

## Description

The invention relates to a light source apparatus for culturing plants comprising a condensing lens for collecting sunlight, having a light input surface and a light output surface; a light conducting cable having a light receiving end which is positioned on an optical axis of the condensing lens, said light receiving end being movable into the focal point of rays transmitted through the lens and having different wavelengths.

In the EP—A—0062847 such a system has been proposed, in which the sunlight converged by a lens into a light conducting member propagates therethrough to a desired location for lighting and other applications. For example, the converged light is usable for photosynthesis, that is, cultivation of chlorella or forcing culture of plants. In such an application, infrared rays and ultraviolet rays contained in the solar energy are harmful for photosynthetic reactions.

In the EP—A—0062847 document the optical cable is, therefore, movable along the axis of the condensing lens so that the light receiving end of the optical cable can be positioned at different focal points of the different light rays for transmitting the desired wavelength. However, when the light receiving end of the optical cable is positioned at the focal point of visible rays it cannot prevent that also UV rays are guided into and through the optical cable.

It has recently been found that only in a specific stage of cultivation the applying of ultraviolet rays to plants is desirable. It was found that the applying of ultraviolet rays to plants, which are ready for harvest, promotes secretion of dead hormone of the plants, or maturing of the plants, thereby increasing the sweetness or giving better smell and/or colour. In the other stages of cultivation, ultraviolet rays should not be used because they are harmful for the desired photosynthetic reactions.

It is, therefore, the object of the present invention to provide an apparatus of the type as mentioned above which allows ultraviolet rays to selectively reach plants in a specific stage of cultivation.

This task is solved with the apparatus mentioned above being characterized in that an optical filter is deposited on the central zone of the lens, said filter intercepting ultraviolet rays and infrared rays and that said light receiving end being movable into the focal point of visible rays transmitted through the lens body and into the focal point of the ultraviolet rays transmitted through the lens body.

With these features the condensing lens carries an optical filter in a central portion thereof which includes the optical axis. The filter intercepts ultraviolet rays and infrared rays, except for those which are incident on an exposed peripheral portion of the lens. The filtered light is conducted by a light conducting cable to a plant cultivating station for photosynthesis. The light receiving

end of the cable is usually located at the focal point of visible rays output from the lens and at the time of harvest may be placed at the focal point of ultraviolet rays.

Preferred embodiments of the invention are disclosed in the depending claims.

The invention will now be described with reference to the accompanying drawings.

## Brief Description of the Drawing

Figs. 1—4 are sections of various embodiments of a condensing lens, used in an apparatus in accordance with the present invention.

Referring to Fig. 1 of the drawing, a condensing lens is shown and generally designated by the reference numeral 10. The lens 10 comprises a lens body 12. The sunlight, or optical energy, L is incident on the condensing lens 10 and converged thereby into a light conducting member 14, which is located on an optical axis of the lens 10. The lens body 12 may be made of any desired material (quartz, glass, acrylic resin, etc.) or provided with any desired configuration (Fresnel lens, single lens, etc.).

An optical filter member 16 is fit on a radially central area of the lens body 12 which includes the optical axis. The filter member 16 comprises a thin layer of gold which is deposited on the lens body 12 by evaporation. Therefore, the filter member 16 is reflective for infrared rays and ultraviolet rays (and X-rays) while being transmissive for visible rays. That is, infrared rays and ultraviolet rays in the sunlight L are reflected by the filter member 16 before reaching the light conductor 14, except for the peripheral exposed portion of the lens body 12.

In detail, the optical energy L containing infrared rays and ultraviolet rays is converged by the peripheral portion of the condensing lens 10 into the light conductor 14. The visible end of the infrared rays R is focussed to a point  $R_0$ , and the visible end of the ultraviolet rays V to a point  $V_0$ . In the situation depicted in Fig. 1 the diameter of the light conductor 14 and the position of a light receiving end 14a of the light conductor 14 on the optical axis are so selected as to prevent the converged infrared and ultraviolet rays from reaching the interior of the light conductor 14. Thus it is possible to introduce only the visible rays into the light conductor 14.

