

Description

This invention relates to a device for dispersing light rays issuing from a light guide, said device comprising a body of a rigid transparent material, one end of said body being in a light receiving relationship to the light guide and the upper end of said body being tapered to define a nearly conical peripheral surface tapering towards a point located in alignment with the axis of said body and pointing away from said light guide so that those light rays entering from said light guide into that body at a small angle of intersection with respect to the axis of the body are reflected back into the body at least one time by the internal boundary of said nearly conical peripheral surface, thereby to propagate through the body at a larger angle of intersection with respect to said axis, whereby said light rays issuing from the light guide, the other end of which is in a light receiving relationship to a light source, are dispersed as they leave said body.

More specifically, this invention relates to a light dispersing device utilizing solar radiation as a source of light energy and wherein a light guide, such as an optical fiber bundle, is employed to conduct light energy from a light source.

The use of visible light energy from solar radiation for interior lighting purposes has been proposed and various lighting systems utilizing solar radiation have been contemplated. Such lighting systems generally comprise a solar beam receiver for collecting and collimating solar radiation and a light guide for conducting light energy from the receiver to an area to be illuminated. The lighting system utilizing solar radiation as a source of light energy has acquired considerable industrial applicability because of the development of an optical fiber cable of a high quality. The optical fiber bundle, now available on the market, is not only able to transmit light energy at an extremely low transmission loss, but has sufficient flexibility to enable light rays to be conducted along a curved complex optical path provided between a light source and the area to be illuminated. An optical fiber cable or bundle comprises a plurality of individual optical fibers, each consisting of a central core glass and a surrounding clad layer. During transmission through the core glass, those light rays having an angle of incidence smaller than the critical angle of incidence of the core forming glass are not totally reflected by the interface or boundary defined between the core and clad and, therefore, penetrate wholly or partially therethrough toward the clad layer to leak out of the optical fiber. Thus, only those light rays having an angle of incidence larger than the critical angle of incidence of the core material are totally reflected by the boundary and, on repeating reflection, transmit throughout the fiber. This results in the cone angle, defined by issuing light rays at the exit end of the optical fiber, being limited so that if light rays are allowed to issue out of the end of the optical fiber cable, illumination takes place only in a spotlight-like

fashion. Normally, the cone angle of light rays issuing from an optical fiber cable does not exceed about 48 degrees for an optical fiber cable having a value of numerical aperture (NA) of about 0.2.

It has also been proposed to use solar radiation for underwater lighting purposes. A solar receiver or collector is provided on the sea or water surface and an optical fiber cable may be extended therefrom to the bottom of the body of water. The visible or non-visible light energy conducted through the fiber cable is used to illuminate areas underwater, so that fishes can be gathered or plant planktons or edible sea vegetables can be raised. In the case of lighting an aerial space with the optical fiber cable, there is a substantial refraction at the exit end of the cable due to difference between indices of refraction of two adjacent mediums, because light rays transmit from the core glass, which has a high index of refraction, to the air, which has a low index of refraction. However, when the optical fiber cable is placed in an aqueous medium, such as water for underwater illumination purposes, the core glass of the cable is obliged to contact the water. The index of refraction of water is lower than that of the core glass but is higher than that of the air. Thus, the difference of indices of refraction between the core glass and water is little, so that the cone angle of issuing light rays is further narrowed.

Further, US-A-2,080,259 discloses a light dispersing device of the general type indicated above, namely an artificial candle having an integral tip member so constructed that it simulates a candle in appearance when illuminated. The tip member is intended to produce therein an illuminated image of the member, this image being clearly defined and producing a flame-like effect. To this end, lateral surface of the tip member T is made concave for the major portion of its length. Further, an incandescent electrical light bulb is used as a light source.

Moreover, US-A-1,351,562 discloses an illusion apparatus having a glass rod being transparent except at its upper end. The upper end is translucent, as by being ground or frosted, to render it light diffusing. The upper end can also be designed to represent a candle flame, the surface of which is rendered capable of diffusing light by frosting. Again an electrical light bulb is used as a light source.

Therefore, an object of the present invention is to provide a device for dispersing light rays issuing from a light guide, which device is simple in construction and easy to manufacture, which is effective in broadening the cone angle of the light rays issuing from the light guide and which is effectively operable, even in an aqueous medium.

