

SOLAR LIGHT COLLECTING AND REDIRECTING SYSTEM

TECHNICAL FIELD OF THE INVENTION

[0001] The present embodiment generally relates to a Tubular Daylight Device, and more particularly relates to an optic system that can be mounted onto the tubular daylight device for optimized collection and redirection of uniform solar light into the tubular daylight device

BACKGROUND OF THE INVENTION

[0002] Day lighting devices includes an internally reflective tube that are mounted onto a roof of a building for transporting or distributing natural and/or artificial light for the purpose of illumination inside the building. These day lighting devices are generally referred as Tubular Daylight Devices (TDD), Tubular Daylight delivery systems (TDDS), and/or Tubular Skylight devices (TSD). The day lighting device also includes a dome shaped collector fixed onto the top of the tubular daylight device to collect light which is then redirected into the building via tubes.

[0003] Conventional tubular day lighting device includes a stationary collector which is not adjustable with respect to the change in position or path of the sun in the sky during day time. For example, the solar light entering the tubular day lighting device is much lower during sunrise and sunset, whereas during midday, the solar light entering the tubular day lighting device is much higher than adequate and sometimes harsh enough too. FIGS. 1-2 illustrate a bell curve graph 10 and 15 indicating sun azimuth and altitude along with a trajectory. The light intensity in a room during day time is indicated by arrow 11. The sun moves on a trajectory with respect to the sky and variations in the azimuth and altitude angles of the sun varies significantly to its position in the sky, as shown in FIGS. 1-2. The movement of the sun affects the amount of light entering the tubular day lighting devices with respect to the change in time during day, which results in deficiency of solar light in the spaces where the tubular day lighting devices are installed.

[0004] Many prior art approaches for collecting solar light use a uni-directional redirector, however such redirector is not adequate owing to the changing angles of the sun during the day and throughout the year. Furthermore, such prior art approaches have

high efficiency at delivering solar light during the noon when solar light directly falls onto the reflecting inner surface of the tube. But during sunrise and sunset, when the rays are tangential, the light transmitted indoors is effectively low using such conventional day lighting devices.

[0005] Further, some other prior art lighting devices uses parabolic mirrors, helical mirrors, hinged mirrors, prisms, etc for collecting solar light. Such prior art approaches use a separate opto-electronic circuit to make the reflectors/collectors face the direction of sun based either on a feedback loop system or a preloaded function. The problem associated with the prior art approaches is that the parabolic mirrors are difficult to manufacture and are comparatively costlier, which increases complexity and overall cost of the day lighting devices. Also, this system requires an external power source and collects solar light in only one direction, which is too large to be used effectively for indoor lighting. Such prior art approaches are complex in structure and not achieving optimized direction of the solar light into the tubular skylight devices throughout the day-time irrespective of sun's position, i.e. not effective collection of solar light especially during sunrise and sunset.

[0006] Hence, there is a need for an improved and optimized solar light collecting and redirecting system having multiple mirror array configuration that is calibrated to change their angles with respect to sun's position, as described in greater detailed herein.

SUMMARY OF THE INVENTION

[0007] The following summary is provided to facilitate an understanding of some of the innovative features unique to the disclosed embodiments and is not intended to be a full description. A full appreciation of the various aspects of the embodiments disclosed herein can be gained by taking the entire specification, claims, drawings, and abstract as a whole.

[0008] The present embodiments seek to provide a solar light collecting and redirecting system for a tubular daylight device, which may be capable of achieving optimized collection and redirection of uniform solar light into the tubular daylight device irrespective of sun's position in the sky.

[0009] The present embodiment also seek to provide a solar light

collecting and redirecting system for a tubular daylight device, which may improve efficiency of the tubular daylight device by allowing more sunlight during low angles of the sun and suppressing entry of more sunlight during midday.

[0010] The present embodiments further seek to provide a solar light collecting and redirecting system for a tubular daylight device, which may be retrofittable to any existing tubular daylight device.

