

Description

The present invention relates to an optical filter device for filtering optical energy having a high energy density which propagates along a predetermined optical path, with a rotatable optical filter located to constantly intersect the optical path at a part thereof and with drive means comprising a motor output shaft for rotating said optical filter whereby the optical energy becomes incident on the part of the optical filter which changes every moment due to rotation of the same. An optical filter device of this type is known from DE-B-1260819.

The optical filter device uses a rotatable filter to avoid warm-up effects of the filter which could damage same, as is the case with fixed optical filters.

Optical filters of this type may even be used when solar energy or the energy of artificial light is converged by lenses or the like into light conducting cables or fiber optic cables to propagate therethrough to desired locations.

While the conducted optical energy may be used with all the wavelength components contained therein, a specific component or components of the optical energy may be separated from the others to be used for particular applications. For example the applicant has proposed the use of optical energy conducted by a light conductor as a light source for photosynthesis, typically cultivation of chlorella or forcing culture of plants. For photosynthetic reactions, ultraviolet rays, infrared rays and like components contained in optical energy are harmful. A solution to such a problem may be the use of such a rotatable optical filter to intercept the ultraviolet, infrared or undesirable light components contained in the conducted optical energy while transmitting visible light components only.

However, due to the fact that the optical filter is just rotatable about the axis of the motor output shaft the region on which the high energy containing light hits the filter is always the same. Over long periods of time this may lead to wearing of the optical filter so that service is required from time to time.

It is, therefore, the object of the present invention to provide an optical filter device having an increased service life.

This task is solved in a device as illustrated above, characterized therein that the motor output shaft is movable perpendicularly to its axis of rotation.

With this measure, the area of the filter which is available for the purpose described is widened so that several parts of the filter may be brought into the optical path by moving the filter in a direction perpendicular to the axis of rotation of same.

Preferred embodiments of the invention are claimed in the sub-claims.

The invention will now be described, in detail, with reference to the accompanying drawings:

Figure 1 is a schematic elevation of an artificial

light source apparatus to which the present invention is applicable;

Figure 2 is a view of an optical filter device embodying the present invention;

Figure 3 is a section of another embodiment of the present invention; and

Figure 4 is a view similar to Figure 3 but showing still another embodiment of the present invention.

While the optical filter device of the present invention is susceptible of numerous physical embodiments, depending upon the environment and requirements of use, substantial numbers of the herein shown and described embodiments have been made, tested and used, and all have performed in an eminently satisfactory manner.

Referring to Fig. 1 of the drawing, an artificial light source apparatus to which the present invention is applicable is shown. The apparatus includes an artificial light source 10 which is disposed in a housing 12. A lens 14 is fixed in place inside a hollow cylindrical member 16 which extends from one end of the light source housing 12 to a second housing 18. The arrangement is such that the focal point of the lens 14 is located in a predetermined position in the housing 18. The housing 18 is formed with a window 20 through a side wall thereof so that one may see the neighborhood of the focal point of the lens 14. A light conducting cable 22 is fixed to the housing 18 through a connector 24 such that a light receiving end thereof is positioned at the focal point of the lens 14 within the housing 18.

In the apparatus shown in Fig. 1, the light source 10, lens 14 and a member for fixing the light receiving end of the fiber optic cable 22 are constructed integrally with each other so as to define the focal point of the lens 14. Meanwhile, an arrangement is made such that the light receiving end of the cable 22 is adjustable in position relative to the focal point of the lens 14 within a plane which is perpendicular to the optical axis of the lens 14. These allow the light receiving end of the cable 22 to be accurately positioned at the focal point of the lens 14.

As previously described, the converged optical energy introduced into the cable 22 is usable as a light source for photosynthesis such as forcing culture of plants or chlorella cultivation. For such applications, the light source 10 may comprise a xenon lamp or the like whose luminous intensity is relatively high. In such a case, ultraviolet rays, infrared rays and like components contained in the optical energy emanating from the light source 10 have to be cut off because they are harmful for photosynthetic reactions. Such may be implemented by placing an optical filter in the optical path between the light source 10 and the light conductor 22. However, problems have been left unsolved as already discussed concerning the use of an optical filter.

Referring to Fig. 2, an optical filter device embodying the present invention is shown and comprises a circular optical filter, or disc, 30. The filter 30 is mounted on drive means such as an

output shaft 32 of a motor 34. The rest of the construction is similar in principle to the light source apparatus shown in Fig. 1 and, therefore, employs like reference numerals to designate similar structural elements.

