gradually coinciding towards the target surface and/or the exit aperture of the apparatus, thereby significantly increasing its concentration ratio.

[0022] In some embodiments an array of rotatable mirrors is mounted along the exit aperture of each of the central and lateral collectors. The mirrors may be two sided mirrors. The rotatable mirrors being configured to direct radiation outputted from the exit aperture towards at least one target surface of the apparatus. In some embodiments the apparatus comprises two target surfaces, each being located adjacent a free end of a respective lateral collector and configured to face the mirrors of the other lateral collector and of the central collector. In some embodiments the apparatus comprises an additional target surface located adjacent to the exit aperture of the central collector and substantially centered thereabout, and an additional array of rotatable mirrors arranged in a base section of the apparatus extending underneath the free ends of the lateral collectors and configured to direct radiation outputted from the exit apertures towards the additional target surface.

[0023] One inventive aspect of the subject matter disclosed herein relates to an apparatus for collection of incident radiation emitted from a moving radiation source. The apparatus comprises a central two-dimensional trough-shaped (e.g., CPC) radiation collector and two lateral two-dimensional trough-shaped (*e.g.*, CPC) radiation collectors, where the lateral and central collectors have a same plane of symmetry, and each one of the lateral collectors extends from a respective end side of the central collector with a predetermined tilt angle defining an obtuse angle (*e.g.,* about 100° to 150°) between elongated symmetry axes of exit apertures of the central and lateral collector. Optionally, and in some embodiment preferably, central reflective surfaces of the apparatus are asymmetrically displaced relative to the symmetry plane within a predefined displacement angle relative to said plane and determined according to a trajectory of the radiation source.

[0024] Optionally, and in some embodiment preferably, exit apertures of the lateral two-dimensional collectors are of a same length such that a substantially isosceles trapezoidal shape of the apparatus is obtained and radiation outputted through the exit apertures of the lateral and central collectors is directed towards a target surface located below said central collectors and being substantially parallel to its exit aperture.

[0025] One or more guiding elements can be used for guiding the radiation from the target surface to one or more remote location.

[0026] According to the invention, reflectors of the central collector are substantially of isosceles trapezoidal shape. In this configuration entrance aperture of the central collector is formed by the major bases of the reflectors and its exit aperture is formed by minor bases of the reflectors. Optionally, a ratio of the lengths of the exit aperture of the central collector and of each exit aperture of the lateral collectors is about 1:1 to 1:3.
In some embodiment the apparatus comprises two overlapping guiding panels extending from the exit apertures of the two-dimensional collectors and configured for enclosing the radiation outputted from the exit apertures between them. The inner sides of the panels have reflective surfaces facing each other for guiding the collected radiation towards the target surface or an exit aperture of the apparatus. Optionally, a plurality of parabolic ribs are mounted between the guiding panels and substantially parallel to them, where two side surfaces of each parabolic rib being reflective, and each rib having one end thereof located adjacent to one of the exit apertures of the two-dimensional collectors and its other end extending towards an exit aperture of the apparatus.

[0027] Each lateral collector can comprise a side reflector mounted at its free end substantially perpendicular to the reflective surfaces of said lateral collector and to its exit aperture. Optionally, and in some embodiments preferably, each lateral two-dimensional collector comprises a trap reflector mounted adjacent to the central collector substantially perpendicular to reflective surfaces of the lateral collector and in a predetermined angle with respect to its exit aperture. In some embodiments the apparatus comprises an additional two-dimensional trough-shaped collector coaxially enclosed inside the central two-dimensional collector and substantially perpendicular thereto.

[0028] In some applications an array of rotatable mirrors is mounted in the exit aperture of each two-dimensional collector. Axis of rotation of each rotatable mirror being substantially perpendicular to the elongated axis of symmetry of the exit aperture in which it is mounted, and each of the mirrors configured at a specific angle to direct radiation outputted from its respective exit aperture onto at least one target surface. For example, the apparatus can comprise two target surfaces, each position near a free end of one of the lateral collectors and facing the exit apertures of the central collector and of the other lateral collector.

[0029] In some embodiments the apparatus comprises a target surface positioned adjacent and substantially parallel to the central collector, and an additional array of rotatable mirrors located in a base section of the apparatus extending underneath the free ends of the lateral collectors, the mirrors of the additional array being substantially parallel to the mirrors of the other array and configured to receive radiation outputted from the exit apertures and direct it to the target surface.

[0030] Optionally, and in some embodiments preferably, the rotary movement of the mirrors can be controllably operable to direct the radiation onto a specific target selected according to a direction of arrival of the incident radiation from the radiation source.

[0031] Another inventive aspect of the subject matter disclosed herein relates to an apparatus for collection of incident radiation emitted from a moving radiation source, comprising a central three-dimensional rectangular funnel-shaped radiation collector and two lateral three-dimensional rectangular funnel-shaped radiation collectors, where the lateral and central collectors have a same plane of symmetry and each one of the lateral collectors extends from a respective end side of the central collector with a predetermined tilt angle defining an obtuse angle between elongated symmetry axes of exit apertures of said central and lateral collector. Optionally, and in some embodiments preferably, the central collector is tilted a predetermined tilt angle relative to the plane of symmetry.

[0032] Yet another inventive aspect of the subject matter disclosed herein relates to an apparatus for collection of incident radiation emitted from a moving radiation source, comprising a central funnel-shaped radiation collector, two lateral funnel-shaped radiation collectors, the lateral and central collectors having a same plane of symmetry, and each one of said lateral collectors extends from a respective end side of the central collector with a predetermined tilt angle defining an obtuse angle between elongated symmetry axes of exit apertures of the central and lateral collector, and a concentrating structure comprising a plurality of parabolic ribs, each rib reflective surfaces at both sides thereof where an upper end thereof is located adjacent one of the exit apertures, and a lower end thereof is located adjacent a target surface or an exit aperture of the apparatus.

[0033] Still yet another inventive aspect of the subject matter disclosed herein relates to an apparatus for collection of incident radiation emitted from a moving radiation source, comprising a central funnel-shaped radiation collector, two lateral funnel-shaped radiation collectors, the lateral and central collectors having a same plane of symmetry, and each one of the lateral collectors extends from a respective end side of said central collector with a predetermined tilt angle defining an obtuse angle between elongated symmetry axes of exit apertures of the central and lateral collector, and an array of rotatable mirrors mounted in the exit apertures of the lateral and central collectors, the mirrors configured to direct radiation outputted through the exit apertures towards at least one target surface of the apparatus. Optionally, and in some embodiments preferably, the apparatus comprises two target surfaces, each located adjacent a free end of a respective lateral collector and facing the mirrors in the central collector and in the other lateral collector.

[0034] In some embodiments, the apparatus comprises a target surface positioned adjacent and substantially parallel to the central collector, and an additional array of rotatable mirrors located in a base section of the apparatus extending underneath the free ends of the lateral collectors, the mirrors of the additional array being substantially parallel to the mirrors of the other array and configured to receive radiation outputted from the exit apertures and direct it to the target surface.

[0035] Still yet another inventive aspect of the subject matter disclosed herein relates to a system for collecting radiation from a celestial radiation source, comprising a light collection apparatus as described hereinabove or hereinbelow, a light guiding support for mounting the apparatus thereon, receiving light collected by the apparatus and deliver it towards a target location, where the light guiding support configured to set the apparatus mounted thereon in a defined orientation required for optimal radiation collection by the device at a certain latitude.

[0036] Still yet another inventive aspect of the subject matter disclosed herein relates to a system for collecting radiation from a celestial radiation source, comprising a light collection apparatus having rotatable mirrors as described hereinabove or hereinbelow, actuating means (*e.g.*, one or more electric motors) configured to controllably affect rotary movement of the rotatable mirrors, and a control unit configured and operable to control operation of the actuating means and set orientation of at least some of the mirrors to direct radiation outputted through the exit apertures of the collectors towards at least one target surface or exit aperture of the apparatus. Optionally, the control unit is configured and operable to select a target surface for the at least some of the mirrors according to an angle of arrival of the radiation from the radiation source.

[0037] In some embodiments the system comprise a light guiding support for mounting the apparatus thereon, receiving light collected by the apparatus and deliver it towards a target location, where the light guiding support configured to set the apparatus mounted thereon in a defined orientation required for optimal radiation collection by the device at a certain latitude.

BRIEF DESCRIPTION OF THE DRAWINGS

[0038] In order to understand the invention and to see how it may be carried out in practice, embodiments will now be described, by way of non-limiting example only, with reference to the accompanying drawings. Features shown in the drawings are meant to be illustrative of only some embodiments of the invention, unless otherwise implicitly indicated. In the drawings like reference numerals are used to indicate corresponding parts, and in which:

Figs. 1A to **1D** schematically illustrate a radiation collector apparatus according to possible embodiments having a trapezoid profile, wherein **Fig. 1A** is a perspective view, **Fig. 1B** is a side view of the apparatus, **Fig. 1C** is a top view of the apparatus, and **Fig. 1D** is a perspective view of a modification of the apparatus with guiding panels;

Figs. 2A to **Fig. 2I** schematically illustrate a radiation collector apparatus according to possible embodiments having three adjacently located three-dimensional collectors, wherein **Fig. 2A** is a perspective view of the apparatus, **Fig. 2B** is a side view of the apparatus, **Fig. 2C** is a top view of the apparatus, **Fig. 2D** is an exploded view of the apparatus, and **Figs. 2E** to **2I** are ray diagrams illustrating radiation collection of the apparatus for various angles of incident radiation;

Fig. 3 shows graph plots of annual solar altitude at latitude 40°;

Fig. 4 is a top view of a radiation collector apparatus as shown in **Figs. 1A** to **1D** with central surfaces curved/twisted for improved radiation collection at northern/southern latitudes;

Figs. 5A to **5C** schematically illustrate a radiation collector apparatus as shown in **Figs. 2A** to **2I** with curved/twisted central surfaces for improved radiation collection at northern/southern latitudes;

Figs. 6A to **6C** schematically illustrate a radiation collector apparatus as shown in **Fig. 1D** having a concentrating structure mounted within its guiding panels, wherein **Fig. 6A** is a perspective view of the apparatus, **Fig. 6B** is a top view of the apparatus, and **Fig. 6C** is an exploded view of the apparatus;

Figs. 7A to **7L** schematically illustrate a radiation collector apparatus as shown in **Fig. 1D** having a rotating mirrors arrangement at exit apertures thereof, wherein **Fig. 7A** is a perspective view of the apparatus, **Fig. 7B** is a top view of the apparatus, **Fig. 7C** is a sectional view of the apparatus, and **Figs. 7D** to **7L** are ray diagrams showing various radiation collection schemes;

Fig. 8 is a perspective view of the radiation collector apparatus shown in **Figs. 5A** to **5C** operably installed using a curved light guide to collect radiation from a celestial radiation source;

Fig. 9 show annual equatorial radiation collection plots as obtained by computer simulation for the radiation collector apparatuses shown in **Figs. 2A-2I;** and

Figs. 10A and **10B** show annual radiation collection plots at latitude 33° as obtained by computer simulation for the radiation collector apparatuses shown in **Figs. 2A-2I** and **Figs. 5A-5C,** respectively.

DETAILED DESCRIPTION OF EMBODIMENTS

[0039] One or more specific embodiments of the present disclosure will be described below with reference to the drawings, which are to be considered in all aspects as illustrative only and not restrictive in any manner. In an effort to provide a concise description of these embodiments, not all features of an actual implementation are described in the specification. Elements illustrated in the drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the invention. This invention may be provided in other specific forms and embodiments without departing from the essential characteristics described herein.

[0040] The present invention devise static radiation collectors designed to provide substantially uniform collection profiles of radiation emitted from a celestial radiation source throughout the planet orbit thereabout, at different latitudes on the surface of the planet, and with improved concentration ratios. Particularly, the static radiation collectors of the present invention are designed to provide substantial uniform collection of sun light during the different seasons of the year by adjusting geometries of reflective surfaces thereof in the seasonal (North-South) and horizon (East-West) planes of the sun.