[0011] In one aspect, a solar light collecting and redirecting system for a tubular daylight device includes a reflector having a number of trapezium shaped mirrors attached to a mount disk via a mounting surface at inner side of a top end of the reflector. The mount disk is attached to a collection area of the tubular daylight device via a mounting means. A carriage disk is connected to a bottom end of the reflector through a plurality of linkages and the reflector is placed at an angle initially and moved in an angle determined by a law of reflection with respect to time and solar light incident angle. A screw rod part connected to the carriage disk vertically moves the carriage disk when the screw rod part is turned. The carriage disk moves up and down on the screw rod part such that the linkages move the reflector back and forth affecting an angle of reflected light entering the tubular daylight device. An actuator is mounted on the mount disk and synchronizes the movement of the reflector and the screw rod part with respect to the movement of the sun in the sky.

[0012] Further, the screw rod part includes a pitch thread through which the carriage disk moves up and down on the screw rod part when the screw rod part is turned by the actuator. An angle of the trapezium shaped mirrors is controlled in relation to an angle of incidence of solar light in order to receive the solar light from a declination angle and reflect the light into a duct of the tubular daylight device thereby increasing the efficiency of the tubular daylight device by allowing more sunlight during low angles of the sun and suppressing entry of more sunlight during midday.

[0013] Moreover, the reflector comprises at least twelve trapezium shaped mirrors and the mount disk comprises at least twelve faced polygon layer to omnidirectionally redirect the solar light. The top mount disk is configured to arrest a part of the near vertical

and vertical sunrays from entering the tubular daylight device. Each of trapezium shaped mirrors is at the same angle to a horizontal axis at all times and the limit angles are calculated using the laws of reflection with respect to the solar light incident angles from 10° to 35° from vertical so that the reflected rays enter the tubular daylight device. The solar light incident angles are then divided into equal parts over an operating hour during sunrise and sunset, when the rays are tangential. The controller drives the motor assembly at regular intervals to move the minors to preset angles calculated using the laws of reflection for the solar light incident angles.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The disclosed embodiments may be better understood by referring to the figures, in which like reference numerals refer to identical or functionally-similar elements throughout the separate views, further illustrate the present embodiment and, together with the detailed description of the embodiment, serve to explain the principles of the present embodiments.

[0015] FIGS. 1-2 illustrate a bell curve graph indication of sun azimuth and altitude along with a trajectory;

[0016] FIG. 3 illustrates a perspective view of a solar light collecting system, in accordance with the present embodiments;

[0017] FIG. 4 illustrates an exploded view of the solar light collecting system, in accordance with the present embodiments;

[0018] FIG. 5 illustrates a perspective VICW of the solar light collecting system showing an angle of the trapezium shaped mirrors with respect to a vertical axis for 6 am light, in accordance with the present embodiments;

[0019] FIG. 6 illustrates a perspective view of the solar light collecting system showing an angle of the trapezium shaped mirrors with respect to the vertical axis for 10 am light, in accordance with the present embodiments;

[0020] FIG. 7 illustrates a perspective view of the solar light collecting system showing solar light incident angles with respect to the mirrors calculated using the laws of reflection during sunrise and sunset, when the rays are tangential (e.g., 6 am and 6 pm), in accordance with the present embodiments;

[0021] FIG. 8 illustrates a perspective view of the solar light collecting system

showing solar light incident angles with respect to the minors calculated using the laws of reflection during sunrise and sunset (e.g., 10 am and 2 pm), in accordance with the present embodiments; and

[0022] FIG. 9 illustrates a graphical representation of an average light input into a day light delivering device utilizing the solar light collecting system, in accordance with the present embodiments.

DETAILED DESCRIPTION OF THE INVENTION

[0023] The particular values and configurations discussed in these non-limiting examples can be varied and are cited merely to illustrate at least one embodiment and are not intended to limit the scope thereof.

[0024] In the following, numerous specific details are set forth to provide a thorough description of various embodiments. Certain embodiments may be practiced without these specific details or with some variations in detail. In some instances, certain features are described in less detail so as not to obscure other aspects. The level of detail associated with each of the elements or features should not be construed to qualify the novelty or importance of one feature over the others.