As shown in Fig. 2, the filter or disc 30 is positioned in such a manner as to intersect the optical path between the light source 10 and the light receiving end of the light conducting cable 22. The filter 30 is rotated by the motor 34 through the motor output shaft 32. While the filter 30 is in rotation, a part thereof through which the converged light from the lens 14 having a high energy density is transmitted sequentially changes moment by moment. Stated another way, a given part of the disc 30 is used once for each rotation of the filter 30.

The filter 30 is heated only in its part on which the optical energy is incident and such an area sequentially changes in accordance with the rotation of the disc 30. The heated part of the filter 30 is cooled while the optical energy is not incident thereon so that, as a whole, the filter 10 is prevented from being heated to an objectionably high temperature. The filter 30 may be rotated at a speed high enough to raise wind therearound which would also serve to suppress temperature elevation of the disc 30. Furthermore, the motor output shaft 32 for rotating the disc 30 is moved perpendicularly to its axis as indicated by a double-headed arrow A in Fig. 2. Such a movement widens the area of the disc 30 which is available for the purpose described, thereby additionally increasing the service life of the disc 30.

Referring to Fig. 3, another embodiment of the present invention is shown which is constructed to filter incident optical energy so as to deliver light components having different wavelengths for different applications. As shown, the optical filter device comprises a filter 36 which has a generally triangular section and is rigidly mounted on a rotatable shaft 38, which may be the motor output as shaft shown in Fig. 2. The filter 36 is positioned to intersect an optical path for light L, while being inclined relative to the optical path by a desired angle θ . A first light conducting cable 40 is located on the optical path downstream of the filter 36, and a second light conducting cable 42 in a position substantially perpendicularly to the optical path. In this particular embodiment, the filter 36 is made of a material which is transparent for visible rays and reflective for ultraviolet rays and/or infrared rays.

In operation, because the filter 36 is positioned at a predetermined angle θ relative to the optical path along which the light L propagates, it may transmit a visible component L_1 of the light therethrough towards the light conductor 40 while reflecting infrared rays L_2 and ultraviolet rays (and X rays) L_3 toward the light conductor 42. The visible rays L_1 may be used for the cultivation of chlorella or forcing culture of plants, for example, and the infrared rays L_2 and ultraviolet rays L_3 for other applications.

The filter 36 may comprise a color glass filter CF

or CF—IRF (TOSHIBA GLASS) which reflects infrared rays only. Alternatively, a thin layer of gold may be deposited by evaporation on the surface of the filter 36 in order to reflect ultraviolet rays as well as infrared rays.

Because the filter 36 in Fig. 3 is rotatably disposed in the optical path, it is prevented from being thermally destroyed or deteriorated by the light L which propagates through the optical path. Wind raised by the rotating filter 36 will also cool the disc as previously described.

Referring to Fig. 4, still another embodiment of the present invention is shown. The filter device in accordance with this embodiment comprises a first filter member 44 and a second filter member 46 which are commonly mounted on the rotatable shaft 38 as illustrated. The filter member 44 is adapted to reflect infrared rays L_2 while transmitting other light components, and the filter member 46 is adapted to reflect ultraviolet rays L_3 (and infrared rays) while transmitting other light components. Constructed in the manner described, the filter device of Fig. 4 is capable of separating infrared rays, ultraviolet rays and visible rays from the incident light L independently of each other.

Although the embodiments of the present invention have been shown and described in conjunction with an artificial light source which emits light containing substantial amounts of infrared and ultraviolet rays, e.g. xenon lamp, it will readily occur to those skilled in the art that the present invention is also applicable to an optical path along which solar energy converged to have a high energy density propagates.

In summary, it will be seen that the present invention provides an optical filter device which is capable of filtering optical energy having a high energy density incident thereon without being thermally destructed or deteriorated.

Claims

1. An optical filter device (30, 32, 34) for filtering optical energy having a high energy density which propagates along a pre-determined optical path with a rotatable optical filter (30, 36, 44, 46) located to constantly, intersect the optical path at a part thereof, with drive means (32, 34, 38) comprising a motor output shaft (32, 38) for rotating said optical filter (30, 36, 44, 46) whereby the optical energy becomes incident on the part of the optical filter which changes every moment due to rotation of the optical filter, characterized in that the motor output shaft (32, 38) is movable perpendicularly (A) to its axis of rotation.

2. An optical filter device as claimed in claim 1, in which the optical filter comprises a disc (30) which is positioned perpendicularly to the optical path to transmit only a component of the optical energy which has a particular wavelength.