While the condensing lens has been shown and described in conjunction with the sunlight, it is similarly applicable to any desired artificial light source. For example, when applied to a xenon lamp or like artificial light source which contains substantial quantities of infrared and ultraviolet rays, the condensing lens 10 will remove the infrared and ultraviolet rays before the light reaches the light conductor. The condenser lens may even be used to cut infrared rays and/or ultraviolet rays contained in light which is emitted from a light source other than those mentioned above.

Referring to Figs. 2—4, other embodiments are shown. In Fig. 2, an optical filter member 22 is

carried on the other or light output surface of the lens body 20. Again, the filter 22 consists of a thin layer of gold deposited on the lens body 20 by evaporation. The lens body 20 may comprise a Fresnel lens. In Fig. 3, a lens body 30 carries thereon a first filter member 32 which is absorptive for infrared rays and a second filter member 34 which is absorptive for ultraviolet rays. The two filter members 32 and 34 are respectively positioned on opposite sides of the lens body 30. In Fig. 4, there is shown a condensing lens which has a first filter member 42 absorptive for infrared rays and a second filter member 44 absorptive for ultraviolet rays, the filter members 42 and 44 being laid one upon the other in a central portion of the lens body 40.

The reflection type filter members such as shown in Figs. 1 and 2 will less suffer from thermal deterioration due to infrared and ultraviolet rays than the absorption type filter members such as shown in Figs. 3 and 4 and, for this reason, they are desirably applicable to an optical path along which optical energy having a high energy density propagates.

In Fig. 1, the light conductor 14 terminates at a plant cultivation chamber (not shown) at its end which is opposite to the light receiving end 14a. An arrangement is made such that the light receiving end 14a of the light conductor is movable on the optical axis of the lens 10 toward and away from the focal point  $V_0$  of ultraviolet rays, which has been previously described.

Usually, the light conductor 14 is located such that the infrared and ultraviolet rays condensed by the peripheral portion of the lens body 12 are prevented from reaching the light receiving end 14a of the light conductor 14. Under this condition, the visible rays allowed to propagate through the light conductor 14 are used for effective photosynthesis of plants in the cultivation chamber. At the time of harvest, on the other hand, the light conductor 14 is moved to have its light receiving end 14a aligned with the focal point  $V_0$  of ultraviolet rays. In such a position, the light conductor 14 transmits the ultraviolet rays to the plant cultivation chamber. When ultraviolet rays are applied to plants which have been matured enough for harvest, they promote secretion of dead hormone of the plants to sweeten the plants (e.g. fruit), give better smell to the plants (e.g. laver), or give better color (e.g. tomato and persimmon).

#### Claims

1. A light source apparatus for culturing plants, comprising a condensing lens (10, 20, 30, 40, 50) for collecting sunlight (L), having a light input surface and a light output surface; a light conducting cable (14) having a light receiving end (14a) which is positioned on an optical axis of the condensing lens, said light receiving end being movable into the focal point ( $V_0$ ,  $R_0$ ) of rays transmitted through the lens and having different wavelengths characterized in that an optical filter

(16, 22, 32, 34, 42, 44, 52) is deposited on the central zone of the lens, said filter intercepting ultraviolet rays and infrared rays and that said light receiving end being movable into the focal point of visible rays transmitted through the lens body and into the focal point of the ultraviolet rays transmitted through the lens body.

2. Apparatus as claimed in claim 1, in which the lens body (12) comprises a Fresnel lens.

3. Apparatus as claimed in claim 1, in which said optical filter (16) is made of a reflection type filter member.

4. Apparatus as claimed in claim 1, in which said optical filter (22, 32, 34, 42, 44, 52) is made of an absorption type filter member.

5. Apparatus as claimed in claim 1, in which said optical filter (16, 32, 42, 44) is deposited on the light input surface of the lens body.

6. Apparatus as claimed in claim 1, in which said optical filter (22, 34, 52) is deposited on the light output surface of the lens body (12).