According to the invention, this object is accomplished in that the light transmitting relationship between the light guide and said one end of said body is achieved by a central opening in said body for receiving therein the end of the light guide, and that said nearly conical peripheral

surface of said body is curved toward said tapered end thereof, so that the angle formed between the axis of the body and the line tangential to said surface in a plane of said axis gradually increases toward said tapered end.

The body of the device according to the invention may be made from any suitable rigid transparent material, such as acrylic resins and glass, but acrylic resins are preferable, since glass absorbs the reddish component in the spectrum of light.

Preferably, the tapered end is hermetically enclosed within a rigid transparent housing to prevent water from entering into said housing during an underwater operation of the device. Further, it is preferred that a pressurized inert gas is filled in said housing to enhance the sealability of said housing at a high water pressure.

According to another preferred embodiment of the invention the tapered end is enclosed with a rigid transparent protective housing to prevent access to said tapered end, said protective housing having a plurality of cooling apertures to allow cooling air to enter into said protective housing. Such protecting housing prevents persons or inflammable materials from contacting the tapered end of the body of the inventive device.

The invention will now be described in more detail with reference to the embodiments thereof illustrated in the accompanying drawings, in which:

Fig. 1 is a cross-sectional elevational view of the device according to the invention;

Fig. 2 is a cross-sectional elevational view of another embodiment provided with a protective housing; and

Fig. 3 is a cross-sectional elevational view of a further embodiment having a sealed housing.

Referring to Fig. 1, there is shown a light dispersing device 10 comprising an elongated body 12 made from transparent rigid acrylic resins. The body 12 consists of an upper cylindrical portion 14 and a lower tapered portion 16 integral to the upper portion. The cylindrical portion 14 is provided with a cylindrical central opening 18 in the form of a blind bore in which an end of an optical fiber bundle 20 is closely fitted. The other end, not shown, of the optical fiber bundle 20 is optically connected to a light source, such as a solar receiver or collector, so that visible light rays are introduced into the optical fiber bundle and are conducted therethrough. The end 22 of the fiber bundle inserted into the central opening 18 is cut perpendicular to the longitudinal axis Y of the body 12 to mate with the bottom of the opening 18 and is firmly bonded thereto by suitable transparent adhesives. The tapered portion 16 defines a nearly conical peripheral surface which is slightly rounded or curved towards the lowermost end, so that the angle formed between the axis of the body and the line tangential to the surface in a plane passing through the body axis gradually increases toward that end.

In operation, light rays are allowed to issue

from the light emitting end 22 of the optical fiber bundle 20. Those light rays, having a large angle of intersection with respect to the axis Y, arrive at the internal boundary of the tapered surface at a small angle of incidence and thus pass therethrough as shown by arrow A. However, those light rays having a small angle of intersection reach the internal boundary at a larger angle of incidence and are reflected totally or partly back into the body as shown by arrow B. As the surface of the tapered portion is inclined with respect to the body axis Y, the reflected light rays B have a larger angle of intersection with respect to the axis Y and it is then possible for these reflected rays to pass through the opposite boundary surface. Those light rays having a further smaller angle of intersection will be reflected more than one time before they leak out of the body. Thus, the angle of cone of light rays issuing from the optical fibers is increased as light rays finally leave the light ray dispersing device of the invention.

In the illustrated embodiment, the peripheral surface of the tapered portion is rounded. This is to prevent the majority of light rays from leaving the area of the surface located in the close vicinity of the light emitting end 22 of the fiber bundle and to ensure that the luminous intensity per unit surface area of the tapered portion's surface is uniformly distributed over the surface. However, the configuration of the tapered portion is not limited to that illustrated and, instead, the tapered portion may be shaped in any other suitable manner.

Fig. 2 shows another embodiment of the invention, wherein like parts are indicated by like reference numerals. In this embodiment, the tapered portion 16, particularly the pointed end thereof, is encapsulated within a protective housing 30 secured to the body 12. The protective housing 30 has a spherical configuration and is made from a similar rigid transparent material, such as acrylic resins. A plurality of apertures 32 are formed on the housing wall to allow cooling air to enter into the housing. The protective housing according to this embodiment ensures isolating the pointed end of the tapered portion from other accessible materials or the human body and, thus, prevents the operator from being burned or injured by the heated pointed end of the device, as well as preventing a fire hazard from occurring when an inflammable material comes close thereto. As an alternative, the protective housing may be made from a network of metal wires or other sufficiently rigid material formed into a spherical shape.