3. An optical filter device as claimed in claim 2, in which the component of the optical energy transmitted through the filter (30, 36, 44, 46) is visible ray.

4. An optical filter device as claimed in claim 1, in

output shaft 32 of a motor 34. The rest of the construction is similar in principle to the light source apparatus shown in Fig. 1 and, therefore, employs like reference numerals to designate similar structural elements.

As shown in Fig. 2, the filter or disc 30 is positioned in such a manner as to intersect the optical path between the light source 10 and the light receiving end of the light conducting cable 22. The filter 30 is rotated by the motor 34 through the motor output shaft 32. While the filter 30 is in rotation, a part thereof through which the converged light from the lens 14 having a high energy density is transmitted sequentially changes moment by moment. Stated another way, a given part of the disc 30 is used once for each rotation of the filter 30.

The filter 30 is heated only in its part on which the optical energy is incident and such an area sequentially changes in accordance with the rotation of the disc 30. The heated part of the filter 30 is cooled while the optical energy is not incident thereon so that, as a whole, the filter 10 is prevented from being heated to an objectionably high temperature. The filter 30 may be rotated at a speed high enough to raise wind therearound which would also serve to suppress temperature elevation of the disc 30. Furthermore, the motor output shaft 32 for rotating the disc 30 is moved perpendicularly to its axis as indicated by a double-headed arrow A in Fig. 2. Such a movement widens the area of the disc 30 which is available for the purpose described, thereby additionally increasing the service life of the disc 30.

Referring to Fig. 3, another embodiment of the present invention is shown which is constructed to filter incident optical energy so as to deliver light components having different wavelengths for different applications. As shown, the optical filter device comprises a filter 36 which has a generally triangular section and is rigidly mounted on a rotatable shaft 38, which may be the motor output as shaft shown in Fig. 2. The filter 36 is positioned to intersect an optical path for light L, while being inclined relative to the optical path by a desired angle θ . A first light conducting cable 40 is located on the optical path downstream of the filter 36, and a second light conducting cable 42 in a position substantially perpendicularly to the optical path. In this particular embodiment, the filter 36 is made of a material which is transparent for visible rays and reflective for ultraviolet rays and/or infrared rays.

In operation, because the filter 36 is positioned at a predetermined angle θ relative to the optical path along which the light L propagates, it may transmit a visible component L_1 of the light therethrough towards the light conductor 40 while reflecting infrared rays L_2 and ultraviolet rays (and X rays) L_3 toward the light conductor 42. The visible rays L_1 may be used for the cultivation of chlorella or forcing culture of plants, for example, and the infrared rays L_2 and ultraviolet rays L_3 for other applications.

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Referring to Fig. 4, still another embodiment of the present invention is shown. The filter device in accordance with this embodiment comprises a first filter member 44 and a second filter member 46 which are commonly mounted on the rotatable shaft 38 as illustrated. The filter member 44 is adapted to reflect infrared rays L_2 while transmitting other light components, and the filter member 46 is adapted to reflect ultraviolet rays L_3 (and infrared rays) while transmitting other light components. Constructed in the manner described, the filter device of Fig. 4 is capable of separating infrared rays, ultraviolet rays and visible rays from the incident light L independently of each other.

Although the embodiments of the present invention have been shown and described in conjunction with an artificial light source which emits light containing substantial amounts of infrared and ultraviolet rays, e.g. xenon lamp, it will readily occur to those skilled in the art that the present invention is also applicable to an optical path along which solar energy converged to have a high energy density propagates.

In summary, it will be seen that the present invention provides an optical filter device which is capable of filtering optical energy having a high energy density incident thereon without being thermally destroyed or deteriorated.

Claims

1. An optical filter device (30, 32, 34) for filtering optical energy having a high energy density which propagates along a pre-determined optical path with a rotatable optical filter (30, 36, 44, 46) located to constantly, intersect the optical path at a part thereof, with drive means (32, 34, 38) comprising a motor output shaft (32, 38) for rotating said optical filter (30, 36, 44, 46) whereby the optical energy becomes incident on the part of the optical filter which changes every moment due to rotation of the optical filter, characterized in that the motor output shaft (32, 38) is movable perpendicularly (A) to its axis of rotation.

2. An optical filter device as claimed in claim 1, in which the optical filter comprises a disc (30) which is positioned perpendicularly to the optical path to transmit only a component of the optical energy which has a particular wavelength.