[0025] The claimed subject matter has been provided here with reference to one or more features or embodiments. Those skilled in the art will recognize and appreciate that, despite of the detailed nature of the exemplary embodiments provided here, changes and modifications may be applied to said embodiments without limiting or departing from the generally intended scope. These and various other adaptations and combinations of the embodiments provided here are within the scope of the disclosed subject matter as defined by the claims and their full set of equivalents.

[0026] The disclosed embodiments relates to a specially designed optics system that can be retrofit and mounted onto a tubular day lighting device (TDD) for collecting and redirecting sunlight into the tubular daylight device. This system is retrofittable to any existing tubular daylight devices. The system captures sunlight using an array of minors that are actively controlled to redirect sunlight into the tubular daylight device. This system is unique and omni-directional in structure, and collects more sunlight even during morning and evening hours (low angle sunlight). In this present embodiment, the array of mirrors can be placed at a specific angle initially and can be moved in a controlled manner with respect to the time, i.e. the movement of these minors is synchronized with the

movement of the sun along the sky. Thus, this present system improves efficiency of the tubular daylight device by allowing more sunlight during low angles of the sun, i.e. during morning and evening, and suppressing entry of more sunlight during midday.

[0027] FIG. 3 illustrates a perspective view of a solar light collecting and redirecting system 50, in accordance with an exemplary embodiment. The solar light collecting and redirecting system 50 primarily includes a reflector 58 having an array of mirrors 12, a mount disk 22 and a carrier disk 32. Hereafter, the solar light collecting and redirecting system 50 can be referred as the solar light collecting system throughout the description only for the purpose of explanation but not by means of any limitations. The solar light collecting system 50 serves to collect light from an external source, such as natural light, i.e. solar light from sun, and allows the light to enter a tubular day lighting device 60. The light collecting system 50 is positioned to transmit daylight to the tubular daylight device 60 which in turn diffuses light inside a target area of a building. The light collecting system 50 is mounted on a collection area 62 of the tubular daylight device 60 via a mounting means 70 and is positioned on a roof of the building and/or in an area outside the building as shown in FIGS. 7-8.

[0028] The reflector 58 includes the array of minors 12 that can be shaped in a trapezoidal manner, based on design considerations. In a preferred embodiment, the trapezium shaped minors 12 can be made by a film for example, reflective material such as aluminum film and the minors 12 are then cut into the trapezoid shape. The mount disk 22 can be constructed for example, by a molding process and the dowels are cut into required sizes, and the edges are machined and welded into a polygon shape. Note that in FIGS. 3-9, identical or similar parts are generally indicated by identical reference numerals.

[0029] The trapezium shaped mirrors 12 includes at least twelve minors 52 and the mount disk 22 includes at least twelve faced polygon layer 54 to omnidirectionally redirect solar light. Note that the embodiments discussed herein should not be construed in any limited sense. It can be appreciated that such embodiments reveal details of the structure of a preferred form necessary for a better understanding of the invention and may be subject to change by skilled persons within the scope of the invention without departing from the concept thereof

[0030] FIG. 4 illustrates an exploded view of the solar light collecting system 50, in

accordance with an exemplary embodiment. The trapezium shaped minors 12 includes a top end 14, bottom end 16, an extremal reflective surface 18 and an internal surface 20, where each of the trapezium shaped mirrors 12 are arranged and attached to a mount disk 22 through a mounting surface 26 welded at the top end 14 of the trapezium shaped mirrors 12 facing at its internal surface 20 in such a way that the reflecting surface of the mirrors 12 are exposed to receive solar light.

[0031] A top side 24 of the mount disk 22 is attached to the collection area 62 of the tubular daylight device 60 via the mounting means 70. The mounting means 70 includes for example, an adhesive layer 74 and/or a screw connector 76, depending upon design consideration. However, it will be apparent to those of skill in the art that other attachment components can be utilized as desired without departing from the scope of the invention. In a preferred embodiment, the collection area 62 with a height to diameter ratio of 1:1 is used for installing the solar light collecting system 50 to the tubular daylight device 60, depending upon design consideration. The size of the solar light collecting system 50 is proportional to the size of a duct 64 used in tubular daylight device 60. The solar light collecting system 50 is installed by fastening to the collection area 62 and the wiring for a power source is made before mounting the collection area 62 onto the tubular daylight device 60.

