(12) PATENT (11) Application No. AU 200058048 B2
(19) AUSTRALIAN PATENT OFFICE (10) Patent No. 767224

(54) Title
Device which follows the position of the sun

(51)6 International Patent Classification(s)
G01S 003/786 G02B 026/08
F24J 002/08 G05D 003/10
G02B 005/18 H01L 031/052
G02B 005/32

(21) Application No: 200058048 (22) Application Date: 2000.05.26

(87) WIPO No: WO00/73810

(30) Priority Data

(31) Number	(32) Date	(33) Country
19924783	1999.05.29	DE

(43) Publication Date : 2000.12.18
(43) Publication Journal Date : 2001.03.01
(44) Accepted Journal Date : 2003.11.06

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(56) Related Art
US 4765726

(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

(19) Weltorganisation für geistiges Eigentum
Internationales Büro

(43) Internationales Veröffentlichungsdatum
7. Dezember 2000 (07.12.2000)

PCT

(10) Internationale Veröffentlichungsnummer
WO 00/73810 A1

(51) Internationale Patentklassifikation[7]: G01S 3/786, F24J 2/08, H01L 31/052, G02B 5/18, 26/08, 5/32, G05D 3/10

(21) Internationales Aktenzeichen: PCT/DE00/01778

(22) Internationales Anmeldedatum: 26. Mai 2000 (26.05.2000)

(25) Einreichungssprache: Deutsch

(26) Veröffentlichungssprache: Deutsch

(30) Angaben zur Priorität:
199 24 783.8 29. Mai 1999 (29.05.1999) DE

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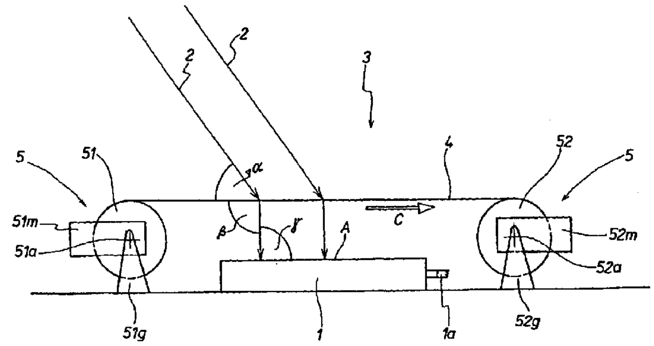
(81) Bestimmungsstaaten (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Bestimmungsstaaten (*regional*): ARIPO-Patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), eurasisches Patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), europäisches Patent (AT, BE, CH, CY, DE, DK, ES, FI,

[Fortsetzung auf der nächsten Seite]

(54) **Title:** DEVICE WHICH FOLLOWS THE POSITION OF THE SUN

(54) **Bezeichnung:** SONNENFOLGEVORRICHTUNG



(57) **Abstract:** The invention relates to a solar installation comprising a solar element and a diffractively and/or refractively functioning optical device via which the incident sunlight is guided onto the solar element in a vertically oriented manner. The optical device is panned by a panning device such that it follows the position of the sun. The optical device (3) uses a light diffracting film (4) which has differently configured sections each comprising a structure the exhibits a different optical effect. The holographic film is moved in relation to the solar element by the operation of the panning device (5) so that consecutive different sections of the film enter an active position above the solar element (1) during panning.

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Optical apparatus

The invention concerns a diffractively and/or refractively operating optical apparatus for passing incident light, preferably sunlight, on to a receiver, preferably on to a solar element, comprising a tracking device which is controlled in dependence on the variation in respect of time of the relative position of the light source and the receiver, preferably in dependence on the position of the sun.

Optical apparatuses of that kind are known from a practical context for use in solar installations. They are associated with the solar elements, to make the most efficient possible use of the sunlight, in order to feed the incident sunlight on to the solar element in as perpendicular a direction as possible. In the practical context of solar engineering that purpose is generally served by using focusing systems with lenses and parabolic mirrors, which suitably deflect and concentrate the light. In order to achieve a respective optimum effect those systems are caused to track the movement of the sun. That requires tracking devices of an expensive structure, which precisely track these generally bulky and heavy optical apparatuses.

A press release in the newspaper 'Frankfurter Allgemeine Zeitung' supplement No 144 of 28th July 1994 contained a report about the use of holographic foil for applying sunlight to solar cells. The holographic foil is intended to replace conventional prisms and lenses. The foil is intended to provide for dividing up the light spectrum in order to supply the light divided up in that way to solar cells which are specifically designed for the respective spectral range.