3. An optical filter device as claimed in claim 2, in which the component of the optical energy transmitted through the filter (30, 36, 44, 46) is visible ray.

4. An optical filter device as claimed in claim 1, in



which the optical filter comprises a filter member (36, 44, 46) which is inclined at a pre-determined angle (θ) relative to the optical path (L) to transmit a component of the optical energy having a particular wavelength and reflect at least one of the components in the other wavelength range.

5. An optical filter device as claimed in claim 4, in which said component of the optical energy transmitted through the filter (36, 44, 46) is a visible ray and said at least one of the components reflected by the filter is at least one of infrared or ultraviolet rays.

Patentansprüche

1. Optische Filtereinrichtung (30, 32, 34) zum Filtern optischer Energie mit einer hohen Energiedichte, die sich entlang eines vorbestimmten optischen Weges fortpflanzt, mit einem drehbaren optischen Filter (30, 36, 44, 46), das so angeordnet ist, daß es den optischen Weg in einem Teil konstant unterbricht, mit einer Antriebseinrichtung (32, 34, 38), die zum Drehantrieb des optischen Filters (30, 36, 44, 46) eine Motorausgangswelle (32, 38) aufweist, so daß die optische Energie auf einen Teil des optischen Filters fällt, der sich fortlaufend aufgrund der Drehung des optischen Filters ändert, dadurch gekennzeichnet, daß die Motorausgangswelle (32, 38) senkrecht (A) zu ihrer Drehachse bewegbar ist.

2. Optische Filtereinrichtung nach Anspruch 1, wobei das optische Filter eine Scheibe (30) aufweist, die senkrecht zum optischen Weg angeordnet ist, so daß sie nur eine Komponente der optischen Energie mit einer bestimmten Wellenlänge überträgt.

3. Optische Filtereinrichtung nach Anspruch 2, wobei die Komponente der optischen Energie, die durch das Filter (30, 36, 44, 46) übertragen wird, sichtbare Strahlen sind.

4. Optische Filtereinrichtung nach Anspruch 1, wobei das optische Filter ein Filterelement (36, 44, 46) umfaßt, welches in einem bestimmten Winkel (θ) bezüglich des optischen Wegs (L) angeordnet ist, um eine Komponente der optischen Energie einer bestimmten Wellenlänge zu übertragen und wenigstens eine der Komponenten anderer Wellenlängen zu reflektieren.

5. Optische Filtereinrichtung nach Anspruch 4, wobei die durch das Filter (36, 44, 46) übertragene optische Energiekomponente eine sichtbare Strahlung ist und wobei die wenigstens eine vom Filter reflektierte Komponente wenigstens Infrarot- oder Ultraviolett-Strahlung ist.

Revendications

1. Dispositif de filtre optique (30, 32, 34) pour filtrer de l'énergie optique à forte densité énergétique, se propageant suivant un chemin optique prédéterminé, comprenant un filtre optique rotatif (30, 36, 44, 46) positionné pour couper constamment le chemin optique par une partie de filtre, un moyen d'entraînement (32, 34, 38) avec un arbre de sortie de moteur (32, 38) pour faire tourner le filtre optique (30, 36, 44, 46), de sorte que la partie du filtre sur laquelle tombe l'énergie optique change sans cesse à cause de la rotation du filtre, caractérisé en ce que l'arbre de sortie de moteur (32, 38) est déplaçable perpendiculairement (A) à son axe de rotation.

2. Dispositif selon la revendication 1, dans lequel le filtre optique est un disque (30) orienté perpendiculairement au chemin optique et conçu pour transmettre seulement une composante de longueur d'onde particulière de l'énergie optique.

3. Dispositif selon la revendication 2, dans lequel la composante de l'énergie optique transmise à travers le filtre (30, 36, 44, 46) est formée de rayons visibles.

4. Dispositif selon la revendication 1, dans lequel le filtre optique comprend un élément filtrant (36, 44, 46) qui est incliné sous un angle (θ) prédéterminé par rapport au chemin optique (L), en vue de la transmission d'une composante de l'énergie optique ayant une longueur d'onde particulière, et en vue de la réflexion d'au moins l'une des composantes ayant d'autres longueurs d'onde.

5. Dispositif selon la revendication 4, dans lequel la composante de l'énergie optique transmise à travers le filtre (36, 44, 46) est formée de rayons visibles et la composante ou les composantes réfléchi(e)s par le filtre est ou sont formée(s) de rayons infrarouges et/ou de rayons ultraviolets.



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