[0032] The carriage disk 32 is connected to the bottom end 16 of the reflector 58 through a number of linkages 34. The trapezium shaped mirrors 12 are placed at an angle initially and are moved in an angle determined by a law of reflection with respect to time (daytime) and solar light incident angle. The system 50 further includes a screw-rod part 36 connected to the carriage disk 32 that allows the carriage disk 32 to move vertically when the screw rod part 36 is turned. The linkages 34 move the trapezium shaped mirrors 12 back and forth, which affects an angle of reflected light entering the tubular daylight device 60 when the carriage disk 32 moves up and down on the screw rod part 36.

[0033] The mount disk 22 further includes an actuator 42 mounted on a bottom side 23 of the mount disk 22 and at a top side 37 of the screw rod part 36, and a gear assembly (not shown) connected to the top side of the screw rod part 36 for providing a rotary motion of the screw rod part 36, where the actuator 42 is a motor assembly. A controller 72 is mounted on the mount disk 22 to control movement of the trapezium shaped minors 12 and the screw rod part 36 with respect to the position of sun during daytime, which

thereby invariably collects solar light in accordance with variations and declination angle of the sun. The carriage disk 32 can be made by cutting disks of required thickness from a solid bar of uniform diameter and then drilling the holes using a table drilling machine/ handheld drilling machine at the specified positions. The linkages 34 and the screw rod part 36 can be made from dowels of the uniform diameter as specified and machining the edges to required shapes. The screw rod part 36 has a fine pitch thread (not shown) and is connected to the actuator 42 housed on the top over the mount disk 22.

[0034] FIG. 5 illustrates a perspective view of the solar light collecting system 50 showing a limit angle 66 of the mirrors 12 with respect to a vertical axis for 6 am light, in accordance with an exemplary embodiment. In a preferred embodiment, the solar light collecting system 50 is mounted to the collection area 62 of the tubular daylight device 60 via the adhesive layer 74. The adhesive layer 74 is disposed between the collecting area 62 and the top side 24 of the mount disk 22 to timely affix the solar light collecting system 50 to the tubular daylight device 60. A limit angle 68 of the mirrors 12 with respect to the vertical axis for 10 am light is shown in FIG. 6. The declination angle of the solar light hits the trapezium shaped mirrors 12 at an incident and arc reflected away into the duct 64 of the tubular daylight device 60 and an angle of incidence is controlled by the angle of the trapezium shaped mirrors 12, which thereby increases the efficiency of the tubular daylight device by allowing more sunlight during low angles of the sun and suppressing entry of more sunlight during midday.

[0035] The angle 66 and 68 of mirror surfaces to the vertical axis depends upon the position of sun in order to optimize collection and redirection of uniform solar light into the tubular daylight device 60 irrespective of sun's position in the sky. The trapezium shaped mirrors 12 are at the same angle to the horizontal at all times. The controller 72 drives the actuator 42 at regular intervals to move the mirrors 12 to preset angles calculated using the laws of reflection for the solar light incident angles. Note that the solar light collecting system 50 is also attached to the collection area 62 of the tubular daylight device 60 via the screw connector 76 attached to the mount disk 22 by a screwing mechanism, as shown in FIG. 6. The screw connector 76 is connected between the collecting area 62 and the mount disk 22 to mechanically fasten the solar light collecting system 50 to the tubular daylight device 60.

[0036] FIGS. 7-8 illustrates a perspective view of the solar light collecting system 50

showing solar light incident angles with respect to the mirrors 12 calculated using the laws of reflection during sunrise and sunset, when the rays are tangential, in accordance with an exemplary embodiment. The limit angles 68 and 66 of the minors 12 are calculated to be 10° to 35° to vertical for the angles of sun at sunrise to a 3hr duration and sunset and 3hr prior. The limit angles 66 and 68 are calculated using the laws of reflection for the solar light incident angles from 10° to 35° from vertical so that the reflected rays enter the tubular daylight device 60. The solar light incident angles are then divided into equal parts over an operating hour during sunrise and sunset, when the rays are tangential (i.e., 6AM to 10AM & 2PM to 6PM) as shown in FIGS. 7-8.