DE 31 41 789 A1 discloses a sun ray concentrator having a body which is in the form of a prism and which on the entrance face and on the reflection face has a respective material layer with a hologram structure. The parameters of the hologram structure are so selected that the radiation is passed by means of the hologram into the prism and within the prism in such a way that it issues focused at a plurality of end faces of the prism. In that situation, the radiation is concentrated and at the same time the arrangement provides for division into the various spectral ranges, with concentration of the various spectral ranges on the various ray exit faces. The aim is that in that way specific photoconverters can be fed for the respective spectral range. That sun ray concentrator consisting of prisms suffers from the above-described disadvantages in terms of tracking. In addition, because of the prisms, shadow effects occur which reduce the conversion rate.

US No 4 054 356 Al discloses a sun ray concentrator which is in the form of a hologram of a light spot source. The focal point of the hologram lens however is found to be so large that, for the purposes of arranging a receiver for concentrated radiation at the focal point of the lens, an auxiliary device connecting the receiver to the lens is required. In addition this arrangement involves irregular distribution of energy at the surface of the receiver.

DE 30 12 500 Al discloses a retroreflector for use in light barriers and light curtains. The reflector uses diffraction gratings which are formed by holographic procedures in a photosensitive material.

When the reflector is illuminated the radiation impinging thereon is reflected and focused outside the reflector plate with the hologram.

Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is solely for the purpose of providing a context for the present invention. It is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed before the priority date of each claim of this application.

Throughout this specification the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

According to the present invention, there is provided a diffractively and/or refractively operating optical apparatus comprising a receiver, having at least one solar element, for passing incident light, on to the solar element, comprising a tracking device which is controlled in dependence on the variation in respect of time of the relative position of the light source and the receiver wherein it is provided that

the optical apparatus has a transparent or reflective optical body having diffractive and/or refractive and/or holographic regions which deflect and/or concentrate the light, and the optical body is in the form of a foil and/or is on a foil which has portions of a different nature in respect of one or more of its optical parameters along the tracking direction and which can be caused to track by way of the tracking device with relative movement with respect to the receiver by rolling up and unrolling the foil, wherein the different portions of the optical body can be brought into and out of the operative position by virtue of rolling up and unrolling of the foil, and the relative movement of the foil and the solar element,

characterised in that the foil co-operates with the solar element in such a way that light is passed on to the solar element and that the regions of the foil which are different in nature along the tracking direction are associated with at least one solar element and are of a different nature in such a way that a first of the regions co-operates for a first period of time of one or more days with the solar element and a second region adjacent the first region co-operates for a subsequent second period of time of one or more days with said solar element.

The present invention may provide an optical apparatus which is of a simple structure and affords the respectively desired light deflection and/or light concentration effect. The optical apparatus may permit particularly efficient conversion of light in relation to uses in solar installations.

Precise tracking can be implemented in a particularly simple manner by virtue of the fact that in accordance with combination a) the optical body having diffractive and/or refractive and/or holographic regions has portions of a different nature in terms of its optical parameters. The tracking device which acts on the optical body and/or on the receiver produces a relative movement between the optical body and the receiver. In that situation a tracking movement occurs, in which the different portions of the optical body move successively into the operative position. In that situation, the portion of the optical body which in each case is at the time in the operative position forms the portion which is respectively operative at that time and which feeds the light incident at that time to the receiver at the desired irradiation angle or with the desired concentration.

If in accordance with combination b) the optical body is in the form of a foil and/or is on a foil which can be rolled up and unrolled by way of the tracking device, that affords fundamental advantages in terms of simplicity of structure and costs.

Particular advantages are enjoyed in terms of uses in solar installations. The receiver is in the form of a solar element which can remain stationary while the optical device is caused to track the position of the sun. Corresponding advantages are enjoyed in relation to uses in hothouses.

The body of the optical apparatus, which has diffractive and/or refractive and/or holographic regions, has a preferably flat light entrance face and an also preferably flat light exit face. The sunlight impinges on the light entrance face at a given angle of incidence in dependence on the instantaneous position of the light source relative to the receiver, that is to say, in solar installations, in dependence on the position of the sun. The light incident in that fashion passes through the body and in so doing is deflected or concentrated so that the light issues from the body at the light exit face at a given exit angle or with a given concentration and is thus passed to the receiver. The optical parameters of the body are so selected that the exit angle desired for the respective use or the desired concentration is obtained. In relation to uses in solar engineering the optical parameters of the body are such that the exit angle required to make optimum use of the sunlight from the body and the corresponding irradiation angle on to the solar element, as far as possible an irradiation angle of 90°, or maximum concentration, is achieved.

The portions of the optical body, which differ in terms of their optical parameters, can be arranged on or in the body in mutually juxtaposed relationship in the tracking direction, in which respect the portions can be in the form of portions which blend continuously into each other or in the form of separate discrete portions. An arrangement with a continuous transition of the portions affords advantages in regard to continuous tracking. Particular advantages in that respect are achieved if the variation in the optical parameters in the tracking direction is also continuous with a steady progression.