Fig. 3 illustrates another embodiment of the invention which is designed for lighting areas underwater. The tapered portion 16 of the device is enclosed by a liquid tight protective housing 40 which is sealingly secured to the cylindrical portion 14 to prevent water from entering into the housing. With this arrangement, the tapered portion is always surrounded by an air layer, even though the device is submerged underwater. This

ensures refraction to take place as light rays pass from the body of acrylic resins to air and also ensures reflection to take place at the boundary of the tapered portion, such that light rays are dispersed in the same manner as when the device is operated in ambient air. This embodiment is particularly useful in underwater illumination for the purposes of artificially growing edible sea herbs or raising fishes on the sea bottom or in the sea. The underwater lighting system utilizing the optical fiber cable and the light dispersing device according to the invention does not need an electrical element and, thus, is free from the problem of electric leakage that would occur in an electric light system. Preferably, the protective housing 40 is filled in with a pressurised inert gas, such as nitrogen, carbon dioxide or argon, in order to reduce the pressure difference between the housing and the surrounding water and to improve the seal of the housing.

Claims

1. A device for dispersing light rays issuing from a light guide (20), said device comprising a body (12) of a rigid transparent material, one end of said body (12) being in a light receiving relationship to the light guide (20) and the upper end of said body (12) being tapered to define a nearly conical peripheral surface (16) tapering towards a point located in alignment with the axis (Y) of said body (12) and pointing away from said light guide (20) so that those light rays entering from said light guide (20) into that body (12) at a small angle of intersection with respect to the axis (Y) of the body (12) are reflected back into the body (12) at least one time by the internal boundary of said nearly conical peripheral surface (16), thereby to propagate through the body (12) at a larger angle of intersection with respect to said axis (Y), whereby said light rays (A, B) issuing from the light guide (20), the other end of which is in a light receiving relationship to a light source, are dispersed as they leave said body (12), characterized in that the light transmitting relationship between the light guide (20) and said one end of said body (12) is achieved by a central opening (18) in said body (12) for receiving therein the end of the light guide (20), and that said nearly conical peripheral surface (16) of said body (12) is curved toward said tapered end thereof, so that the angle formed between the axis (Y) of the body (12) and the line tangential to said surface in a plane of said axis (Y) gradually increases toward said tapered end.

2. A device as claimed in claim 1, characterized in that said tapered end (16) is hermetically enclosed with a rigid transparent housing (40) to prevent water from entering into said housing (40) during an underwater operation of the device.

3. A device as claimed in claim 2, characterized in that a pressurized inert gas is filled in said housing (40) to enhance the sealability of said housing (40) at a high water pressure.

4. A device as claimed in claim 1, characterized in that said tapered end (16) is enclosed with a rigid transparent protective housing (30) to prevent access to said tapered end (16), said protective housing (30) having a plurality of cooling apertures (32) to allow cooling air to enter into said protective housing (30).