[0041] Figs. **1A** to **1D** schematically illustrate a radiation collector apparatus **10** according to some possible embodiments. The radiation collector apparatus **10 is** comprised of three trough-shaped two-dimensional collectors **T1, T2** and **T3.** The long axes of the three collectors, **T1, T2** and **T3,** are aligned in the horizon plane **(19),** and the collectors share the same plane of symmetry **19.** As seen, the apparatus **10** is symmetric about the plane of symmetry **18.** The central collector **T2** is substantially parallel to the ground surface **(15)** to provide optimal radiation collection during midday (11-13), and the lateral collectors, **T1** and **T3,** are tilted downwardly relative to the central collector **T2** in a predetermined tilt angle to provide optimal radiation collection during the morning (08~10) and the afternoon (14-16), respectively.

[0042] Each of the lateral collectors, **T1** and **T3,** comprises a side reflector, **11c** and **13c,** respectively, at its free end *i.e.,* at the extremities of the apparatus. The side reflector, **11c** and **13c,** are configured to collect light at certain angles of the celestial source relative to the respective lateral collector, and thus typically not trapped by the collectors, **T1, T2** and **T3.** In this way, additional light rays can be collected by the collector apparatus **10.**

[0043] The trough shaped collector **T1** comprises two reflectors, **11a** and **11b,** symmetric about the horizon plane, and positioned such that their reflective surfaces are facing each other. The upper edges of the symmetric reflectors **11a** and **11b** form an entrance aperture **11i** of the collector **T1,** and their lower edges form an exit aperture **11u** of the collector **T1.** Similarly, the trough shaped collector **T2** comprises two reflectors, **12a** and **12b,** symmetric about the horizon plane, and positioned such that their reflective surfaces are facing each other, where the upper edges of the symmetric reflectors **12a** and **12b** form an entrance aperture **12i** of the collector **T2,** and their lower edges form an exit aperture **12u** of the collector **T2.** And the trough shaped collector **T3** comprises two reflectors, **13a** and **13b,** symmetric about the horizon plane, and positioned such that their reflective surfaces are facing each other, where the upper edges of the symmetric reflectors **13a** and **13b** form an entrance aperture **13i** of the collector **T3,** and their lower edges form an exit aperture **13u** of the collector **T2.**

[0044] The reflectors of the symmetric reflector pairs **11a-11b, 12a-12b** and **13a-13b,** preferably have curved/concaved surfaces (*e.g.*, using parabolic reflectors, circular reflectors, elliptical reflectors, hyperbolic reflectors, or any combination thereof). Optionally, and in some embodiments preferably, each pair of symmetric reflectors **11a-11b, 12a-12b** and **13a-13b,** is configured to form a compound parabolic concentrator (CPC). Optionally, the symmetric reflectors **11a-11b, 12a-12b** and **13a-13b,** are configured to provide uniform radiation collection profile throughout the trajectory of the radiation source (*i.e.,* in the horizon plane), as described in Israeli patent application No. 243116, filed on December 15, 2015.

[0045] The symmetric reflectors **12a** and **12b** of the central collector **T2** have a substantially isosceles trapezoidal shape for connection of the lateral collectors, **T1** and **T3,** to the central collector **T2** at the desired tilt angle (*e.g.,* in range of 135° to 150° relative to the exit aperture of the central collector). As seen, the major bases of the trapezoidal-shaped symmetric reflectors **12a** and **12b** form the entrance aperture **12i** of the central collector **T2,** and their minor bases form the exit aperture of the central collector **T2.** This configuration provides the radiation collector apparatus **10** a substantially isosceles trapezoidal profile. As also seen, the upper corners of the symmetric reflector pairs **11a-11b** and **13a-13b,** of the lateral collectors **T1** and **T3,** are truncated at their free ends, which has a minor effect on light collection properties of the apparatus, while allowing a tighter packing of several collectors in multiple collector configurations.

[0046] As seen in **Fig. 1A,** showing a perspective view of the radiation collector apparatus **10,** the exit apertures, **11u, 12u** and **13u,** of the collectors, **T1, T2** and **T3,** respectively, forms a substantially isosceles trapezoidal exit aperture **10u** of the apparatus **10.** The collectors **T1, T2** and **T3,** are configured to collect the incident sunlight trapped at the entrance apertures, **11i, 12i** and **13i,** respectively, and concentrate it through the exit apertures **11u, 12u** and **13u,** respectively, onto a target surface **15** being substantially parallel to the ground surface.

[0047] In order to obtain substantial uniform collection profile throughout the trajectory of the sun, the lengths **L1, L2** (shown in **Fig. 1C)** and **L3,** of the exit apertures **11u, 12u** and **13u,** respectively, in the horizon plane should be properly set. While the lengths, **L1** and **L3,** of the lateral exit apertures, **11u** and **13u,** are substantially equal (**L1** = **L3** = L), the central exit aperture **12u** has a substantially smaller length since the intensity of the incident sunlight collected by the central collector **T2** during the midday time is substantially higher than the incident sunlight collected by the lateral collectors **T1** and **T3,** during the morning and afternoon times, respectively. In some embodiments the ratio **L2/L** (between lengths of central exit aperture and any of the lateral exit apertures) is set to about 1:1 to 1:3.

[0048] Fig. 1D is a perspective view of a radiation collector apparatus **10'** being a modification of the radiation collector **10** shown in **Figs. 1A** to **1C,** and comprising two guiding panels **14a** and **14b,** configured to extend from the exit aperture **10u** of the apparatus **10** and enclose the concentrated radiation outputted therethrough. The guiding panels **14a** and **14b** are substantially flat elements, each having a generally isosceles trapezoidal shape, and an inner reflective surface thereby enclosing the radiation outputted from the exit apertures of the collectors and directing it towards a target surface and/or an exit aperture of the apparatus **10'.**

[0049] Figs. 2A to **Fig. 2D** schematically illustrate a radiation collector apparatus **20** according to possible embodiments. The radiation collector apparatus **20** is designed to improve the radiation collection capabilities of the apparatus **10** shown in **Figs. 1A** to **1C,** by introducing additional reflecting surfaces into the lateral and central collectors. With this configuration three adjacently located three-dimensional collectors, **C1, C2** and **C3,** are obtained. The central three-dimensional collector **C2** is set with its entrance aperture **22i** substantially parallel to the ground surface, to optimize radiation collection during the midday time, and the lateral three-dimensional collectors, **C1** and **C3,** are extending from the central three-dimensional collector **C2** in sideway directions, and their entrance apertures, **21i** and **23i,** are tilted downwardly in a predefined tilt angle (*e.g.,* in range of 150° relative to the entrance aperture of the central collector, according to the solar angle at start and end of the desired collection period), to optimize radiation collection during the morning and afternoon times, respectively.

[0050] Each of the three-dimensional collectors **C1, C2** and **C3,** has a generally rectangular funnel-shape configuration tapering from the entrance aperture towards the exit aperture.

[0051] The three-dimensional collector **C1** comprises a trough shaped two-dimensional collector formed by the pair of symmetric reflectors **21a** and **21b** positioned in the horizon plane, and an additional trough shaped two dimensional collector formed by the side reflector **21c** located at its free end and the trap reflector **21d** abutting to the central three-dimensional collector **C2.** While the geometry of the pair of symmetric reflectors **21a-21b** is substantially the same as the pair of symmetric reflectors **11a-11b** described hereinabove with reference to **Figs. 1A** to **1D,** the side reflector **21c** and the trap reflector **21d** form a two dimensional collector which is not necessarily symmetric, and its main purpose is to capture incident light during the early morning time *(i.e.,* to capture light rays that are parallel, or nearly parallel to the ground surface).

[0052] Similarly, the three-dimensional collector **C3** comprises a trough shaped two-dimensional collector formed by the pair of symmetric reflectors **23a** and **23b** positioned in the horizon plane, and an additional trough shaped two dimensional collector formed by the side reflector **23c** located at its free end and the trap reflector **23d** abutting to the central three-dimensional collector **C2.** The geometry of the pair of symmetric reflectors **23a-23b** is substantially the same as the pair of symmetric reflectors **13a-13b** described hereinabove with reference to **Figs. 1A** to **1D,** and the side reflector **23c** and the trap reflector **23d** form a two dimensional collector which is not necessarily symmetric, and its main purpose is to capture incident light during the late afternoon time (*i.e.,* light rays that are parallel, or nearly parallel to the ground surface).

[0053] Optionally, and in some embodiments preferably, the pairs of symmetric reflectors **21a-21b** and **23a-23b** are each configured to from a CPC, as described hereinabove, while the pairs of side and trap reflectors **21c-21d** and **23c-23d** are implemented by substantially flat surfaces oriented to form two dimensional collector structure tapering from their entrance apertures, **21i** and **23i,** towards their exit apertures **21u** and **23u.**

[0054] Optionally, and in some embodiment preferably, the central three-dimensional collector **C2** is comprised of two pairs of symmetrical two-dimensional CPC collectors, **22a-22b** and **22x-22y,** configured as described hereinabove, forming a rectangular funnel shape structure.

[0055] As in the radiation collector apparatus **10** shown in **Figs. 1A** to **1D,** the lengths **L** of the exit apertures **21u** and **23u** of the three-dimensional collectors **C1** and **C3,** in the horizon plane, are substantially greater than the horizon length **L2** of the exit aperture **22u** of the three-dimensional collector **C2.** In some embodiments, the ratio of the aperture horizon-plane-lengths L2/L is set to about 1:1 to 1:3, in order provide substantially uniform radiation collection profile throughout the trajectory of the radiation source. As seen, the apparatus **20** is symmetric about the symmetric planes **18** (a seasonal plane) and **19** (the horizon plane).

[0056] In some embodiments the radiation collector apparatus **20** comprises guiding panels **24a** and **24b** having internal reflective surfaces and extending from the exit apertures **21u, 22u** and **23u,** towards the free ends of the reflector pairs **21a-21b** and **23a-23b,** so as to enclose the concentrated radiation outputted through the exit apertures. **Figs. 2A** to **2I** further exemplify use of rectangular funnel-shaped radiation collector concentrator **25** attached to the guiding panels **24a** and **24b** for delivering the collected radiation to the light guide **26.**

[0057] Figs. 2E to **2I** show diagrams illustrating radiation collection of the radiation collection apparatus **20** simulated for different time of the day. **Fig. 2E** demonstrates the radiation collection during early morning time, around 8:00, and late afternoon time, around 16:00, wherein a portion of the incident radiation **U1** is delivered directly by the lateral collector **C3** to the light guide **26,** and another portion **U2** of the incident radiation is delivered by the lateral collector **C3** with the aid of the trap reflector **23d.** Although this specific example show radiation collection around 16:00, due to the symmetric configuration of the apparatus **20,** the same collection pattern is obtained around 8:00 by the lateral collector **C1.**

[0058] As seen in **Fig. 2F,** as the location of the radiation source is elevated around 9:00 and 15:00 more incident radiation **U1** is delivered directly by the lateral collector **C3** (by the collector **C1** around 9:00) to the light guide **26.** Around 14:00, as shown in **Fig. 2G,** the altitude of the radiation source is such that substantially all of the incident radiation **U1** is delivered directly to the light guide **26** by the lateral collector **C3** (by the collector **C1** around 10:00), without hitting the trap reflectors **21d/23d.**

[0059] With reference to **Fig. 2H,** around 13:00 a significant portion of the incident radiation **U1** is delivered to the light guide **26** directly by the lateral collector **C3,** a smaller portion **U2** by the central collector **C2,** without hitting the seasonal-plane reflector **22x,** and yet another smaller portion **U3** is delivered by the seasonal-plane reflector **22x** of the central collector **C2.** Similarly, around 11:00 (not shown) a significant portion of the incident radiation **U1** is delivered to the light guide **26** directly by the lateral collector **C1,** a smaller portion **U2** by the central collector **C2,** without hitting the seasonal-plane reflector **22y,** and yet another smaller portion **U3** is delivered by the seasonal-plane reflector **22y** of the central collector **C2.**

[0060] As seen in **Fig. 2I,** when the radiation source reaches its highest altitude around 12:00, a significant portion of the incident radiation **U1** is delivered to the light guide **26** directly by the central collector **C2** without hitting the horizon-plane reflectors **22x** and **22y,** a smaller portion of the incident radiation **U2** is delivered to the light guide **26** directly by the lateral collectors **C1** and **C2,** and yet a smaller portion of the incident radiation **U3** is delivered by the horizon-plane reflectors **22x** and **22y** of the central collector **C2.**

[0061] The radiation collector apparatuses shown in **Figs. 1A-D** and **2A-I** are particularly suitable for equatorial geographical regions characterized by symmetrical seasonal solar movement. In some applications, these embodiments are implemented utilizing modified CPC designs, as described and illustrated in Israeli patent application filed on December 14, 2015, under attorney docket No. 2373886, *e.g.,* to provide a daily coverage of 120° (8 hours) and a seasonal coverage of ±25°.

