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(54) **ELECTRICALLY ADJUSTABLE OPTICAL
DIFFUSION FOR LUMINAIRES**

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G02B 26/02 (2006.01)
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H04N 5/225; G02F 1/1334
USPC 349/16, 86, 193; 348/370; 359/599;
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See application file for complete search history.

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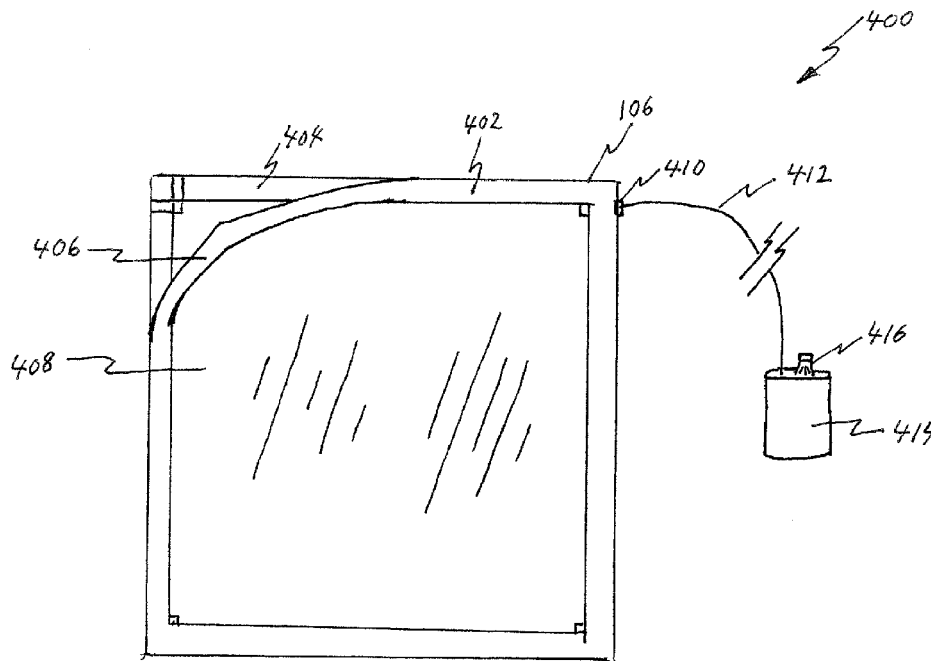
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(57) **ABSTRACT**

An electrically adjustable optical diffusion panel for use in film or video production having a frame, diffusion material affixed to the frame, where the transparency of the material is continuously and variably changeable between a substantially transparent state and a substantially opaque state in response to an electric potential applied to electrodes of the material and a controller and battery. The electrically adjustable diffusion panel eliminates the need for manually changing diffusion papers or other filters and provides a continuous range of selectable levels of transparency/diffusion.