10 **[0037]** FIG. 9 illustrates a graphical representation of an average light input 80 into the day light delivering device 60 utilizing the solar light collecting system 50, in accordance with an exemplary embodiment. The enhanced performance of the solar light collecting system 50 is indicated by arrow 82. The solar light collecting system 50 improves the efficiency of the day light delivering device 60 by allowing more solar light during low angles of the sun and suppressing extra solar light entering the day light delivering device 60 during midday.

[0038] The solar light collecting system 50 works omni-directionally and performance is not affected by the sun's azimuth positions. Also, the bright midday light entering the day light delivering device 60 is reduced as the solar light collecting system 50 from a partial obstacle. The top mount disk 22 arrest a part of the near vertical and vertical sunrays from entering the day light delivering device 60. Thus, the solar light collecting system 50 optimizes collection and redirection of uniform solar light into the tubular daylight device 60 irrespective of sun's position in the sky, which results in uniform lighting effect on the target area inside the building.

25 **[0039]** It will be appreciated that variations of the above-disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications. Also, that various presently unforeseen or unanticipated alternatives, modifications, variations or improvements therein may be subsequently made by those skilled in the art which are also intended to be encompassed by the following claims.

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WE CLAIM:

1. A solar light collecting and redirecting system for a tubular daylight device, comprising:

5 a reflector having a plurality of trapezium shaped mirrors attached to a mount disk via a mounting surface at inner side of a top end of the reflector, wherein the mount disk is attached to a collection area of the tubular daylight device via a mounting means;

a carriage disk connected to a bottom end of the reflector through a plurality of linkages wherein the reflector placed at an angle initially and moved in an angle

10 determined by a law of reflection with respect to a time and a solar light incident angle;

a screw rod part connected to the carriage disk to vertically move the carriage disk when the screw rod part is turned, wherein the carriage disk moves up and down on the screw rod part such that the linkages move the reflector back and forth affecting an angle of reflected light entering the tubular daylight device; and

15 an actuator mounted on the mount disk synchronizes the movement of the reflector and the screw rod part with respect to the movement of the sun in the sky.

2. The system of claim 1, wherein the actuator comprises a gear assembly and is housed on the top side over the mount disk to turn the screw rod part at a regular interval, 20 where the actuator is a motor assembly.

3. The system of claim 1 and 2, wherein the actuator comprises a controller mounted on the mount disk for controlling the movement of the reflector and the screw rod part.

25 4. The system of claim 1, wherein the reflector comprises an external reflective surface.

5. The system of claim 1, wherein the screw rod part comprises a pitch thread through which the carriage disk moves up and down on the screw rod part when the screw rod part 30 is turned by the actuator.

6. The system of claim 1, wherein the plurality of trapezium shaped mirrors is angularly controlled in relation to the solar light incident angle in order to receive the solar light from a declination angle and reflect the light into a duct of the tubular daylight device.

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7. The system of claim 1, wherein the reflector comprises at least twelve trapezium shaped mirrors and the mount disk comprises at least twelve faced polygon layer to omnidirectionally redirect the solar light into the tubular daylight device.

10 8. The system of claim 1, wherein the top side of the mount disk is configured to arrest at least a portion of vertical light from entering the tubular daylight device.

9. The system of claim 1, wherein each of the plurality of trapezium shaped minors is operated to be placed at a uniform angle to a horizontal axis of the mount disk.

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10. The system of claim 1, wherein the controller determines an angle of reflection with respect to the reflector by the laws of reflection for the solar light incident angles from 10° to 35° from a vertical axis, such that the reflector reflects solar light to enter the tubular daylight device.

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11. The system of claim 10, wherein the solar light incident angles are divided into equal parts over an operating period during sunrise and sunset, when the reflected solar light are tangential.

25 12. The system of claim 1, wherein the controller drives the actuator at a regular interval to move the reflector to a preset angle determined using the laws of reflection for the solar light incident angles.

13. The system of claim 1, wherein the mounting means comprises at least one of the
30 following types of components: an adhesive layer and a screw connector.