[0062] As illustrated in **Fig. 3** in more northern (and southern) latitudes the solar movement is not seasonally symmetrical such that during the summer time periods the location of the sun falls outside of the coverage of the radiation collection apparatuses shown in **Figs. 1A-D** and **2A-I** during the midday times (10:30 to 13:30), and during the early morning (7:00 to 8:30) and late afternoon (15:30-17:00) time during the winter. **Fig. 3** shows the annual solar altitude at latitude 40° and the angular acceptance provided by the radiation collection apparatuses shown in **Fgs. 1A-D** and **2A-I**, as indicated by the solid lines **3a** and **3b,** where the center line **3q** is the elongated axis of symmetry of the apparatuses (in the horizon plane). As seen in **Fig. 3,** the coverage is insufficient, while in some areas **W** there is wasted coverage.

[0063] In order to prevent flux collection losses during midday time periods of the summer months, and wasted coverage during midday time periods of the winter months, in some embodiments central horizon-plane reflective surfaces of the radiation collecting apparatuses are elevated relative to the horizon plane, as indicated by the dashed lines **3a', 3q'** and **3b'.** In a similar fashion, in some possible embodiment lateral reflecting horizon-plane surfaces of the radiation collecting apparatuses are lowered (not shown) relative to the horizon plane, in order to prevent flux collection losses during early morning and late afternoon times of the summer months, and wasted coverage during early morning and late afternoon times of the winter months. By so curving/twisting the central horizon-plane reflective surfaces area of the radiation collector the angular acceptance of the central section the apparatus is adapted for northern (or southern) latitudes. Apparently different designs may be required at different latitudes according to the tilt angle required.

[0064] Fig. 4 is a top view of a radiation collector apparatus **10"** as shown in **Figs. 1A** to **1D** in which central horizon-plane surfaces **12a'** and **12b'** of the central collector **T2** had been curved/twisted in order to improve the radiation collection profiles at northern (or southern if the apparatus is turned 180° about its central collector) latitudes. As seen, the exit apertures, **11u, 12u** and **13u,** and their lengths, remain substantially unchanged, and also the heights of the reflectors. In this non-limiting, the horizon-plane reflective surfaces **12a'** are elevated relative to the long axis of symmetry **3q** to provide substantially smooth curved reflective surfaces **12a'** and **12b'.** As illustrated by the dashed lines, **12a"** and **12b",** in some possible embodiments the elevation of the horizon-plane central reflective surface is not so smooth, and a substantially isosceles trapezoidal shape is formed by the elevated horizon-plane reflective surfaces.

[0065] Figs. 5A to **5C** schematically illustrate a radiation collector apparatus **20'** as shown in **Figs. 2A to 2I** with curved/twisted central surfaces for improved radiation collection at northern (or southern) latitudes. In this embodiment the central three-dimensional collector **C2'** is tilted by **α** degrees relative to symmetry axis **55** (a 10° tilt in this example) *i.e.,* thereby actually curving the axis of symmetry. As exemplified in **Fig. 5A-C**, the upper edges of the reflective surfaces of the lateral collectors **C1'** and **C3'** are also curved/twisted near their connection to the central collector **C2',** in order to provide substantially uniform/smooth radiation collection profiles during the movements of the radiation source. Accordingly, different tilt angles will be required at different geographical latitudes.

[0066] Figs. 6A to **6C** schematically illustrate a radiation collector apparatus **60** having substantially the same structure of the radiation collector **10'** shown in **Fig. 1D,** and further comprising a concentrating structure **66** mounted within its guiding panels, **14a** and **14b.** The concentrating structure **66** comprises a plurality of parabolic ribs **6a, 6b, 6c,...** (collectively referred to herein as parabolic ribs **6;** in this non-limiting example **16** parabolic ribs are used) each being positioned substantially perpendicular to the guiding panels, **14a** and **14b,** and having an upper end thereof located at (or adjacent) one of the exit apertures, **11u, 12u** and **13u,** and a lower end located at (or adjacent) the exit aperture **10u** of the apparatus. The two sides of each of the parabolic ribs **6** are reflective to provide total internal reflection of light between each pair of adjacently located parabolic ribs **6.**

[0067] The concentrating structure **66** thus forms a manifold of parabolic ribs **6** extending from the exit apertures, **11u, 12u** and **13u,** and extending towards the exit aperture **10u** of the apparatus. Adjacently located parabolic ribs **6** are thus adapted to concentrate the collected and concentrated incident light at certain times of the day. The parabolic ribs **6** are configured to receive the concentrated light outputted from each of the two-dimensional collectors, **T1, T2** and **T3,** and as their manifold structure coincides towards the smaller sized exit aperture **10u** of the apparatus **60,** there substantially increase the concentration ration of the apparatus (in this example by 1/8). As in the previously described embodiments, in some embodiments the radiation collection profile of the radiation collector **60** is adapted for improved coverage at northern (or southern) latitudes, by curving/twisting central horizon-plane reflective surfaces, as described hereinabove.

[0068] Figs. 7A to **7C** schematically illustrate a radiation collector apparatus **70** having substantially same structure as the radiation collector **10'** shown in **Fig. 1D,** and further comprising a rotating mirrors (collectively referred to as mirror **m)** arrangement having a substantially isosceles trapezoidal shape. Each mirror **m** is a controllably rotatable panel, having reflective surface at both sides thereof. As seen, the at exit aperture each two-dimensional collector, **T1, T2** and **T3,** and the base section **14u** of the apparatus **70,** comprises a set of spaced-apart controllably rotatable mirrors, **m1, m2, m3,** and **m4,** respectively. The radiation collector apparatus **70** comprises three different target surfaces, as follows; target surface **71** located between the base section **14u** and the free end of the two-dimensional collector **T1,** target surface **72** located at (or adjacent) the center of the exit aperture **12u** of the two-dimensional collector **T2,** and target surface **73** located between the base section **14u** and the free end of the two-dimensional collector **T3.** While the target **72** is substantially parallel to the exit aperture 12u (and to the ground surface), targets **71** and **73** are tilted relative by about 100° to 150°, optionally by about 120°, relative to the base section **14u** (and thus also to the ground surface).

[0069] A control unit and actuating means (not shown) are used to simultaneously adjust all of the angles of each of the mirrors **m,** and configured to thereby direct the light collected and concentrated by each of the two dimensional collectors, **T1, T2** and **T3,** onto at least one of the target surfaces, **71, 72** and **73.** Possible control schemes for setting the angles of the mirrors **m** to direct the collected and concentrated radiation onto selected target surfaces are shown in **Figs. 7D** to **7L,** wherein **Figs. 7D** to **7F** demonstrate radiation collection around 7:00 by target surfaces **71, 73** and **72,** respectively, **Figs. 7G** to **7I** demonstrate radiation collection around 10:00 by target surfaces **71, 73** and **72,** respectively, and **Figs. 7J** to **7L** demonstrate radiation collection around 12:00 by target surfaces **71, 73** and **72,** respectively.

[0070] The use of the rotating mirrors **m** to direct the collected and concentrated radiation onto selected target surfaces provides substantially improved concentration ratios (1/30 concentration). In addition, with this embodiment, by proper control of the mirrors angles, a constant section towards the sun at all hours can be obtained and thus equal flux collection. In addition, since in this embodiment the rotating mirrors along each exit apertures and the base section concentrate radiation towards a target situated (roughly) at the opposing side/vertex, minimal mirror interference occurs during the mirrors rotations.

[0071] Fig. 8 is a perspective view of the radiation collector assembly **80** comprising the radiation collector apparatus **20'** shown in **Figs. 5A** to **5C** operably installed on a curved light guide **81** to collect radiation from a celestial radiation source. As seen, in this embodiment curved light guide **81** communicates the collected radiation between the collector **20'** and the substantially vertical light guide **26,** configured to deliver the collected radiation to a target location (e.g., into a building). In this way the collector **20'** is provided readily set in proper orientation for optimal radiation collection, as may be required in a specific geographical latitude. Of course, all other embodiments illustrated and described herein can be similarly mounted on the curved light guide **81** in the same manner.

EXAMPLES

[0072] Fig. 9 show annual equatorial radiation collection plots as obtained by computer simulation for the radiation collector apparatuses shown in **Figs. 2A-2I,** simulating the annual performance at equatorial geographical regions (simulated for latitude 0° and 90° vertical angle i.e., exactly perpendicular to the horizon). As this concentrator was specifically designed for such angles, performance is very good throughout the year, resulting in large relative collection values from favorable solar angles.

[0073] Figs. 10A and **10B** show annual radiation collection plots at latitude 33° and vertical angle of 45° tilt from the horizon, as obtained by computer simulation for the radiation collector apparatuses **20** shown in **Figs. 2A-2I** and **20'** shown in **Figs. 5A-5C,** respectively. In this example solar raytracing simulations were performed at global location of Tel-Aviv in Israel, with a constant Solar source of power 1366 W/m^2 (arbitrary but constant), sampling at 0.5 hours intervals at the 21th of each month (Solstice is at that day so maximal and minimal values).

[0074] As seen in **Fig. 10A,** during May, June and July, the radiation collection profiles falls to zero during midday time using the collector apparatus **20** shown in **Figs. 2A-2I** at latitude 33°. The results presented in **Fig. 10B** show the significant improvement achieved using the radiation collection apparatus **20'** shown in **Figs. 5A-5C,** comprising the curved/twisted central reflecting surfaces. As seen, the radiation collection profiles obtained using the radiation collection apparatus **20'** are substantially uniform throughout the entire day, without the sudden falls obtained with the apparatus **20** and seen in **Fig. 10A.**

[0075] As described hereinabove and shown in the associated Figs., the present invention provides improved radiation collector apparatuses adapted to optimize flux collection and concentration ratios at different geographical latitudes. While particular embodiments of the invention have been described, it will be understood, however, that the invention is not limited thereto, since modifications may be made by those skilled in the art, particularly in light of the foregoing teachings. As will be appreciated by the skilled person, the invention can be carried out in a great variety of ways, employing more than one technique from those described above, all without exceeding the scope of the invention.

REFERENCES CITED IN THE DESCRIPTION

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OPTIMERET STATISK STRÅLINGSKOLLEKTOR

PATENTKRAV

1. Anordning (10) til indsamling af indfaldende stråling udsendt fra en bevægelig strålingskilde, hvilken anordning definerer en statisk strålingskollektor, der omfatter:

en central rendeformet strålingskollektor (T2), der omfatter reflektorer (12a, 12b) med en i alt væsentligt ligebenet trapezform, en indgangsåbning (12i), der er defineret af større baser af reflektorerne, og en udgangsåbning (12u), der er defineret af mindre baser af reflektorerne; og

to laterale rendeformede strålingskollektorer (T1, T3), hvor de laterale og centrale kollektorer har et samme symmetriplan (19), hvor hver af de laterale kollektorer (T1, T3) har tilsvarende indgangs- og udgangsåbninger (11i, 13i) og strækker sig fra en tilsvarende endeside af den centrale kollektor (T1), hvorved der defineres en stump hældningsvinkel mellem en forlænget symmetriakse af den centrale kollektors udgangsåbning (12u) og symmetriaksen for udgangsåbningen (11u, 13u) af hver af de laterale kollektorer (T1, T3).