7. Apparatus as claimed in claim 3, in which said optical filter (16) comprises a thin layer of gold which is reflective for ultraviolet rays and infrared rays and deposited on the lens body (12) by evaporation.

8. Apparatus as claimed in claim 4, in which said optical filter comprises a first filter member (32, 42) absorptive for ultraviolet rays and a second filter member (34, 44) absorptive for infrared rays.

9. Apparatus as claimed in claim 8, in which the first filter member (32) is deposited on the light input or the light output surface of the lens body (12), and the second filter member (34) is deposited on the other.

10. Apparatus as claimed in claim 8, in which the first and second filter members (42, 44) are arranged one upon the other on the light input or the light output surface of the lens body (12).

#### Patentansprüche

1. Lichtquellenvorrichtung zur Züchtung von Pflanzen, mit einer Sammellinse (10, 20, 30, 40, 50) zum Sammeln von Sonnenlicht (L), die eine Lichteinfallsfläche und eine Lichtausfallsfläche aufweist; mit einem lichtleitenden Kabel (14), das ein lichtempfangendes Ende (14a) aufweist, das auf der optischen Achse der Kondensorlinse angeordnet ist, wobei das lichtempfangende Ende in den Fokus ( $V_0R_0$ ) von Strahlen bewegt werden kann, die durch die Linse hindurchtreten, und die unterschiedliche Wellenlängen haben, dadurch gekennzeichnet, daß ein optisches Filter 16, 22, 32, 34, 42, 44, 52) im Mittelbereiche der Linse angebracht ist, daß dieses Filter UV-Strahlung und Infrarot-Strahlung filtert, und daß das lichtempfangende Ende in den Fokuspunkt sichtbarer, durch den Linsenkörper hindurchgelangender Strahlung bewegbar ist und in den Fokuspunkt von UV-Strahlen, die durch den Linsenkörper hindurchtreten.

2. Vorrichtung nach Anspruch 1, wobei der Linsenkörper (12) eine Fresnel-Linse umfaßt.

carried on the other or light output surface of the lens body 20. Again, the filter 22 consists of a thin layer of gold deposited on the lens body 20 by evaporation. The lens body 20 may comprise a Fresnel lens. In Fig. 3, a lens body 30 carries thereon a first filter member 32 which is absorptive for infrared rays and a second filter member 34 which is absorptive for ultraviolet rays. The two filter members 32 and 34 are respectively positioned on opposite sides of the lens body 30. In Fig. 4, there is shown a condensing lens which has a first filter member 42 absorptive for infrared rays and a second filter member 44 absorptive for ultraviolet rays, the filter members 42 and 44 being laid one upon the other in a central portion of the lens body 40.

The reflection type filter members such as shown in Figs. 1 and 2 will less suffer from thermal deterioration due to infrared and ultraviolet rays than the absorption type filter members such as shown in Figs. 3 and 4 and, for this reason, they are desirably applicable to an optical path along which optical energy having a high energy density propagates.

In Fig. 1, the light conductor 14 terminates at a plant cultivation chamber (not shown) at its end which is opposite to the light receiving end 14a. An arrangement is made such that the light receiving end 14a of the light conductor is movable on the optical axis of the lens 10 toward and away from the focal point  $V_0$  of ultraviolet rays, which has been previously described.

Usually, the light conductor 14 is located such that the infrared and ultraviolet rays condensed by the peripheral portion of the lens body 12 are prevented from reaching the light receiving end 14a of the light conductor 14. Under this condition, the visible rays allowed to propagate through the light conductor 14 are used for effective photosynthesis of plants in the cultivation chamber. At the time of harvest, on the other hand, the light conductor 14 is moved to have its light receiving end 14a aligned with the focal point  $V_0$  of ultraviolet rays. In such a position, the light conductor 14 transmits the ultraviolet rays to the plant cultivation chamber. When ultraviolet rays are applied to plants which have been matured enough for harvest, they promote secretion of dead hormone of the plants to sweeten the plants (e.g. fruit), give better smell to the plants (e.g. laver), or give better flavor (e.g. tomato and persimmon).