In preferred embodiments the optical body or the foil has at least one region in layer form, with a light diverting and/or concentrating structure. The optical body can be provided with holographic elements, for example the body may have a preferably layered region having a hologram structure. The portions which differ in terms of the optical parameters may be implemented by the portions having different hologram structures. Instead of or in addition to the hologram structure the optical body may have a structure of a diffractive lens or a diffractive mirror in order substantially to concentrate the light. In order to minimise reflection losses at the optical body or the foil the optical body or the foil can be de-reflected on the side which is towards the light source.

The body can be in the form of a rigid or flexible body. Particular advantages are attained when using a holographic foil. The foil can also be in the form of a concentrator foil with the structure of a diffractive lens or a diffractive mirror. The foil may have a plurality of regions involving different lens structures or different mirror structures, those regions being arranged in succession in the tracking direction.

Tracking can be implemented in a particularly simple manner if it is provided that the regions of the foil which are different along the tracking direction are associated with at least one solar element insofar as a first one of the regions co-operates for a first period of time of one or more days with a solar element and a second region of the foil which is adjacent to the first region co-operates for a subsequent second period of time of one or more days with the solar element. For that purpose the foil may have regions which can be associated with the individual days of a year or half-year, preferably 365 or 182 or 183 different regions.

In the case of larger solar installations having a large number of solar elements, a particularly simple structure is afforded if it is provided that a plurality of solar elements are arranged in longitudinal and transverse rows in a grid arrangement and/or the optical body has a plurality of separate regions which are arranged in longitudinal and transverse rows in a grid arrangement, preferably in a corresponding grid arrangement to the solar elements. To implement tracking for compensating for the variation in the position of the light source, it can be provided that the grid arrangement of the solar elements and/or the regions of the optical body is turned through an acute angle relative to the tracking direction and/or the direction of movement of the optical body. Tracking with compensation for the variation in the position of the sun over the course of the year can be achieved if an angle of 0.25° is adopted.

If spectral division of the light occurs at the foil, preferably when the sunlight passes through the holographic foil, it is possible to use spectrum-specific solar cells. It is possible for a plurality of such spectrum-specific solar cells to be arranged in mutually juxtaposed relationship and for the individual light spectra to be fed to the respective solar cells.

When using a flexible foil it is possible to provide for design configurations of the tracking device, which are of a particularly simple structure and which in that respect operate reliably and precisely. The tracking device can be in the form of a foil transport device having at least one foil storage device which receives and/or delivers the foil, preferably a drum. Preferably there is a first drum which winds on the foil during tracking and a second drum which unwinds the foil during tracking. In that case, a foil portion is arranged, preferably in a tensioned condition, between the first and second drums, the foil portion having the respectively operative portion of the light guide and/or light concentrator device. For implementing tracking the first drum is driven in rotation by way of a motor drive. The second drum runs synchronously therewith.

In particular arrangements of the tracking device, there is provided a first transport device which moves the optical body along its main extent. In addition, there can be provided a second transport device which moves the optical body at an angle, preferably at a right angle, with respect to its main extent, or which moves it rotatably about an axis parallel to its main extent. The first or the second transport device is controlled in dependence on the time of day, that is to say in dependence on the position of the sun at the time of day. The other transport device is controlled in dependence on the time of year, that is to say in dependence on the position of the sun at the time of the year.

Further details, features and advantages will be apparent from the description hereinafter of a number of embodiments diagrammatically illustrated in the drawing in which:

Figure 1 is a diagrammatic view of a solar installation,

Figure 2 is a simplified stylised representation of the solar installation of Figure 1 with the position of the sun in the morning,

Figure 3 is a simplified stylised representation of the solar installation of Figure 1 with the position of the sun at midday,

Figure 4 is a simplified stylised representation of the solar installation of Figure 1 with the position of the sun in the afternoon,

Figure 5 is a simplified stylised representation of a solar installation with a foil with a diffractive lens, in the form of a concentrator, with the position of the sun at midday,

Figure 6 is a simplified stylised representation of the solar installation of Figure 5 with the position of the sun in the afternoon,

Figure 7 is a simplified stylised representation of a solar installation with a plurality of solar elements,

Figure 8 shows a foil with lenses in a grid arrangement,

Figure 9 is a simplified stylised representation of a solar installation using the foil of Figure 8, and

Figure 10 is a simplified stylised representation of a solar installation with a foil with a diffractive concave mirror, in the form of a concentrator.