19 Claims, 5 Drawing Sheets



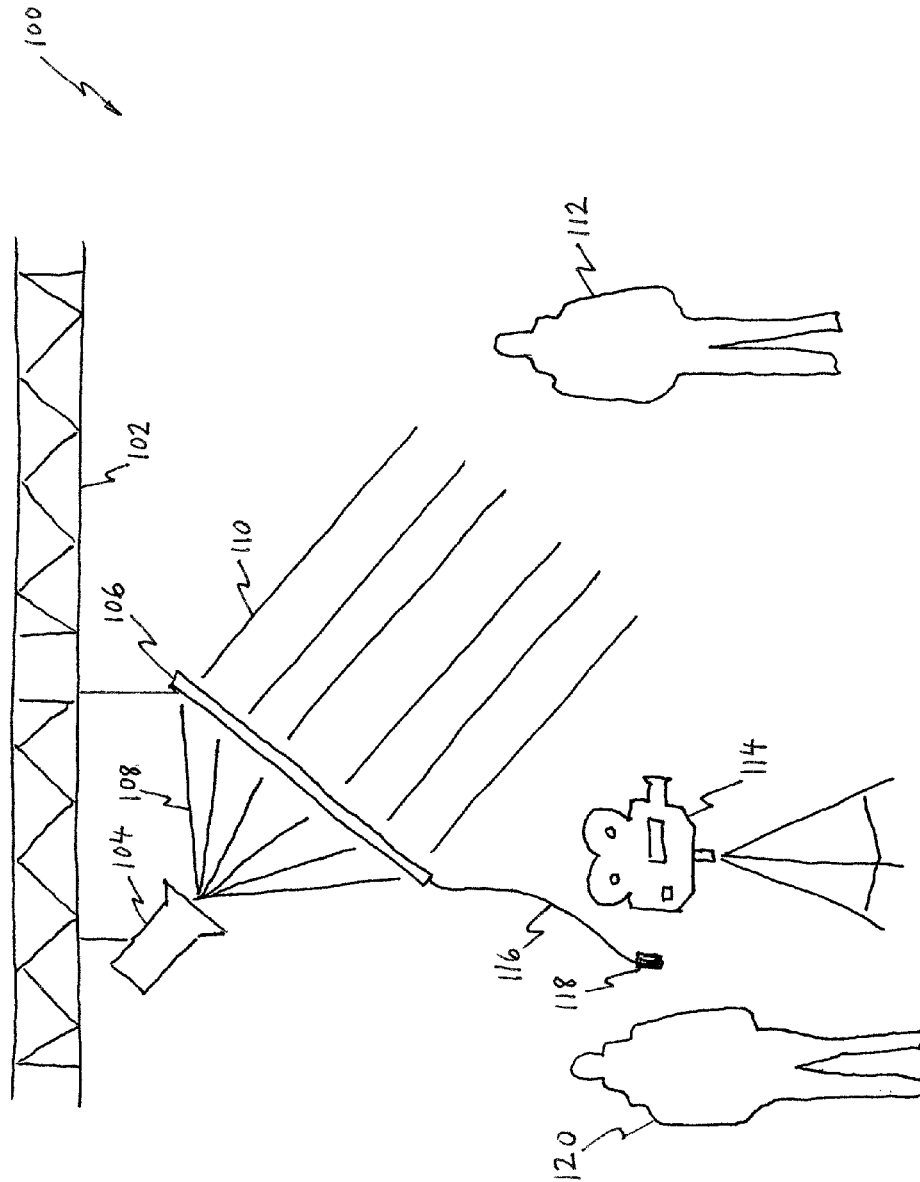
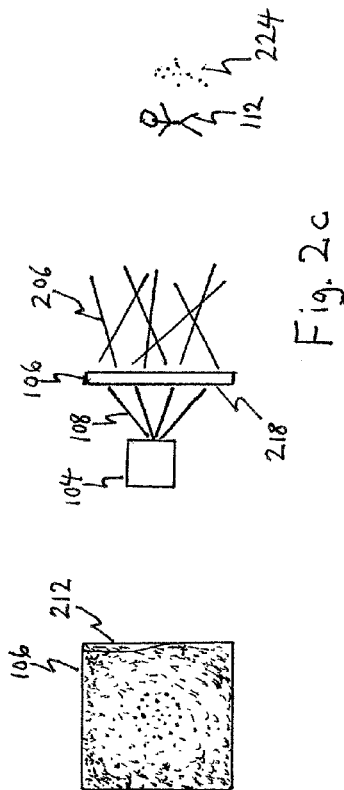
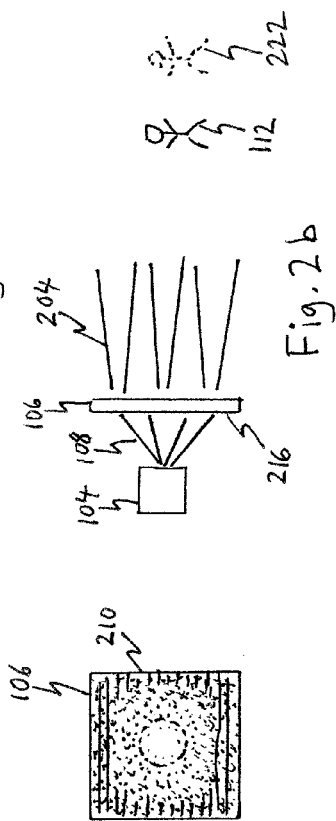
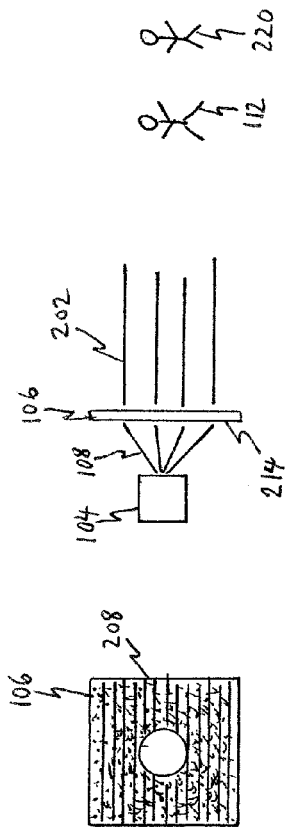