2. Anordning ifølge krav 1, hvor centrale reflekterende flader af den centrale kollektor (12a', 12b') er hævet i forhold til anordningens horisontplan (19) for at forhindre fluxtab.

3. Anordning ifølge et hvilket som helst af kravene 1 og 2, hvor stråling afgivet gennem de laterale (T1, T3) og centrale (T2) kollektorers udgangsåbninger (11u, 12u, 13u) dirigeres mod en målflade (15), der befinder sig under kollektorerne, i alt væsentligt parallelt med den centrale kollektors udgangsåbning, og hvor anordningen omfatter et eller flere strålingsføringselementer (26) til føring af strålingen fra målfladen til et eller flere fjerne steder.

4. Anordning ifølge et hvilket som helst af de foregående krav, hvor et forhold mellem længderne af den centrale kollektors udgangsåbning (12u) og hver af de laterale kollektorers udgangsåbning (11u, 13u) er ca. 1:1 til 1:3.

5. Anordning ifølge et hvilket som helst af de foregående krav, der omfatter to føringspaneler (14a, 14b), der strækker sig fra udgangsåbningerne (11u, 12u, 13u) af de rendeformede strålingskollektorer og har reflekterende flader, der hver vender ind mod hinanden for at indeslutte strålingen afgivet fra udgangsåbningerne.

6. Anordning ifølge et hvilket som helst af de foregående krav, hvor hver af de laterale rendeformede strålingskollektorer (T1, T3) omfatter en sidereflektor (11c, 13c), der er monteret ved dens frie ende ved en ende af anordningen til indsamling af stråling i visse vikler for strålingskilden.

7. Anordning ifølge krav 6, hvor hver af de to laterale rendeformede strålingskollektorer (T1, T3) omfatter en fældereflektor (21d, 23d), der er monteret stødende op til den centrale kollektor (T2) i alt væsentligt vinkelret på reflekterende flader af en tilsvarende af de laterale kollektorer (T1, T3) i en forudbestemt vinkel i forhold til dens udgangsåbning, hvorved der dannes mindst én lateral tredimensional rektangulær tragtformet strålingskollektor.

8. Anordning ifølge krav 5, der omfatter en flerhed af parabolske ribber (6a, 6b, 6c, ...), der er monteret mellem og i alt væsentligt vinkelret på føringspanelerne (14a, 14b), hvilke parabolske ribber strækker sig mellem de rendeformede strålingskollektorers udgangsåbninger (11u, 12u, 13u) og en udgangsåbning af anordningen, hvor to sideflader af hver af de parabolske ribber er reflekterende.

9. Anordning ifølge et hvilket som helst af de foregående krav, der omfatter: en anordning af roterbare spejle (m), der er monteret i udgangsåbningen (11u, 12u, 13u) af hver af kollektorerne og udformet til at modtage stråling fra udgangsåbning af den tilsvarende kollektor, hvori den er monteret, hvor hvert spejls rotationsakse i anordningen af roterbare spejle i alt væsentligt er vinkelret på den forlængede symmetriakse for den udgangsåbning, hvori den er monteret, hvor hver af spejlende er udformet i en specifik vinkel for at dirigere stråling afgivet fra den tilsvarende udgangsåbning over på mindst én målflade (71, 73).

10. Anordning ifølge krav 9, der omfatter en supplerende anordning af roterbare spejle (m4), der befinder sig en basissektion af anordningen strækkende sig under de laterale kollektorers (T1, T3) frie ender, hvor den supplerende spejlanordnings spejle i alt væsentligt er parallelle med den anden anordnings spejle og udformet til at modtage en stråling afgivet fra udgangsåbningerne (11u, 12u, 13u) og dirigere den til en målflade (72), der er placeret stødende op til og i alt væsentligt parallelt med den centrale kollektor (T2).

11. Anordning ifølge et hvilket som helst af kravene 9 og 10, der omfatter et aktiveringsmiddel udformet til at styrbart at indvirke på rotationsbevægelser af spejlene (m); og en styreenhed, der er konfigureret og kan fungere til at styre aktiveringsmidlets funktion og indstille orienteringen af mindst nogle af spejlene for at dirigere strålingen afgivet gennem udgangsåbningen (11u, 12u, 13u) mod mindst én målflade (71, 72, 73) eller anordningens udgangsåbning.

12. Anordning ifølge et hvilket som helst af de foregående krav, hvor mindst én af de rendeformede strålingskollektorer (T1, T2, T3) er en CPC-enhed.

13. System til indsamling af stråling fra en himmelstrålingskilde, hvilket system omfatter: en lyssamlingsanordning ifølge et hvilket som helst af de foregående krav; og en lysføringsstøtte (81) til montering af anordningen derpå, der modtager lyset indsamlet ved hjælp af anordningen og leverer den mod et målsted, hvilken lysføringsstøtte er udformet til at indstille anordningen, der er monteret derpå, i en defineret orientering, der er krævet for optimal strålingssamling ved hjælp af anordningen ved en vis bredde.