The solar installation in Figure 1 has a solar element 1. The solar element 1 can be an individual solar element or also a battery of solar elements arranged in mutually juxtaposed relationship. The solar element 1 can be in the form of a photovoltaic solar cell or a heat-generating solar collector. The sunlight 2 which is irradiated on to the solar element 1 is converted by the solar element 1 into electrical or heat energy. The energy produced is fed at the output 1a of the solar element into a network (not shown) or an energy storage arrangement.

Associated with the solar element 1 is an optical apparatus 3 which passes the sunlight 2 which is incident at the angle α in dependence on the position of the sun, on to the surface of the solar element 1 as perpendicularly as possible in each case, in order to make the most efficient possible use of the sunlight.

The optical apparatus 3 has a diffractively and/or refractively operating optical body 4 through which the sunlight passes and which in that case deflects the sunlight. In the illustrated embodiment the optical body 4 is in the form of a transparent holographic foil which is tensioned at a spacing above the surface of the solar element 1.

The hologram structure of the irradiated portion of the foil 4, which is arranged above the solar element, is such that the sunlight which is incident on the surface of the foil 4 at the angle α, is deflected on passing through the foil and issues at an angle β at the underside of the foil. The arrangement of the solar element 1 is so selected that the sunlight issuing at the angle β is directed at an angle of preferably 90° on to the surface A of the solar element 1. In the illustrated embodiment the exit angle $\beta = 90°$ and the foil is tensioned in a plane parallel to the surface A of the solar element 1.

In order to provide that efficient use is made of the sunlight at any position of the sun the optical apparatus 3 has a tracking device 5 with which the foil 4 is caused to track the position of the sun relative to the stationarily arranged solar element 1. The tracking device 5 has two synchronously driven drums 51, 52. The drums 51, 52 are arranged parallel to each other at a mutual spacing. They are each rotatably supported in stationarily arranged mounting pedestals 51g, 52g. The foil 4 is tensioned between the drums 51, 52, with the two opposite ends of the foil 4 being wound on the drums 51, 52. The drums 51, 52 are driven in controlled manner by motor means in such a way that they rotate synchronously about their drum axis 51a, 52a. The direction of rotation in Figure 1 is in the clockwise direction so that the foil 4 which is tensioned between the drums 51, 52 is transported from left to right in the direction C. The speed of the transport movement is controlled in dependence on the variation in terms of the time of day of the position of the sun.

During that tracking procedure the foil 4 moves continuously in the direction C. In that situation the foil is wound on to the drum 52 and unwound from the drum 51. Only the respective foil portion which is disposed at the time in the tensioned portion above the solar element 1 has the incident sunlight passing therethrough and only that portion is in fact operative at the time.

Along its main extent, that is to say in the direction of its surface and thus in the tracking direction C, the foil 4 has a varying hologram structure. The variation in the parameters of the hologram structure is so selected that, with a given predetermined speed of transport or tracking movement, continuous adaptation of the light deflection effect to the angle of incidence α which is dependent on the position of the sun, is attained. The adaptation of the hologram structure is such that the exit angle β is approximately constant in the course of the day with the angle of incidence α which is dependent on the position of the sun. That means that the angles β and γ

are approximately constant in the course of the day at any position of the sun and thus the sunlight is equally efficiently used at any position of the sun.

In order to provide for adaptation in terms of the time of year, tracking is additionally provided in respect of the angular position of the plane of the foil with respect to the surface A of the solar element 1. In this case, the plane of the foil is pivoted, preferably together with the drums 51, 52, about a pivot axis arranged parallel to the surface of the solar element in the direction C. In this case, it is provided that the drums 51, 51 involve suitable angular tracking by way of a pivoting mechanism (not shown) which for example is arranged in the region of the mounting pedestals 51g, 52g.

The rotary drive for the drums 51, 52 for the above-described tracking of the foil in the direction C, in respect of the time of day, is afforded by way of separate drive motors 51m, 52m. The drive motor 51m drives the drum shaft 51a. For that purpose, the drive output shaft (not shown) of the drive motor 51m is coupled to the drum shaft 51a by way of a transmission (not shown). The drive motor 52m drives the drum shaft 52a in a corresponding manner. The two motors 51m, 52m are controlled synchronously. The control system is of such a nature that the transport speed, that is to say tracking of the foil 4 in the direction C, takes place in dependence on the variation in the position of the sun, in respect of the time of day.

The foil is retracted at night. That is effected by the drive motors running back in the opposite direction and the foil being unwound from the drum 52 and wound on to the drum 51.

The pivotal movement of the drums 51, 52, which is required for tracking in terms of the time of year, can also be effected by motor means, by way of a drive motor (not shown) which actuates the above-discussed pivoting mechanism in a suitably controlled fashion.