#### Claims

1. A light source apparatus for culturing plants, comprising a condensing lens (10, 20, 30, 40, 50) for collecting sunlight (L), having a light input surface and a light output surface; a light conducting cable (14) having a light receiving end (14a) which is positioned on an optical axis of the condensing lens, said light receiving end being movable into the focal point ( $V_0$ ,  $R_0$ ) of rays transmitted through the lens and having different wavelengths characterized in that an optical filter

(16, 22, 32, 34, 42, 44, 52) is deposited on the central zone of the lens, said filter intercepting ultraviolet rays and infrared rays and that said light receiving end being movable into the focal point of visible rays transmitted through the lens body and into the focal point of the ultraviolet rays transmitted through the lens body.

2. Apparatus as claimed in claim 1, in which the lens body (12) comprises a Fresnel lens.

3. Apparatus as claimed in claim 1, in which said optical filter (16) is made of a reflection type filter member.

4. Apparatus as claimed in claim 1, in which said optical filter (22, 32, 34, 42, 44, 52) is made of an absorption type filter member.

5. Apparatus as claimed in claim 1, in which said optical filter (16, 32, 42, 44) is deposited on the light input surface of the lens body.

6. Apparatus as claimed in claim 1, in which said optical filter (22, 34, 52) is deposited on the light output surface of the lens body (12).

7. Apparatus as claimed in claim 3, in which said optical filter (16) comprises a thin layer of gold which is reflective for ultraviolet rays and infrared rays and deposited on the lens body (12) by evaporation.

8. Apparatus as claimed in claim 4, in which said optical filter comprises a first filter member (32, 42) absorptive for ultraviolet rays and a second filter member (34, 44) absorptive for infrared rays.

9. Apparatus as claimed in claim 8, in which the first filter member (32) is deposited on the light input or the light output surface of the lens body (12), and the second filter member (34) is deposited on the other.

10. Apparatus as claimed in claim 8, in which the first and second filter members (42, 44) are arranged one upon the other on the light input or the light output surface of the lens body (12).

#### Patentansprüche

1. Lichtquellenvorrichtung zur Züchtung von Pflanzen, mit einer Sammellinse (10, 20, 30, 40, 50) zum Sammeln von Sonnenlicht (L), die eine Lichteinfallfläche und eine Lichtausfallfläche aufweist; mit einem lichtleitenden Kabel (14), das ein lichtempfangendes Ende (14a) aufweist, das auf der optischen Achse der Kondensorlinse angeordnet ist, wobei das lichtempfangende Ende in den Fokus ( $V_0R_0$ ) von Strahlen bewegt werden kann, die durch die Linse hindurchtreten, und die unterschiedliche Wellenlängen haben, dadurch gekennzeichnet, daß ein optisches Filter 16, 22, 32, 34, 42, 44, 52 im Mittelbereiche der Linse angebracht ist, daß dieses Filter UV-Strahlung und Infrarot-Strahlung filtert, und daß das lichtempfangende Ende in den Fokuspunkt sichtbarer, durch den Linsenkörper hindurchgelangender Strahlung bewegbar ist und in den Fokuspunkt von UV-Strahlen, die durch den Linsenkörper hindurchtreten.

2. Vorrichtung nach Anspruch 1, wobei der Linsenkörper (12) eine Fresnel-Linse umfaßt.



3. Vorrichtung nach Anspruch 1, wobei das optische Filter (16) ein Reflektionsfilterelement enthält.

4. Vorrichtung nach Anspruch 1, wobei das optische Filter (22, 32, 34, 42, 44, 52) ein Absorptionsfilterelement ist.

5. Vorrichtung nach Anspruch 1, wobei das optische Filter (16, 32, 42, 44) auf der Lichteinfallfläche des Linsenkörpers angebracht ist.

6. Vorrichtung nach Anspruch 1, wobei das optische Filter (22, 34, 52) auf der Lichtausfallfläche des Linsenkörpers (12) angebracht ist.