DRAWINGS

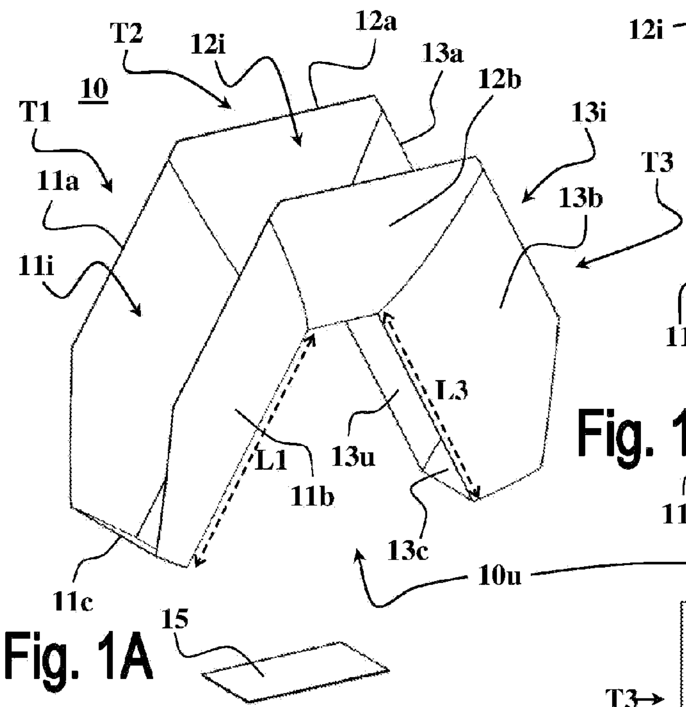


Fig. 1A

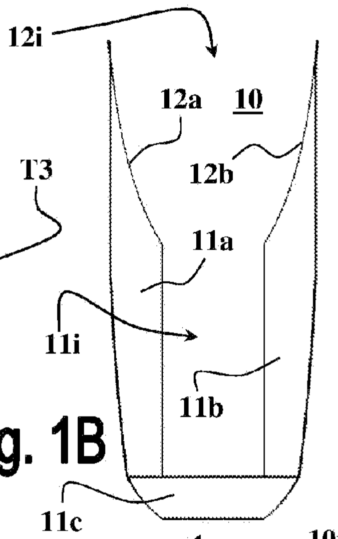


Fig. 1B

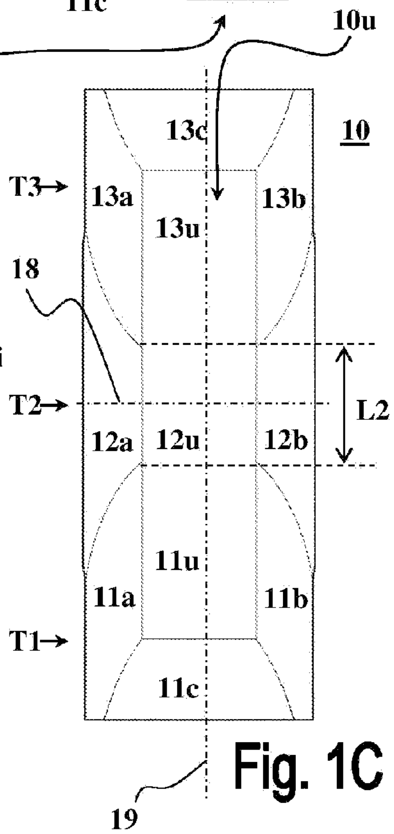


Fig. 1C

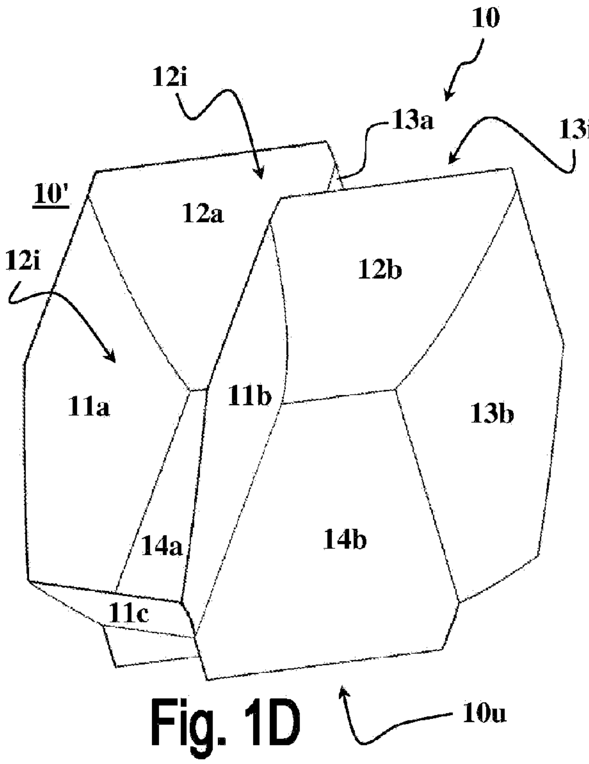


Fig. 1D

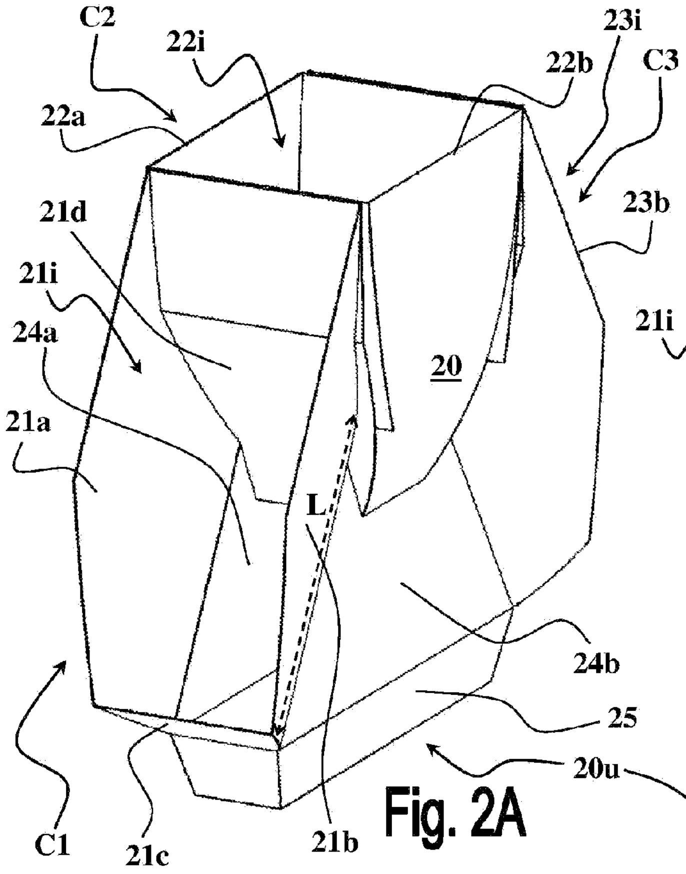


Fig. 2A

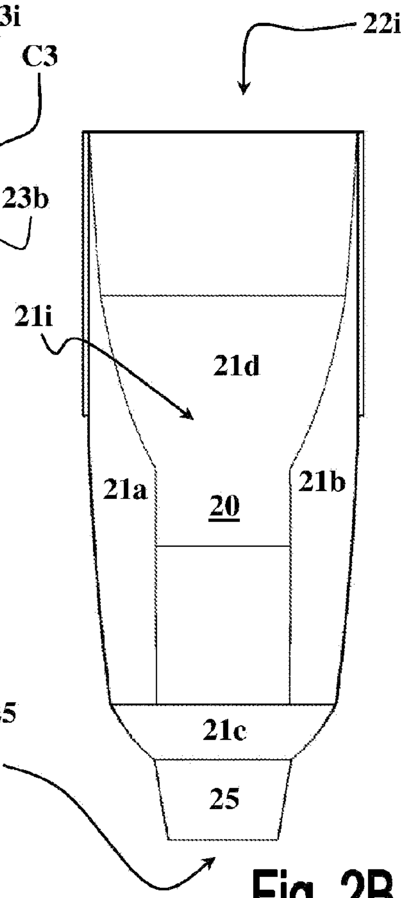


Fig. 2B

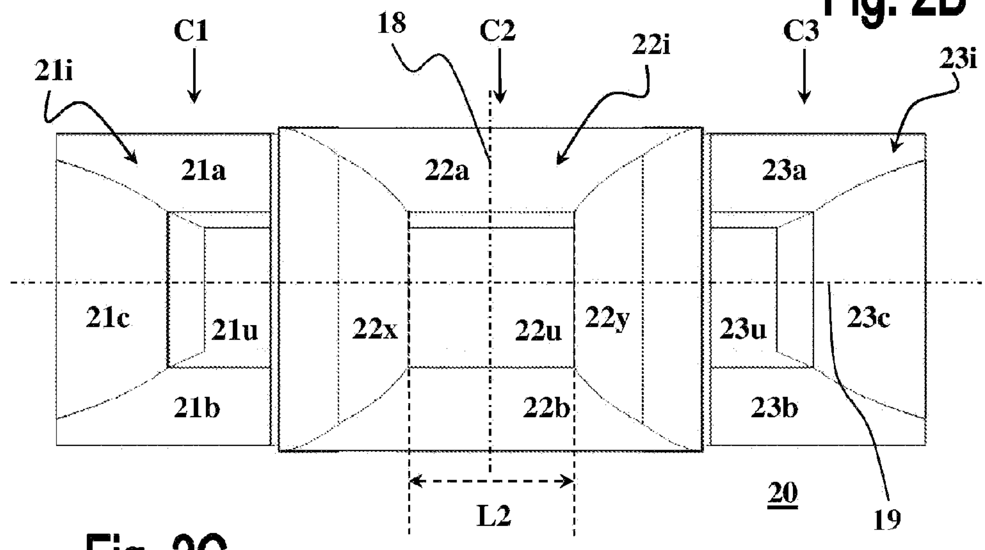


Fig. 2C

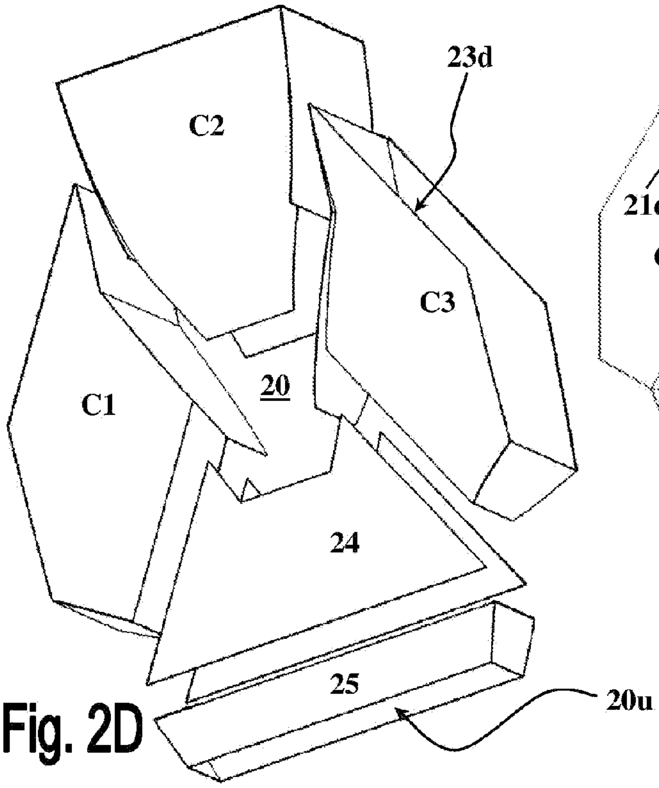


Fig. 2D

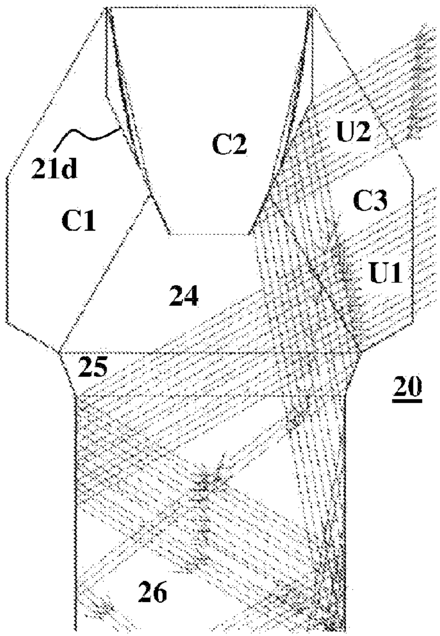


Fig. 2E

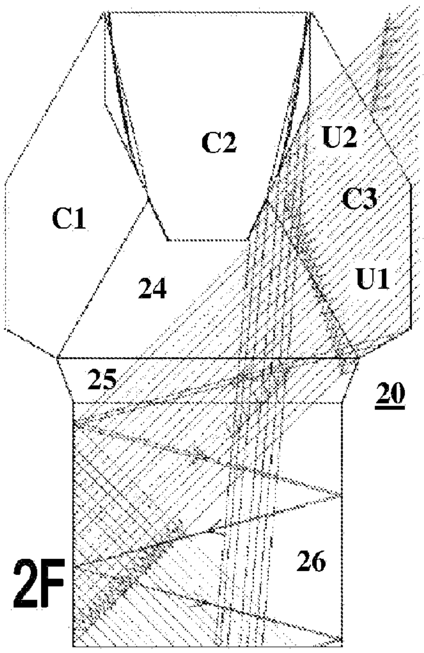


Fig. 2F

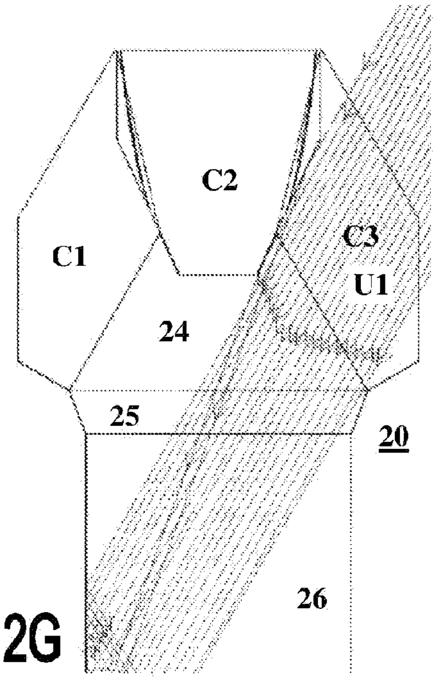


Fig. 2G

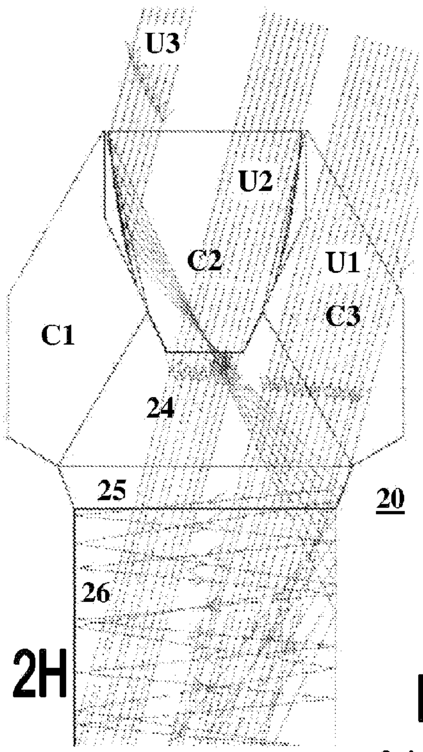


Fig. 2H

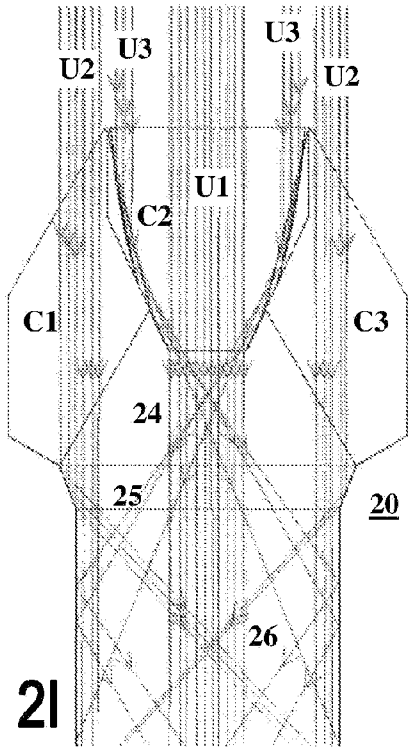


Fig. 2I