While, in the described embodiment, it was assumed that there was a substantially continuously varying, light-deflecting hologram structure on the foil or the transparent optical body and accordingly that the foil performed a continuous movement over the solar element, it will be appreciated that it is also possible for the optical body to be provided in a quasi discontinuous manner with a corresponding, light-deflecting structure, for example in the form of stripes of the same structure, in which case then the optical body would have to be moved in a correspondingly discontinuous or step-wise manner with respect to the solar element.

The embodiment shown in Figures 5 and 6 also involves a solar installation with a diffractive foil which is guided over a solar element 1 and which is caused to track the position of the sun in terms of the time of day by being wound on and off by way of a tracking device 5 with drums 51, 52 which are only diagrammatically indicated and which in actual fact are substantially larger and which are mounted at a suitable spacing from each other. Unlike the preceding embodiments the foil 4 used in Figures 5 and 6 is a foil which concentrates the incident sunlight. This involves a foil concentrator in the form of a diffractive lens 4a. On passing through the lens 4a the incident sunlight is concentrated so that the image of the sun appears in the solar element 1 arranged at the focal point. When using a foil with a lens diameter of between 1 and 5 cm the spacing of the foil 4 relative to the surface A of the solar element is between 10 and 20 cm.

During the day the foil 4 which is tensioned above the solar element 1 is displaced by the tracking device 5 from left to right in the Figures, that is to say in the East-West direction. In that way the image of the sun which shines down more or less inclinedly over the course of the day in dependence on the position of the sun in terms of the time of day is caused to track so that throughout the entire day the image of the sun falls on the solar element 1 which is arranged in a constant position. Figure 5 shows the position with the sunlight being incident in approximately perpendicular relationship at the midday time. Figure 6 shows the position with the sunlight being incident inclinedly in the afternoon. As can be seen from Figure 6 in that position the foil 4 or the lens 4a is caused to track by displacement towards the right.

The transport speed of the foil 4 for the purposes of tracking in terms of the time of day is f x 0.25 per hour wherein 'f' is the focal length of the lens. In that way the change in the angle of light incidence, which occurs by virtue of the variation in the position of the sun in terms of the time of day and which is about 15° per hour is taken into consideration and the result is precise tracking in respect of the time of day.

In modified embodiments a plurality of solar elements 1a, 1b are arranged in succession in the direction of movement of the foil 4. Figure 7 shows such an arrangement of two solar elements 1a, 1b. The foil 4 which is tensioned above the solar elements 1a, 1b has two lenses 4a, 4b which are arranged in succession in the direction of movement C of the foil. As can be seen from Figure 7 the lens 4a is associated with the solar element 1a and the lens 4b is associated with the solar element 1b, by the lens 4a illuminating the solar element 1a and the lens 4b illuminating the solar element 1b. For that purpose the spacing s of the solar elements 1a, 1b is equal to the spacing between the centre lines of the lenses 4a, 4b. Due to the tracking movement of the foil 4, according to the time of day, the image of the sun is caused to perform a tracking movement with the position of the sun at the respective time of day, so that the image of the sun is incident in each case through the lens 4a in a constant position on the solar element 1a and through the lens 4b in a respective constant position on the solar element 1b.

In the embodiments of Figures 5, 6 and 7, a plurality of solar elements 1a, 1b and so forth may be respectively arranged in mutually juxtaposed relationship in one or more rows transversely with respect to the direction of movement of the foil. When using foils with annular lenses, for that purpose a plurality of lenses 4a, 4b and so forth are arranged on the foil in the transverse direction. The lenses and the associated solar elements of a transverse row are respectively arranged in such a way that the spacing between the centre lines of adjacent lenses is equal to the spacing of the associated adjacent solar elements. In that way, a respective lens of a transverse row is associated with each solar element of a transverse row. In that case, the tracking movement of the foil 4, in respect of the time of day, ensures that each solar element is in each case illuminated permanently during the day by way of the lens associated therewith.

Figure 8 shows a foil portion with lenses 4a, 4b, 4c arranged in a raster or grid arrangement on the foil. The lenses are arranged in mutually juxtaposed relationship in longitudinal and transverse rows which extend at a right angle to each other. In that case, that grid arrangement is turned through an angle of about 0.25° with respect to the direction C in which the foil 4 moves and extends. The angle of 0.25° corresponds to the daily change in the angle of the sun with respect to the solar panel; that change in angle is 47°/182 per day. In that way it is possible to compensate for the daily change in angle of the sun merely by displacement of the foil in the direction C, that is to say without additional adjustment.