Patentansprüche

1. Vorrichtung zum Streuen von Lichtstrahlen, die aus einer Lichtführung (20) austreten, wobei diese Vorrichtung einen Körper (12) aus einem starren, transparenten Material umfasst, wobei ein Ende dieses Körpers (12) derart mit der Lichtführung (20) gekoppelt ist, daß er Licht von dieser übernimmt, und wobei das obere Ende dieses Körpers (12) sich derart verjüngt, daß eine nahezu konische Umfangsoberfläche (16) definiert wird, die sich in Richtung auf einen Punkt verjüngt, der mit der Achse (Y) dieses Körpers (12) fluchtet und der von der Lichtführung (20) weg weist, so daß diejenigen Lichtstrahlen, die von der Lichtführung (20) in den Körper (12) unter einem kleinen Winkel bezüglich der Achse (Y) des Körpers (12) eintreten, mindestens einmal durch die interne Grenzfläche der nahezu konischen Umfangsfläche (16) in den Körper (12) zurück reflektiert werden, so daß sie sich durch den Körper (12) unter einem größeren Winkel bezüglich der Achse (Y) ausbreiten, wodurch die Lichtstrahlen (A, B), welche aus der Lichtführung (20) austreten, deren anderes Ende derart mit einer Lichtquelle gekoppelt ist, daß sie von dieser Licht übernimmt, gestreut werden, wenn sie den Körper (12) verlassen, dadurch gekennzeichnet, daß die Lichtübertragungskoppelung zwischen der Lichtführung (20) und dem einen Ende des Körpers (12) durch eine zentrale Öffnung (18) in dem Körper (12) zur Aufnahme des Endes der Lichtführung (20) erreicht wird und daß die nahezu konische Umfangsfläche (16) des Körpers (12) in Richtung auf das sich verjüngende Ende desselben so gekrümmt ist, daß der Winkel zwischen der Achse (Y) des Körpers (12) und einer an diese Oberfläche in einer Ebene dieser Achse (Y) angelegte Tangente allmählich in Richtung auf das sich verjüngende Ende ansteigt.

2. Vorrichtung gemäß Anspruch 1, dadurch gekennzeichnet, daß das sich verjüngende Ende (16) hermetisch von einem starren, transparenten Gehäuse (40) umschlossen wird, um zu verhindern, daß bei einem Unterwasserteinsatz der Vorrichtung Wasser in das Gehäuse (40) eintritt.

3. Vorrichtung gemäß Anspruch 2, dadurch gekennzeichnet, daß in das Gehäuse (40) ein unter Druck stehendes Inertgas eingefüllt ist, um die Abdichtbarkeit des Gehäuses (40) bei hohen Wasserdrücken zu verbessern.

4. Vorrichtung gemäß Anspruch 1, dadurch gekennzeichnet, daß das sich verjüngende Ende (16) von einem starren, transparenten Schutzgehäuse (30) umschlossen ist, um einen Zugriff zu dem sich verjüngenden Ende (16) zu verhindern, wobei das Schutzgehäuse (30) eine Vielzahl von Kühlöff-

ensures refraction to take place as light rays pass from the body of acrylic resins to air and also ensures reflection to take place at the boundary of the tapered portion, such that light rays are dispersed in the same manner as when the device is operated in ambient air. This embodiment is particularly useful in underwater illumination for the purposes of artificially growing edible sea herbs or raising fishes on the sea bottom or in the sea. The underwater lighting system utilizing the optical fiber cable and the light dispersing device according to the invention does not need an electrical element and, thus, is free from the problem of electric leakage that would occur in an electric light system. Preferably, the protective housing 40 is filled in with a pressurised inert gas, such as nitrogen, carbon dioxide or argon, in order to reduce the pressure difference between the housing and the surrounding water and to improve the seal of the housing.

Claims

1. A device for dispersing light rays issuing from a light guide (20), said device comprising a body (12) of a rigid transparent material, one end of said body (12) being in a light receiving relationship to the light guide (20) and the upper end of said body (12) being tapered to define a nearly conical peripheral surface (16) tapering towards a point located in alignment with the axis (Y) of said body (12) and pointing away from said light guide (20) so that those light rays entering from said light guide (20) into that body (12) at a small angle of intersection with respect to the axis (Y) of the body (12) are reflected back into the body (12) at least one time by the internal boundary of said nearly conical peripheral surface (16), thereby to propagate through the body (12) at a larger angle of intersection with respect to said axis (Y), whereby said light rays (A, B) issuing from the light guide (20), the other end of which is in a light receiving relationship to a light source, are dispersed as they leave said body (12), characterized in that the light transmitting relationship between the light guide (20) and said one end of said body (12) is achieved by a central opening (18) in said body (12) for receiving therein the end of the light guide (20), and that said nearly conical peripheral surface (16) of said body (12) is curved toward said tapered end thereof, so that the angle formed between the axis (Y) of the body (12) and the line tangential to said surface in a plane of said axis (Y) gradually increases toward said tapered end.

2. A device as claimed in claim 1, characterized in that said tapered end (16) is hermetically enclosed with a rigid transparent housing (40) to prevent water from entering into said housing (40) during an underwater operation of the device.