7. Vorrichtung nach Anspruch 3, wobei das optische Filter (16) eine dünne Goldschicht umfaßt, die für UV-Strahlung und für Infrarotstrahlung reflektierend ist, und die auf dem Linsenkörper (12) durch Aufdampfen abgetrennt worden ist.

8. Vorrichtung nach Anspruch 4, wobei das optische Filter ein erstes Filterelement (32, 42) umfaßt, das UV-Strahlung absorbiert, sowie ein zweites Filterelement (34, 44), das Infrarotstrahlung absorbiert.

9. Vorrichtung nach Anspruch 8, wobei das erste Filterelement (32) auf der Lichteinfall- oder der Lichtausfallfläche des Linsenkörpers (12) befestigt ist, und wobei das zweite Filterelement (34) auf der jeweils anderen Seite befestigt ist.

10. Vorrichtung nach Anspruch 8, wobei das erste und das zweite Filterelement (42, 44) übereinander auf der Lichteinfall- oder der Lichtausfallfläche des Linsenkörpers (12) liegend angeordnet sind.

#### Revendications

1. Un appareil à source lumineuse pour culture de plantes, comprenant une lentille de concentration (10, 20, 30, 40, 50) pour collecter de la lumière solaire (L), comportant une surface d'entrée de lumière et une surface de sortie de lumière; un câble conducteur de lumière (14) comportant une extrémité réceptrice de lumière (14a) qui est disposée sur un axe optique de la lentille de concentration, ladite extrémité réceptrice de lumière étant déplaçable jusqu'au point focal ( $V_0$ ,  $R_0$ ) de rayons transmis au travers de la lentille et ayant des longueurs d'ondes différentes, caractérisé en ce qu'un filtre optique (16, 22, 32, 34, 42, 44, 52)

est déposé sur la zone centrale de la lentille, ledit filtre interceptant des rayons ultraviolets et des rayons infrarouges, et en ce que ladite extrémité réceptrice de lumière peut être amenée au point focal de rayons visibles transmis au travers du corps de lentille et au point focal de rayons ultraviolets transmis au travers du corps de lentille.

2. Appareil tel que revendiqué dans la revendication 1, dans lequel le corps de lentille (12) comprend une lentille de Fresnel.

3. Appareil tel que revendiqué dans la revendication 1, dans lequel ledit filtre optique (16) est constitué d'un élément de filtrage du type réfléchissant.

4. Appareil tel que revendiqué dans la revendication 1, dans lequel ledit filtre optique (22, 32, 34, 42, 44, 52) est constitué d'un élément de filtrage du type absorbant.

5. Appareil tel que revendiqué dans la revendication 1, dans lequel ledit filtre optique (16, 32, 42, 44) est déposé sur la surface d'entrée de lumière du corps de lentille.

6. Appareil tel que revendiqué dans la revendication 1, dans lequel ledit filtre optique (22, 34, 52) est déposé sur la surface de sortie de lumière du corps de lentille (12).

7. Appareil tel que revendiqué dans la revendication 3, dans lequel ledit filtre optique (16) comprend une mince couche d'or qui réfléchit des rayons ultraviolets et des rayons infrarouges et qui est déposée sur le corps de lentille (12) par évaporation.

8. Appareil tel que revendiqué dans la revendication 4, dans lequel ledit filtre optique comprend un premier élément de filtrage (32, 42) absorbant des rayons ultraviolets et un second élément de filtrage (34, 44) absorbant des rayons infrarouges.

9. Appareil tel que revendiqué dans la revendication 8, dans lequel le premier élément de filtrage (32) est déposé sur la surface d'entrée de lumière ou la surface de sortie de lumière du corps de lentille (12), et le second élément de filtrage (34) est déposé sur l'autre.

10. Appareil tel que revendiqué dans la revendication 8, dans lequel le premier et le second élément de filtrage (42, 44) sont disposés l'un sur l'autre sur la surface d'entrée de lumière ou la surface de sortie de lumière du corps de lentille (12).



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