Figure 9 shows the use of that foil 4 in a solar installation. The foil is tensioned above the solar elements 1a to 1f arranged in a grid arrangement and is wound on and unwound in the direction C, in the East-West direction. In this case, tracking in respect of the time of day takes place as in the preceding embodiments by displacement of the foil in the course of the day from left to right in Figure 9. In that case, throughout the entire day, there is always a respective lens associated with a given solar element so that the solar element is illuminated through that respective lens. For tracking purposes in respect of the time of year the foil is displaced by a line spacing each day so that therefore each solar element is illuminated by a lens for only one day. On the following day the solar element is illuminated through the following lens. The tracking effect is positively produced upon movement of the foil in the direction C, by virtue of the grid arrangement being turned through the angle of 0.25°. For, due to the grid arrangement being turned in that way, with the daily change in the height of the sun in respect of the time of year above the horizon, relative displacement of the lenses perpendicularly to the direction of propagation is achieved and thus the change in the position of the sun, in terms of the time of year, is compensated.

This means that, in the embodiment shown in Figure 9, the tracking action in respect of the time of day and also in respect of the time of year is effected by the tracking movement of the foil 4 in the direction C. For that purpose the foil 4 can have 182 different lenses arranged in succession in the direction of movement and within a year is moved once completely to and fro by way of the tracking device 5, that is to say to the right in the first half-year in Figure 9 and to the left in the second half-year.

In modified embodiments which, unlike Figures 8 and 9, do not have a grid arrangement which is turned through an angle, tracking in respect of the time of year can also be effected by pivotal movement of the plane of the foil about the axis of movement of the sliding motion or by displacement of the foil in a plane which is inclined with respect to the horizontal and which is towards the sun. When the solar element is arranged on the inclined roof structure of a house, which faces towards the sun, tracking in respect of the time of year therefore occurs by displacement of the foil parallel to the inclined roof structure upwardly or downwardly.

In the modified embodiment shown in Figure 10 the foil 4, in place of the diffractive lens, has a diffractive mirror, a concave mirror 4s. The solar element 1 is arranged on the side of the foil 4, which is towards the sun, at a spacing f (= focal length) in relation to the foil 4. The sunlight which is incident on the mirror 4s is concentrated so that the image of the sun falls on the surface A of the solar element. In a corresponding manner to the preceding embodiments, tracking of the foil is effected by way of a tracking device 5, by displacement of the foil in the direction C. The mirror foil may also have a plurality of mirrors 4s arranged in longitudinal and transverse rows. The foil in that respect can be of a corresponding structure to the foils with a lens structure, which have been described with reference to the embodiments of Figures 5 to 9. Embodiments similar to Figures 4 to 9 are possible with the mirror foils.

The heightwise profile of the diffractive lenses and mirrors used in the described embodiments comprises concentric zones of spherical and paraboloidal cross-sections. Instead of or in addition to those concentric structures the foils 4 may also have transverse structures. The foils may be operative to deflect and concentrate light at the same time.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A diffractively and/or refractively operating optical apparatus comprising a receiver, having at least one solar element, for passing incident light, on to the solar element, comprising a tracking device which is controlled in dependence on the variation in respect of time of the relative position of the light source and the receiver wherein it is provided that

the optical apparatus has a transparent or reflective optical body having diffractive and/or refractive and/or holographic regions which deflect and/or concentrate the light, and

the optical body is in the form of a foil and/or is on a foil which has portions of a different nature in respect of one or more of its optical parameters along the tracking direction and which can be caused to track by way of the tracking device with relative movement with respect to the receiver by rolling up and unrolling the foil, wherein the different portions of the optical body can be brought into and out of the operative position by virtue of rolling up and unrolling of the foil, and the relative movement of the foil and the solar element,

characterised in that the foil co-operates with the solar element in such a way that light is passed on to the solar element and that the regions of the foil which are different in nature along the tracking direction are associated with at least one solar element and are of a different nature in such a way that a first of the regions co-operates for a first period of time of one or more days with the solar element and a second region adjacent the first region co-operates for a subsequent second period of time of one or more days with said solar element.

2. Apparatus according to claim 1, wherein the incident light is sunlight and the tracking device is controlled in dependence on the variation in respect of time of the relative position of the sun.

3. Apparatus according to claim 1 or claim 2 characterised in that the foil has different regions which can be associated with the individual days of a year or half-year.

4. Apparatus according to claim 2 wherein there are 365 or 182 or 183 different regions.

5. Apparatus according to claim 1 or claim 2 or claim 3 or claim 4 characterised in that a plurality of solar elements are arranged in longitudinal and transverse rows in a grid arrangement and/or the optical body has a plurality of separate regions which are arranged in longitudinal and transverse rows in a grid arrangement.

6. Apparatus as claimed in claim 5 wherein the plurality of separate regions are arranged in a corresponding grid arrangement to the solar elements.

7. Apparatus according to claim 6 characterised in that the grid arrangement of the solar elements and/or the regions of the optical body is turned through an acute angle relative to the tracking direction and/or the direction of movement of the optical body to compensate for the variation in the position of the sun over the year.