Fig. 1



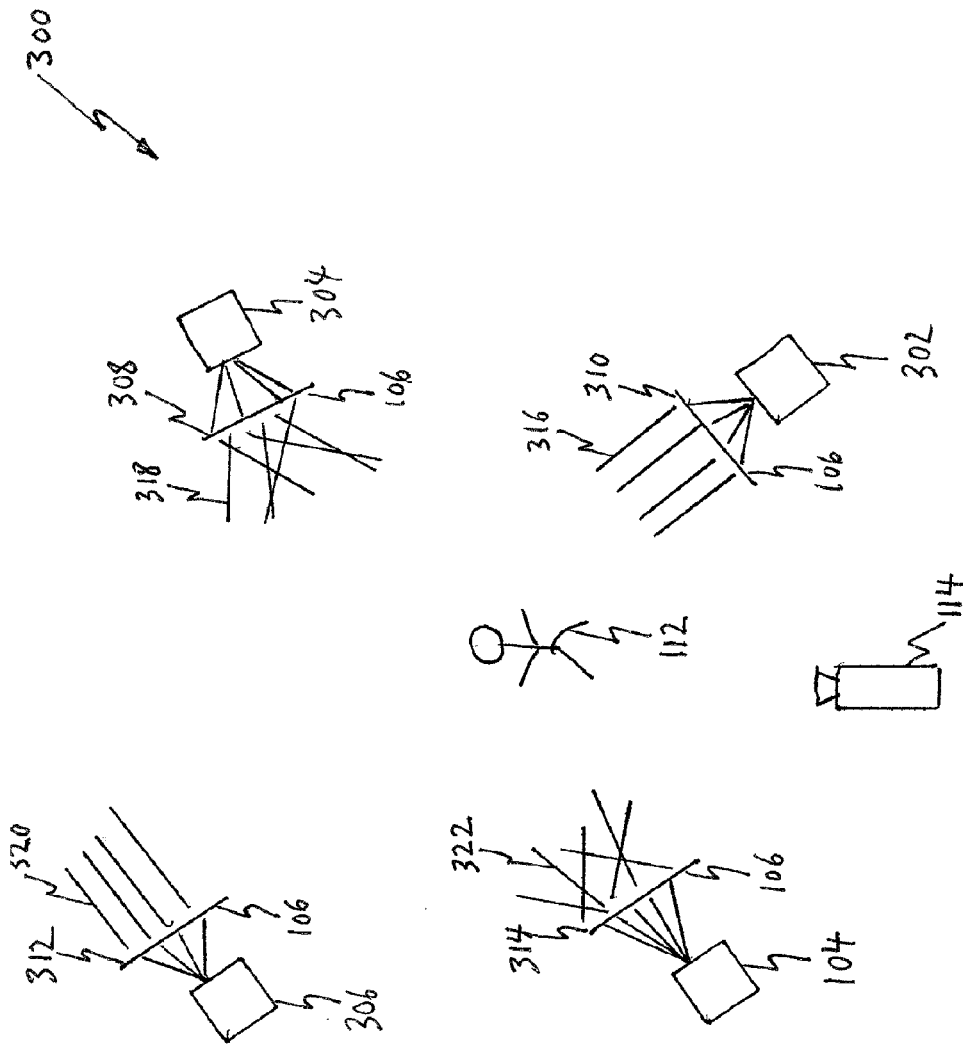


Fig. 3

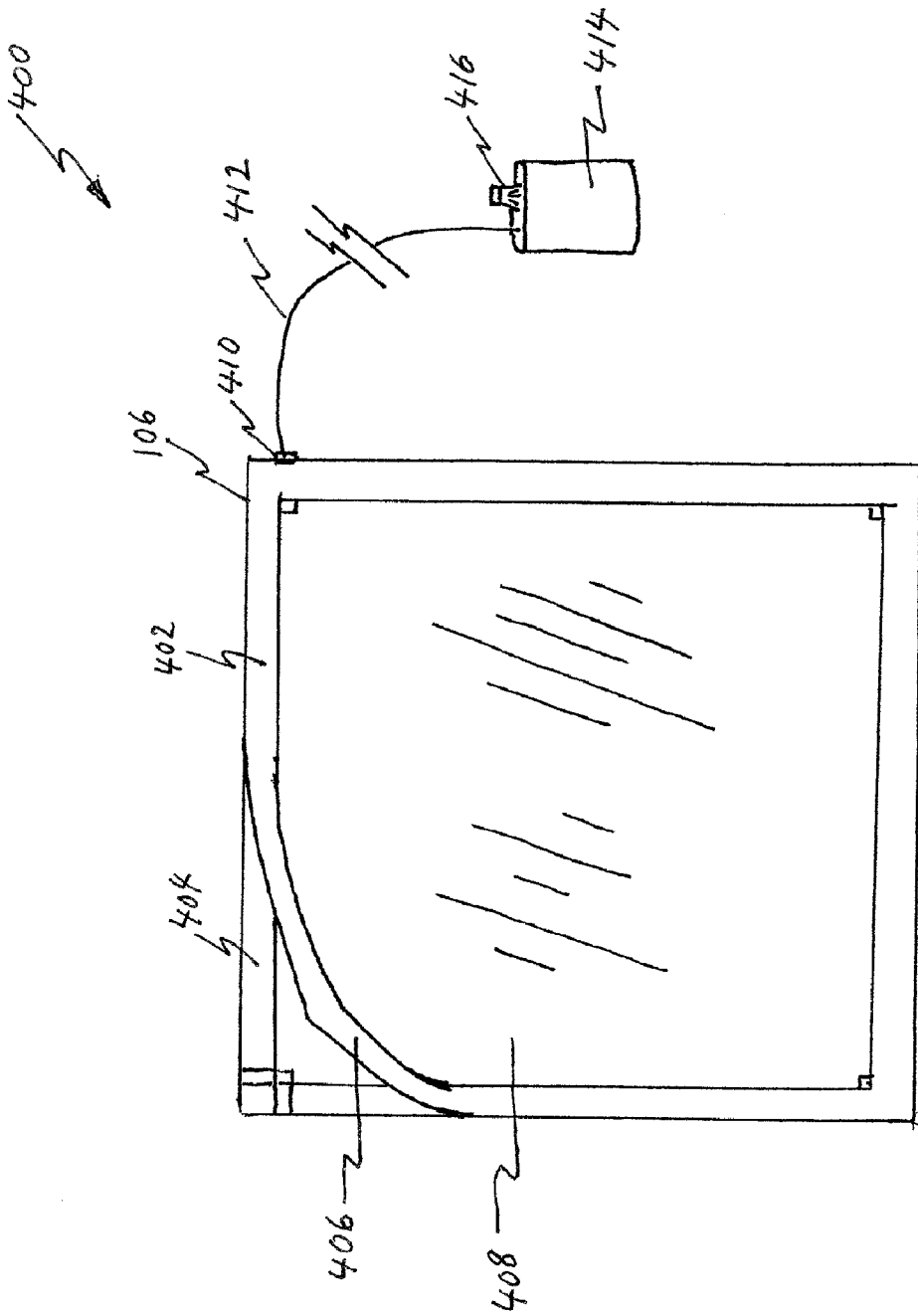


Fig. 4

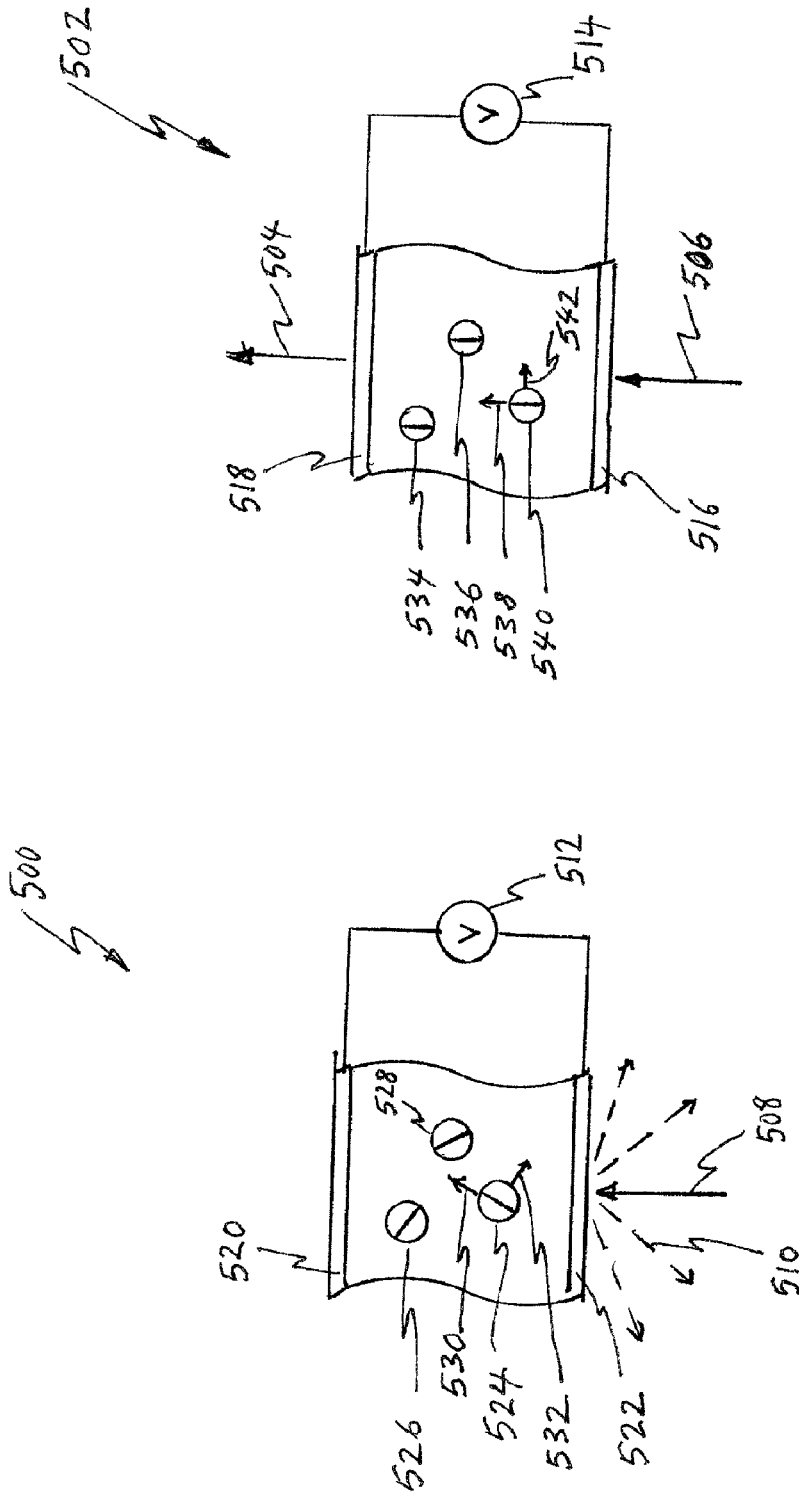


Fig. 5a

Fig. 5b

1

ELECTRICALLY ADJUSTABLE OPTICAL DIFFUSION FOR LUMINAIRES

CROSS-REFERENCE TO RELATED APPLICATIONS

None

BACKGROUND OF THE INVENTION

This disclosure relates to light diffusion techniques used in the film and video production industry and, more particularly, to diffusion of light sources used in film or video production using materials having electrically adjustable light diffusion characteristics.