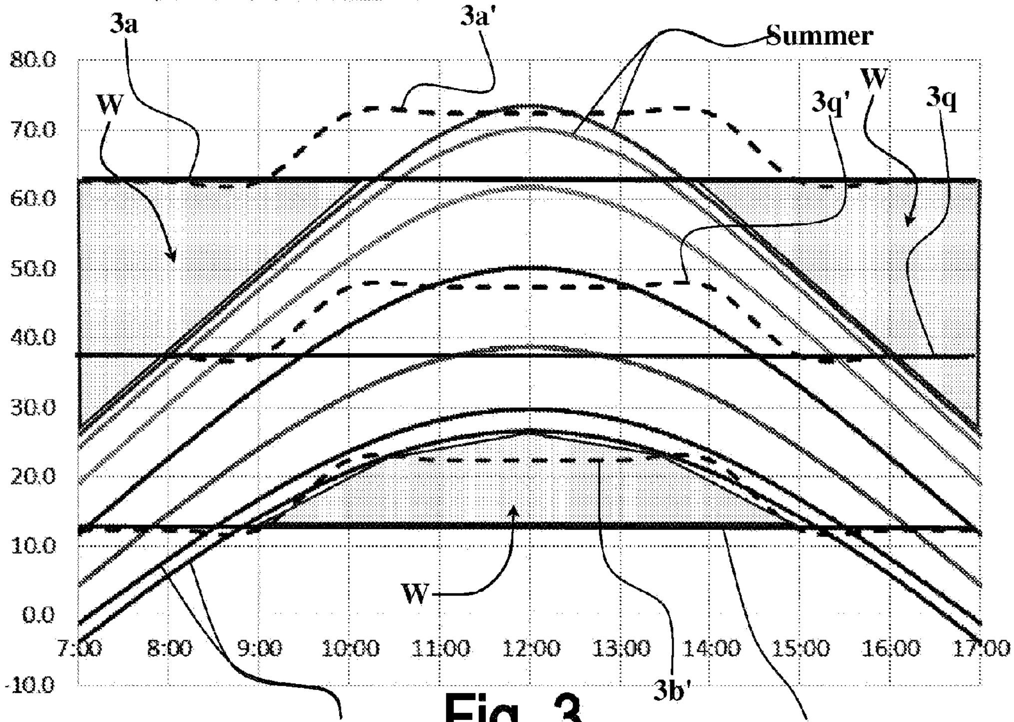


Fig. 3

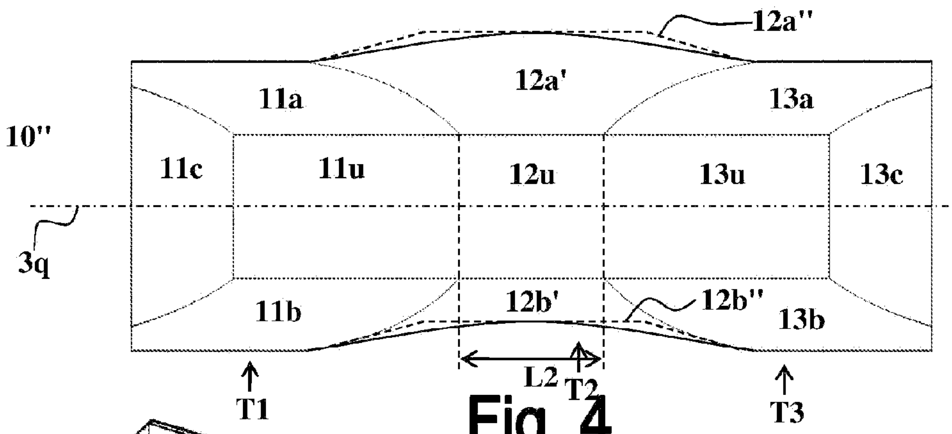


Fig. 4

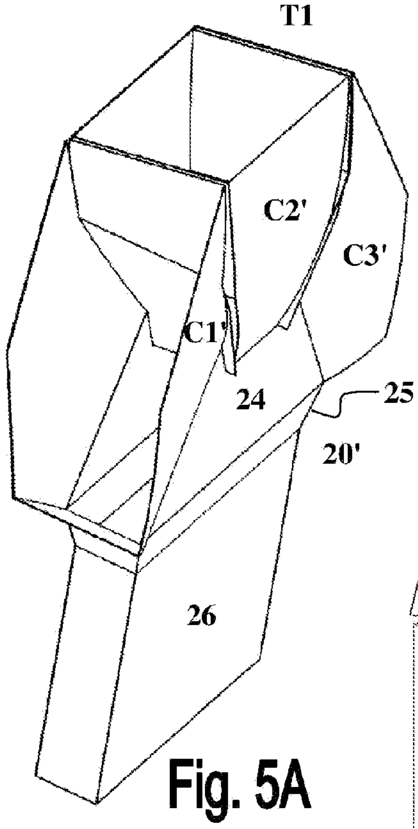


Fig. 5A

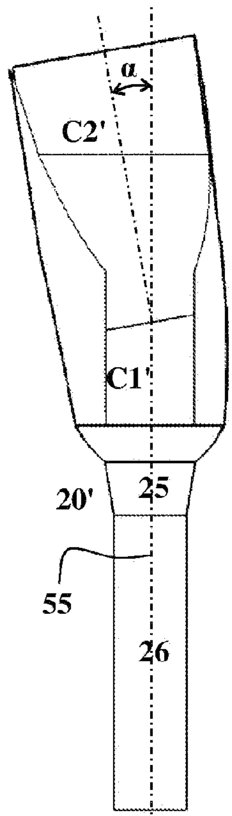
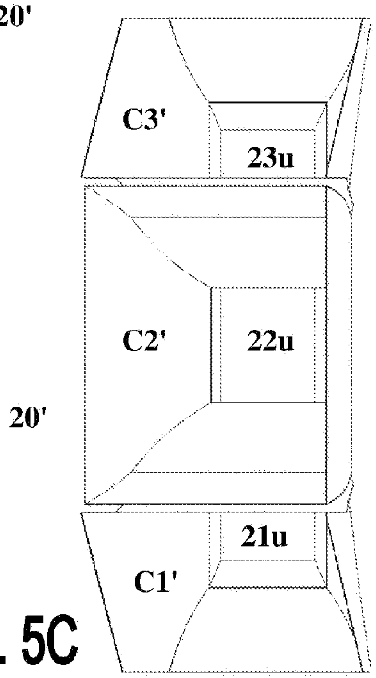


Fig. 5B



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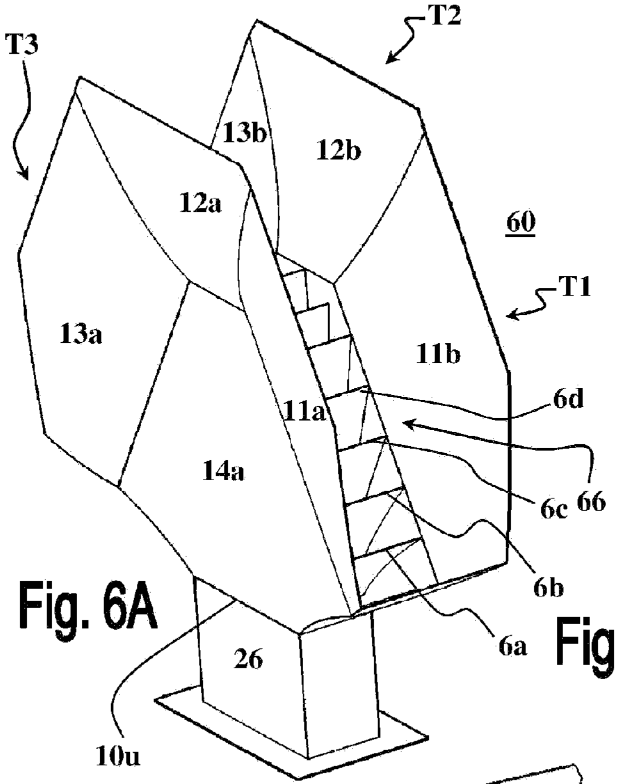

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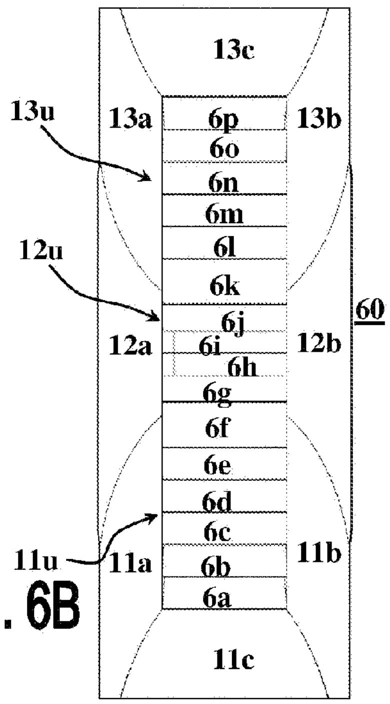
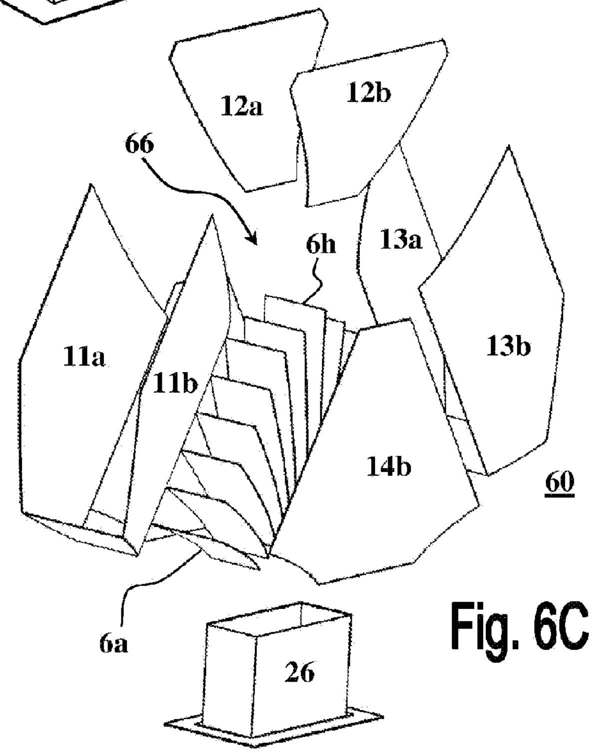


Fig. 6B



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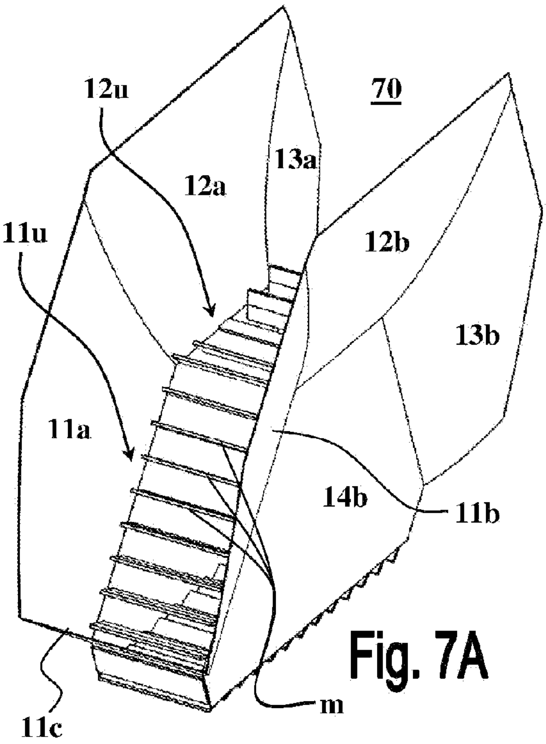


Fig. 7A

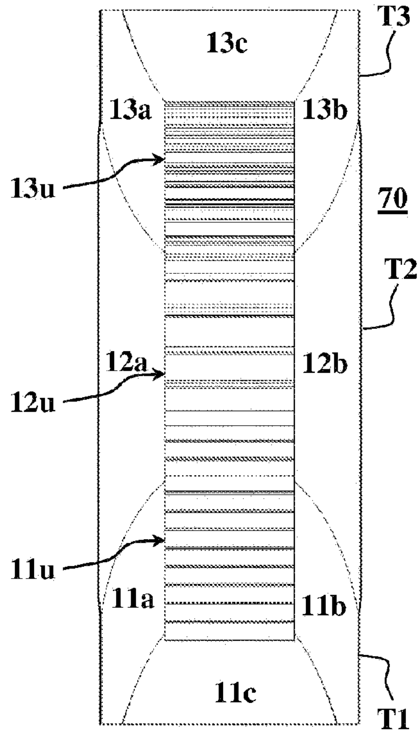
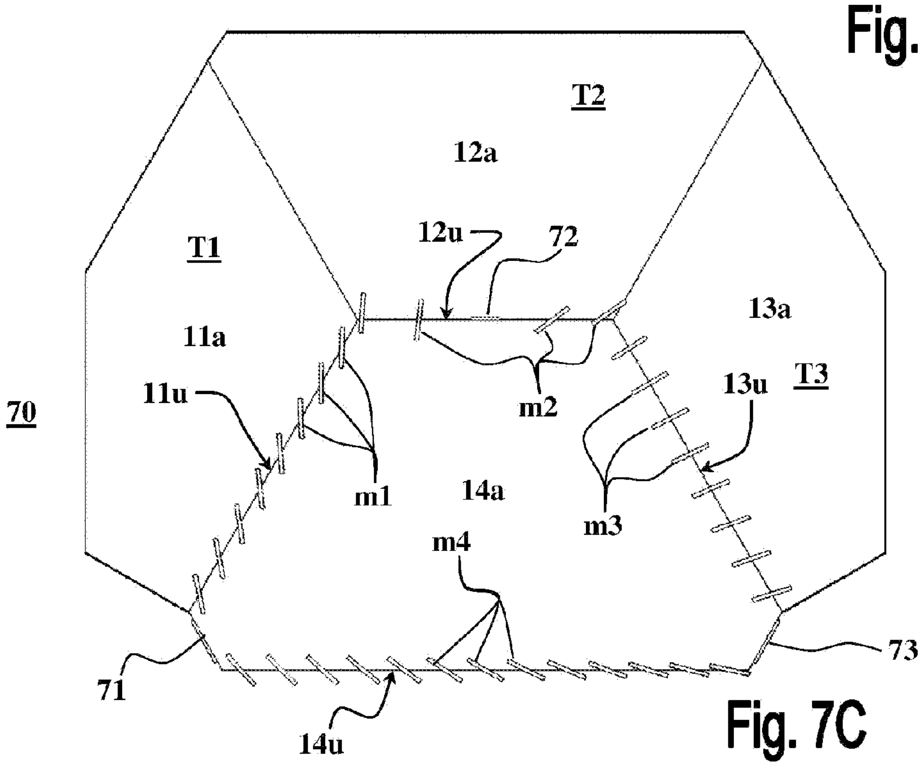