8. Apparatus according to claim 7 characterised in that the grid arrangement is turned through an angle of 0.25°.

9. Apparatus according to any one of the preceding claims characterised in that the tracking device has a first transport device which moves the optical body in a first tracking direction.

10. Apparatus according to claim 9 wherein the transport device includes a motor and moves the optical body linearly along its main extent.

11. Apparatus according to any one of the preceding claims characterised in that the tracking device has a second transport device which moves the optical body in a second tracking direction in angular relationship with its main extent.

12. Apparatus according to claim 11 wherein the second transport device includes a motor which moves the optical body linearly, and/or with a rotational movement about an axis parallel to the main extent of the optical body.

13. Apparatus according to claim 9, 10 11, or 12 characterised in that the first and/or the second transport device is controlled in dependence on the time of day.

14. Apparatus according to claim 11, 12 or claim 13 characterised in that the first or the second transport device is controlled in dependence on the time of year.

15. Apparatus according to one of claims 9 to 14 characterised in that the optical body is in the form of a flexible foil and the transport device is in the form of a foil transport device having at least one foil storage device for receiving and/or delivering the foil.

16. Apparatus as claimed in claim 14 wherein the first storage device is a drum.

17. Apparatus according to claim 16 characterised in that there is provided a first drum which winds up the foil during the tracking operation and that there is provided a second drum which unwinds the foil during the tracking operation and that a foil portion is arranged tensioned over the solar element between the first and second drums, which foil portion has the portion which is operative with the foil in that position.

18. Apparatus according to any one of the preceding claims characterised in that the different portions are arranged on and/or in the optical body in mutually juxtaposed

relationship in the tracking direction, wherein the portions are in the form of portions which blend continuously into each other or in the form of separate discrete portions.

19. Apparatus according to any one of the preceding claims characterised in that the optical body is in the form of a rigid or flexible body.

20. Apparatus according to any one of the preceding claims characterised in that the optical body or the foil has at least one layered region with a structure which deflects and/or concentrates the light.

21. Apparatus according to any one of the preceding claims characterised in that the foil is de-reflected on the side towards the light source.

22 Apparatus according to any one of the preceding claims characterised in that the light-concentrating structure is in the form of a concentrator foil having the structure of a diffractive lens or a diffractive mirror.

23. Apparatus according to claim 22 characterised in that the foil has a plurality of different lens structure regions or mirror structure regions which are arranged in succession in the tracking direction.

24. A diffractively and/or refractively operating optical apparatus substantially as hereinbefore described with reference to the accompanying drawings.

DATED this twelfth day of September 2003

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Patent Attorneys for the Applicant:

F.B. RICE & CO.