3. A device as claimed in claim 2, characterized in that a pressurized inert gas is filled in said housing (40) to enhance the sealability of said housing (40) at a high water pressure.

4. A device as claimed in claim 1, characterized in that said tapered end (16) is enclosed with a rigid transparent protective housing (30) to prevent access to said tapered end (16), said protective housing (30) having a plurality of cooling apertures (32) to allow cooling air to enter into said protective housing (30).

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2. Vorrichtung gemäß Anspruch 1, dadurch gekennzeichnet, daß das sich verjüngende Ende (16) hermetisch von einem starren, transparenten Gehäuse (40) umschlossen wird, um zu verhindern, daß bei einem Unterwassereinsatz der Vorrichtung Wasser in das Gehäuse (40) eintritt.

3. Vorrichtung gemäß Anspruch 2, dadurch gekennzeichnet, daß in das Gehäuse (40) ein unter Druck stehendes Inertgas eingefüllt ist, um die Abdichtbarkeit des Gehäuses (40) bei hohen Wasserdrücken zu verbessern.

4. Vorrichtung gemäß Anspruch 1, dadurch gekennzeichnet, daß das sich verjüngende Ende (16) von einem starren, transparenten Schutzgehäuse (30) umschlossen ist, um einen Zugriff zu dem sich verjüngenden Ende (16) zu verhindern, wobei das Schutzgehäuse (30) eine Vielzahl von Kühlöff-



nungen (32) aufweist, damit Kühlluft in das Schutzgehäuse (30) eintreten kann.

Revendications

1. Un dispositif pour disperser des rayons de lumière sortant d'un guide de lumière (20), ce dispositif comprenant un corps (12) en une matière rigide transparente, une extrémité du corps (12) étant en couplage optique avec le guide (20) de lumière et l'extrémité supérieure dudit corps (12) étant convergente pour délimiter une surface périphérique (16) presque conique convergeant vers un point situé en alignement avec l'axe (Y) dudit corps (12) et orientée en s'éloignant dudit guide (20) de lumière de sorte que ceux des rayons lumineux entrant dans ledit corps (12) en provenance dudit guide (20) de lumière sous un angle d'intersection faible par rapport à l'axe (Y) du corps (12) sont réfléchis en retour dans le corps (12) au moins une fois par la limite interne de ladite surface périphérique (16) presque conique de façon à se propager à travers le corps (12) avec un angle d'intersection plus grand par rapport audit axe (Y), de sorte que les rayons de lumière (A, B) sortant du guide (20) de lumière dont l'autre extrémité est en couplage optique avec une source lumineuse, sont dispersés lorsqu'ils sortent dudit corps (12); caractérisé en ce que la relation de transmission de lumière entre le guide (20) de lumière et ladite une extrémité du

corps (12) est réalisée avec un trou central (18) dans ledit corps (12) pour recevoir dans celui-ci l'extrémité du guide (20) de lumière, et en ce que ladite surface périphérique (16) presque conique dudit corps (12) est incurvée vers ladite extrémité convergente du corps, de manière que l'angle formé entre l'axe (Y) du corps (12) et la tangente à ladite surface dans un plan dudit axe (Y) augmente progressivement en direction de ladite extrémité convergente.

2. Un dispositif tel que revendiqué dans la revendication 1, caractérisé en ce que ladite extrémité convergente (16) est enfermée hermétiquement dans un boîtier rigide transparent (40) pour empêcher l'eau de pénétrer dans ledit boîtier (40) lors du fonctionnement du dispositif sous l'eau.

3. Un dispositif tel que revendiqué dans la revendication 2, caractérisé en ce que ledit boîtier (40) est rempli d'un gaz inerte sous pression afin de renforcer l'étanchéité dudit boîtier (40) sous une pression d'eau élevée.

4. Un dispositif tel que revendiqué dans la revendication 1, caractérisé en ce que ladite extrémité convergente (16) est enfermée dans un boîtier protecteur rigide transparent (30) afin d'empêcher l'accès à ladite extrémité convergente (16), ledit boîtier protecteur (30) comportant plusieurs trous de refroidissement (32) pour permettre à de l'air de refroidissement de pénétrer dans ledit boîtier protecteur (30).