Fig. 7B



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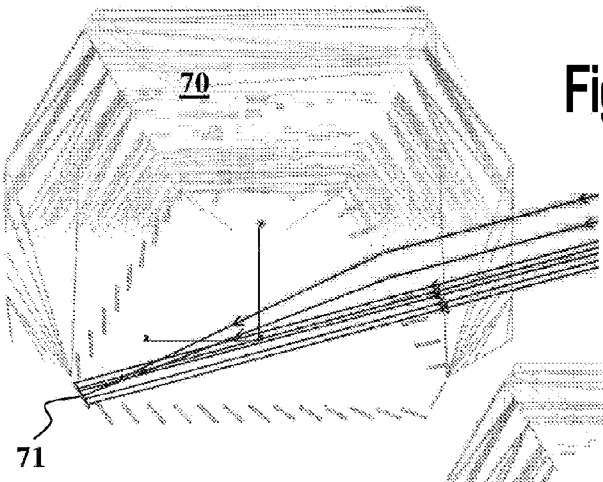
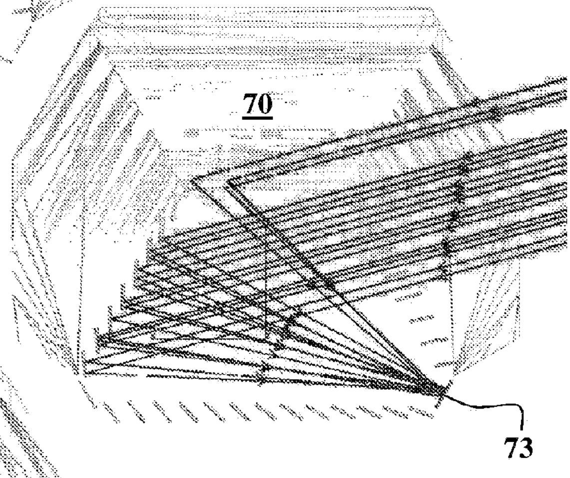


Fig. 7D



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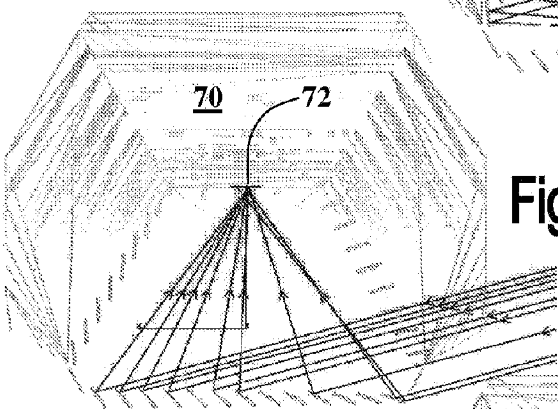

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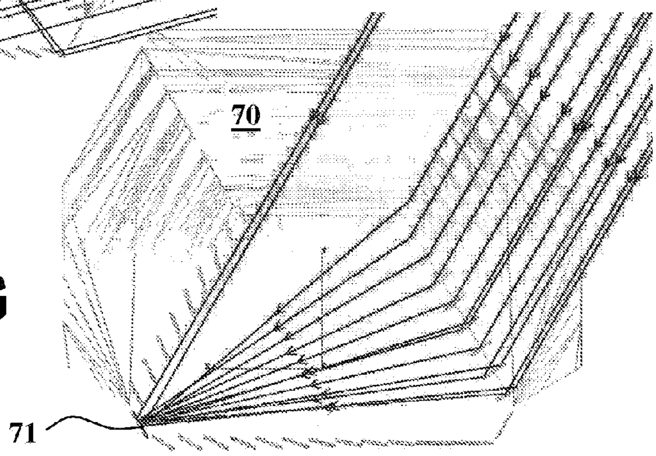
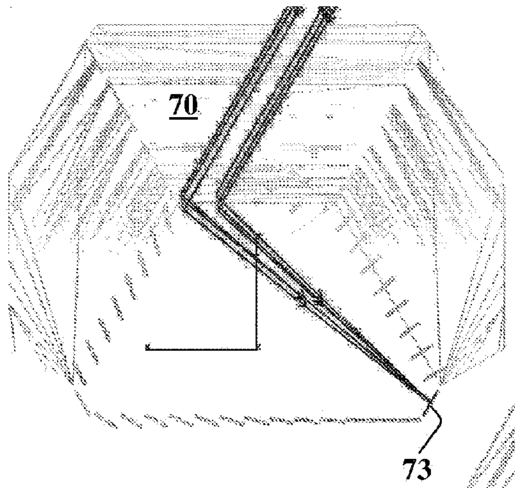


Fig. 7G



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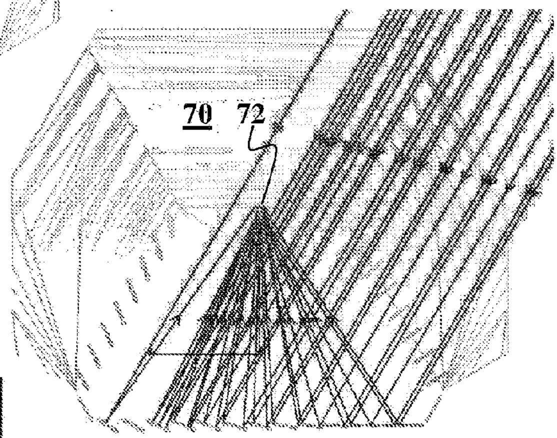
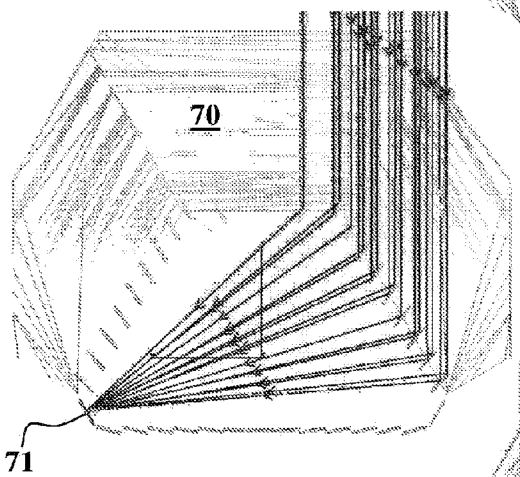


Fig. 7I



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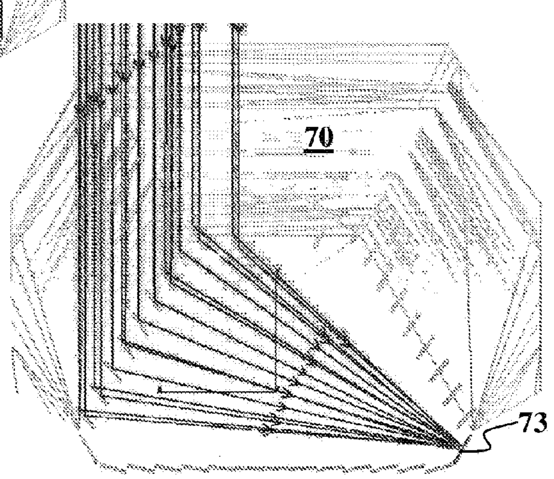
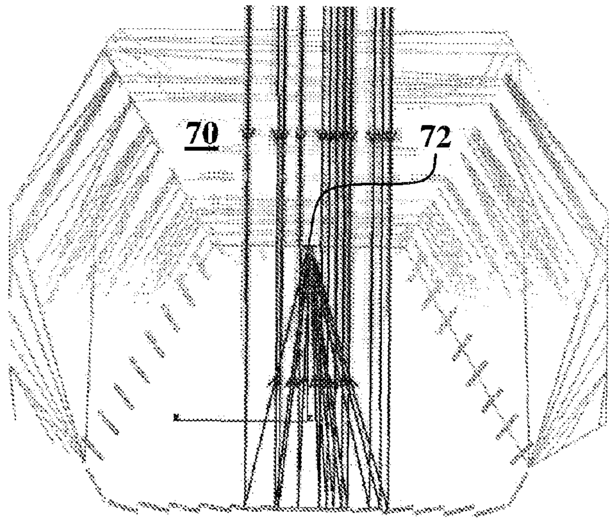
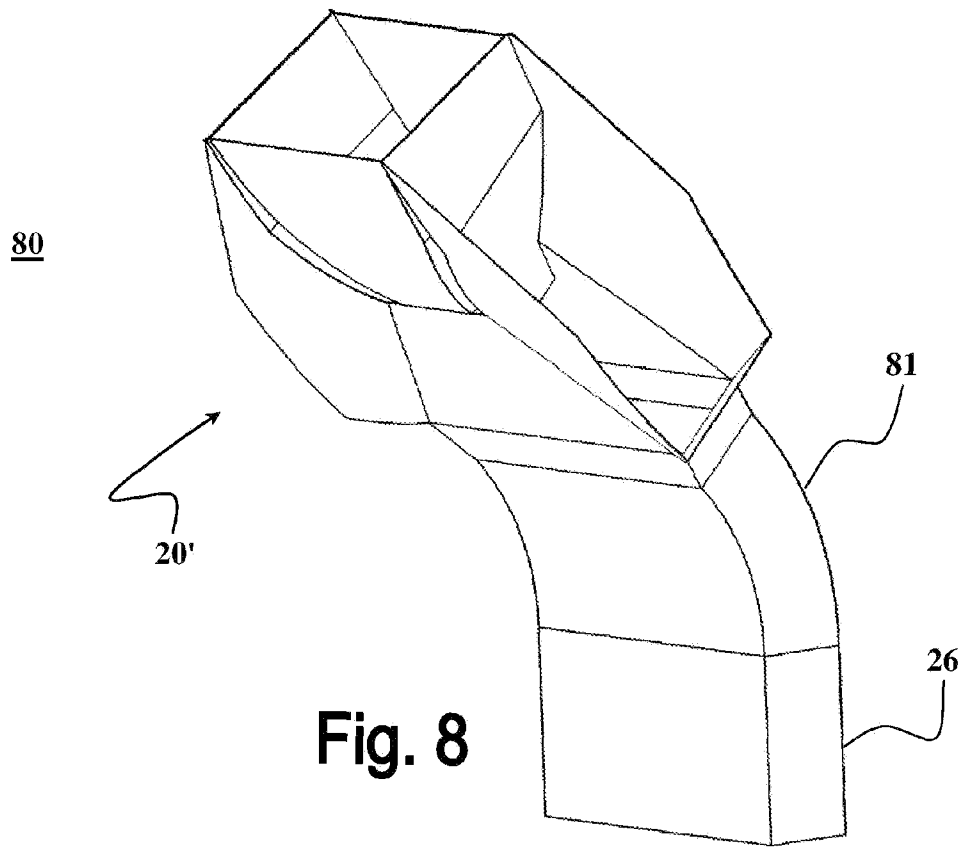