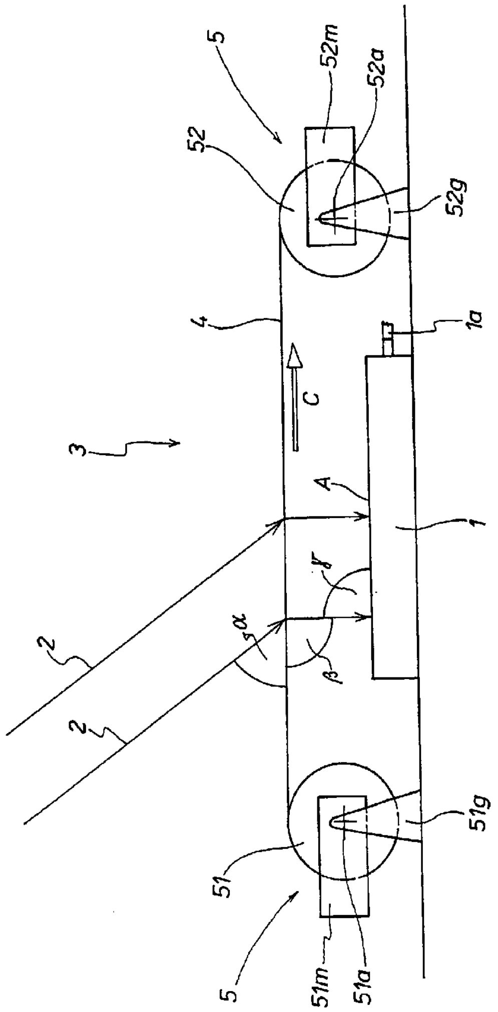

FIG.1

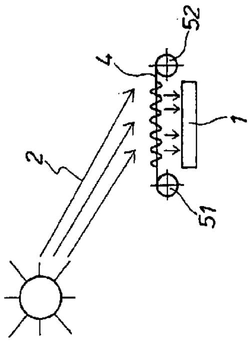

FIG.2

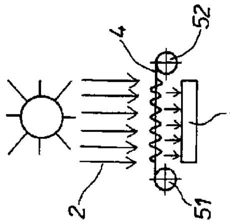

FIG.3

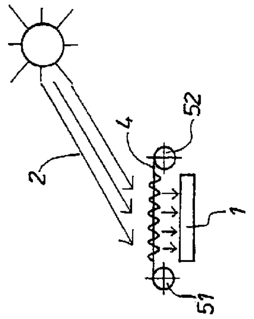

FIG.4

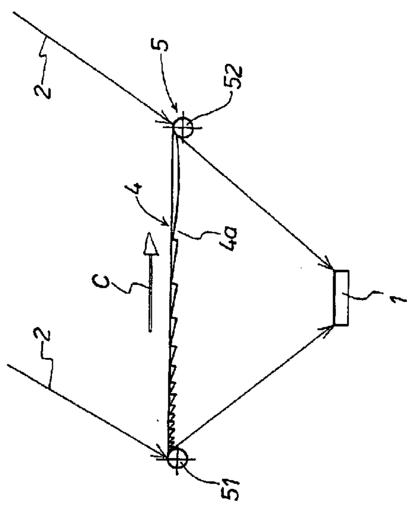

FIG.6

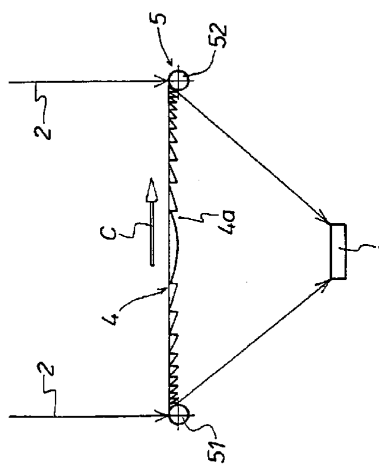

FIG.5

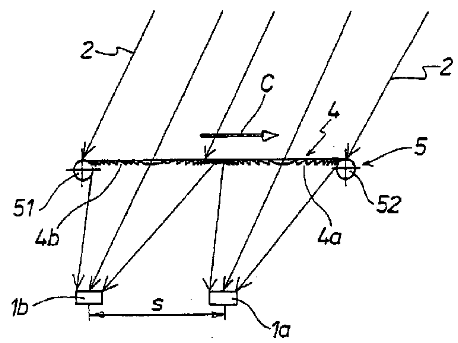

FIG.7

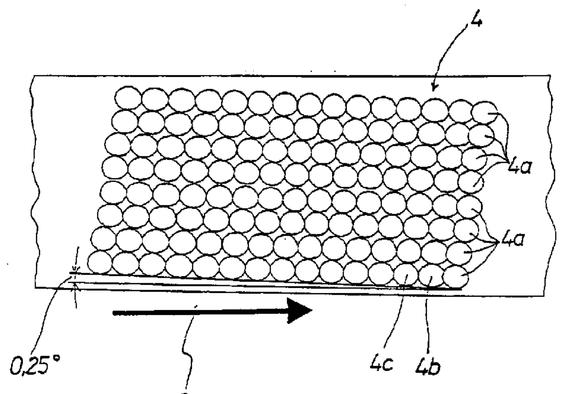

FIG.8

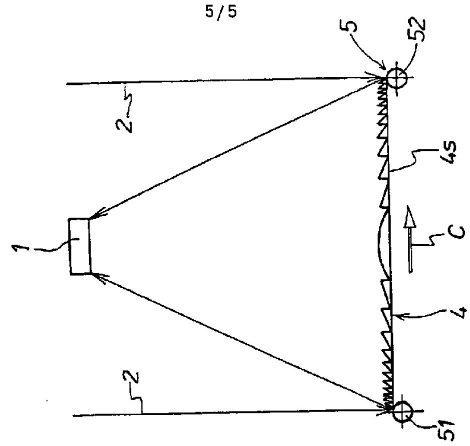

FIG.10

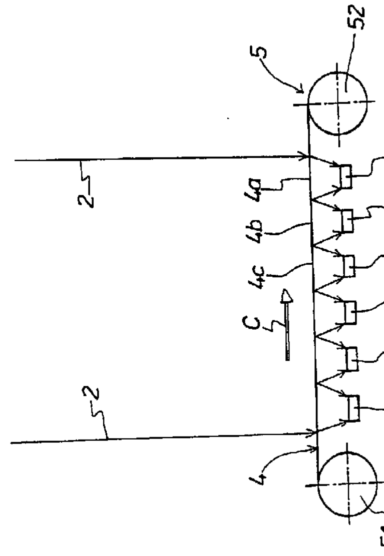

FIG.9