Fig. 7K

Fig. 7L





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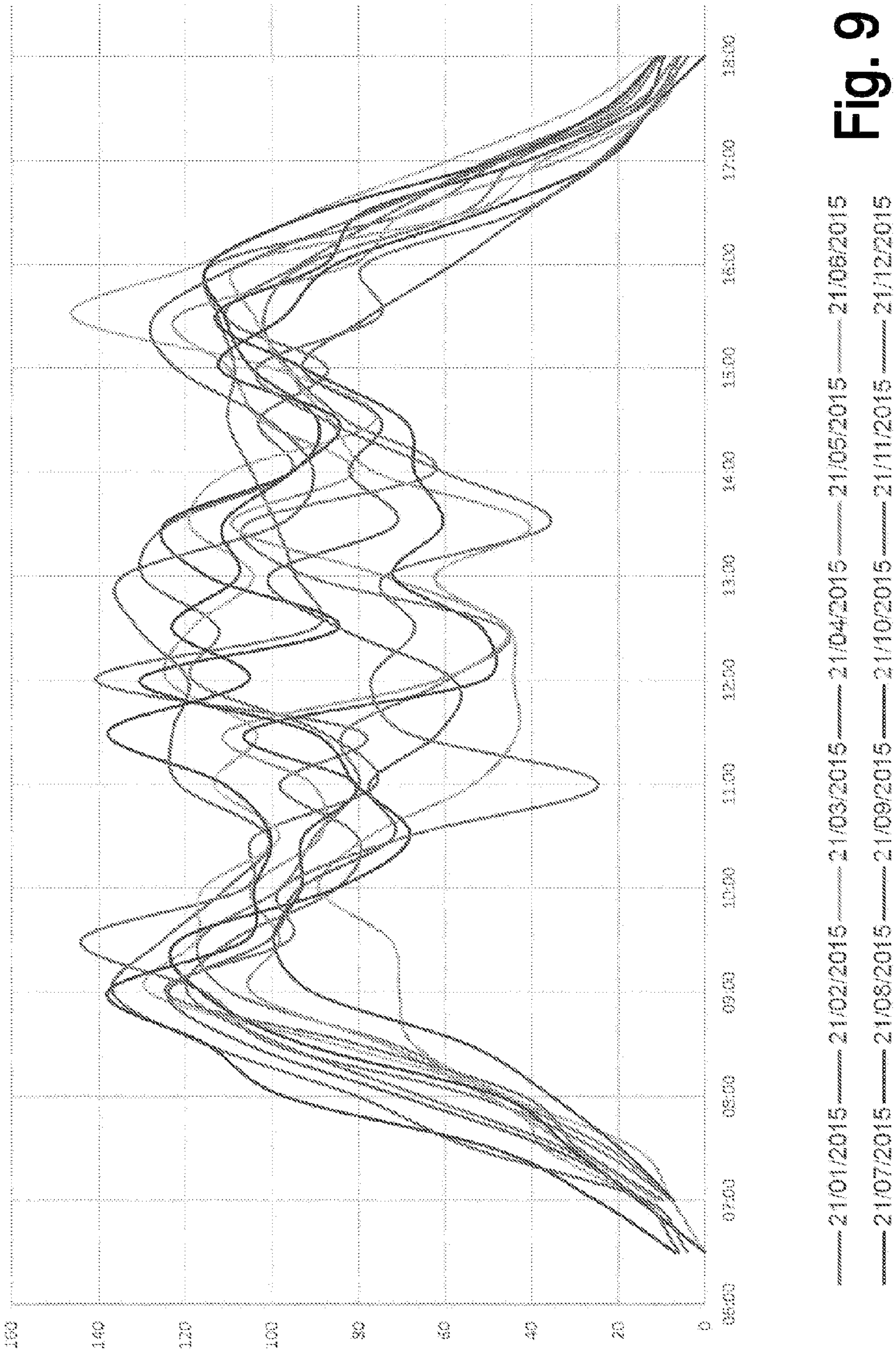
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Fig. 9

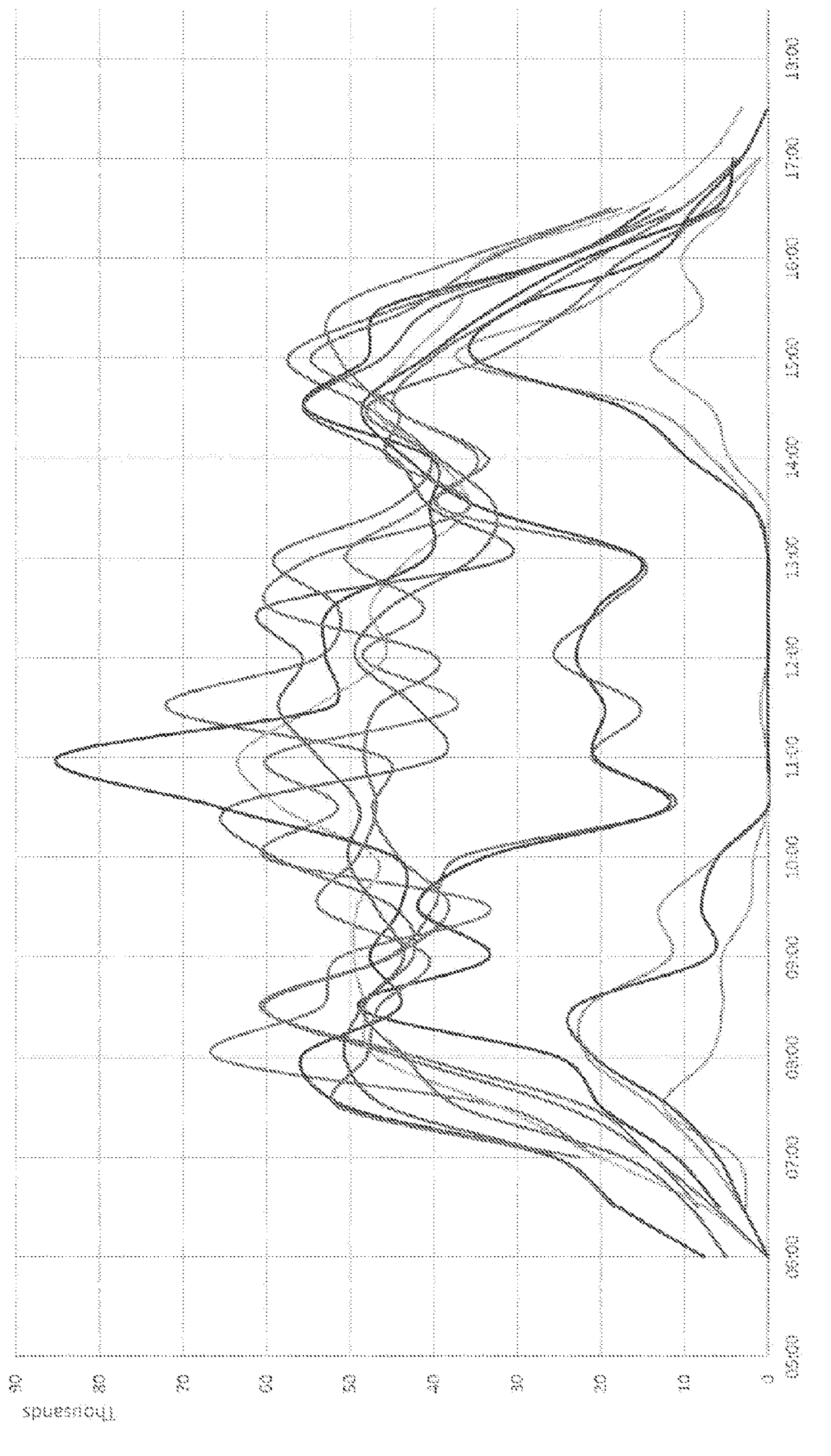
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Fig. 10A

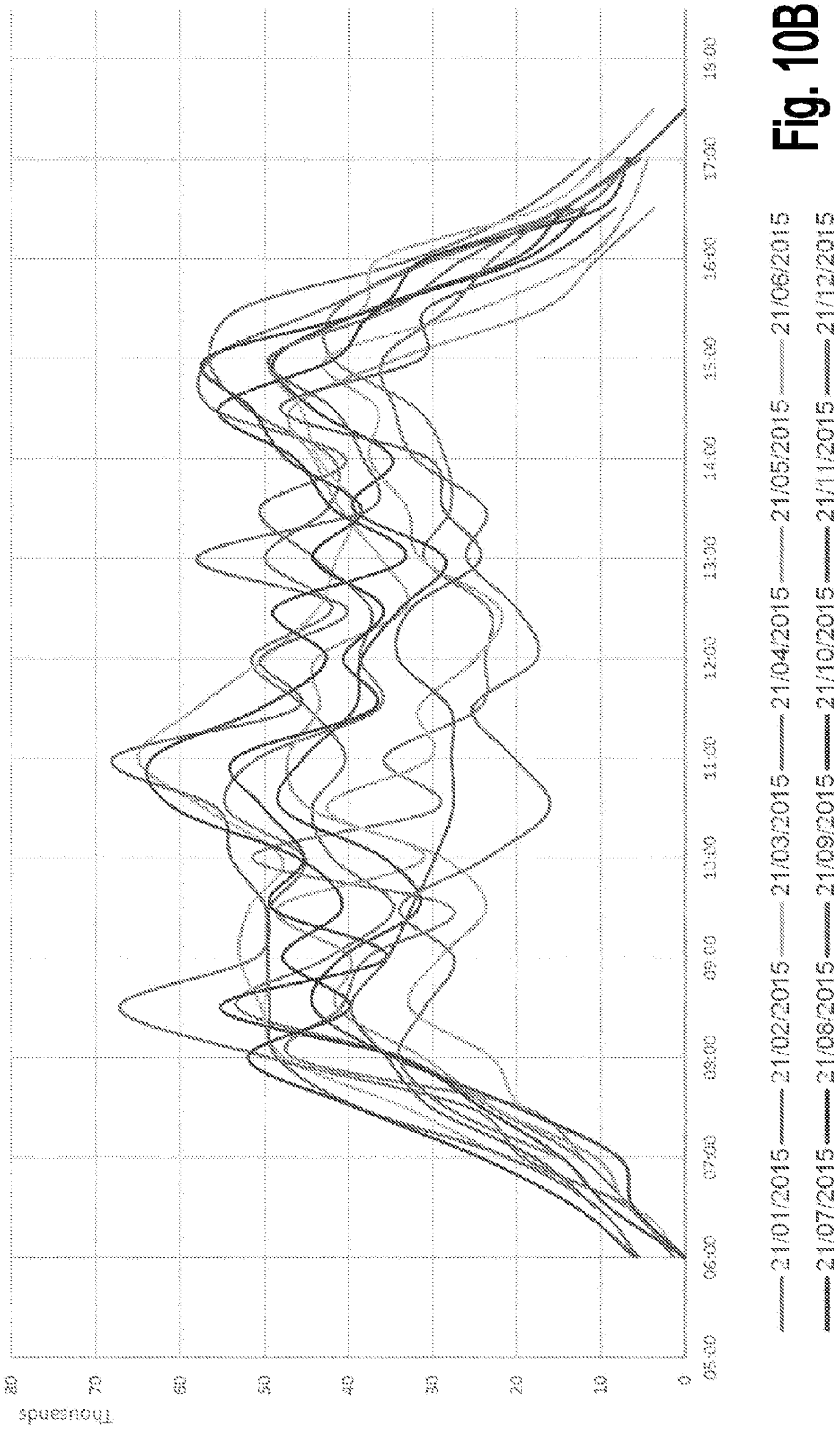
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Fig. 10B