Lighting techniques used in the production of film and video have long been carefully and diligently studied by the artists, technologists, and other professionals practicing in the film and video industry. Careful attention is paid to the creation of lighting conditions so as to achieve particular desired effects. Volumes have been written about the characteristics of light most preferred in a given situation, how various environmental or set conditions impact lighting quality, the considerations that should be given depending upon the subject of the film or video, and so on. Volumes more may be written of the particular equipment preferences that those responsible for lighting on a film or video crew use to accommodate various circumstances. In a conventional motion picture production, the gaffer or lead person on the electrical crew, for example, may work closely with the crew best boy, grips, and other electricians to design and build the lighting setup for a particular production, using experience and industry trade practices to determine the appropriate gels and diffusion materials to put on lights or windows to achieve the desired effects, or to determine whether or not to use various materials and equipment to re-create particular natural effects within a better controlled stage or to adapt such materials and equipment to allow for on-location filming. Much of the expertise of such professionals is likely maintained as closely held tricks of the trade and other proprietary information.

What may be generally true is that innovative approaches to film and video production have been widely sought after and favorably received by the film and video industry in the U.S., particularly where such innovations provide improvements in costs so as to lower overall production costs; improvements in the features and functionality available to the users of newly developed equipment; improvements in quality of equipment or reliability of the equipment or the processes of using various equipment; and improvements in the speed with which film and video production may be successfully completed.

Some of the more labor intensive aspects of film and video production involve engineering lighting effects that deliver desired results, accommodate physical space requirements of the set, and provide means for adapting to changes in set conditions such as weather, natural light position, camera angles, and subject position throughout a scene, and other factors requiring, ideally, instant changes in lighting provided for the shoot. The lighting equipment used should be reconfigurable to accommodate a range of different physical space requirements and adaptable to changing set conditions with a minimum of labor.

What is needed, therefore, are light diffusion techniques and equipment for the diffusion of light sources used in film or video production that address various shortcomings of existing techniques and equipment. The foregoing and other objectives, features, and advantages of the invention will be

2

more readily understood upon consideration of the following detailed description of the invention taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL DRAWINGS

For a more complete understanding of the present invention, the drawings herein illustrate examples of the invention. The drawings, however, do not limit the scope of the invention. Similar references in the drawings indicate similar elements.

FIG. 1 illustrates a film or video set using a remotely adjustable diffusion panel, according to one embodiment.

FIG. 2a illustrates no/low diffusion through an adjustable diffusion panel, according to one embodiment.

FIG. 2b illustrates medium diffusion through an adjustable diffusion panel, according to one embodiment.

FIG. 2c illustrates high/full diffusion through an adjustable diffusion panel, according to one embodiment.

FIG. 3 illustrates lighting with multiple adjustable diffusion panels, according to various embodiments.

FIG. 4 illustrates components of an exemplary adjustable diffusion panel.

FIG. 5a illustrates exemplary material for an adjustable diffusion panel in one state of transmittance, according to one embodiment.

FIG. 5a illustrates exemplary material for an adjustable diffusion panel in another state of transmittance, according to one embodiment.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the present invention. However, those skilled in the art will understand that the present invention may be practiced without these specific details, that the present invention is not limited to the depicted embodiments, and that the present invention may be practiced in a variety of alternate embodiments. In other instances, well known methods, procedures, components, and systems have not been described in detail.

Various operations will be described as multiple discrete steps performed in turn in a manner that is helpful for understanding the present invention. However, the order of description should not be construed as to imply that these operations are necessarily performed in the order they are presented, nor even order dependent.

As an overview, a film or video set **100** using a remotely adjustable (or remotely controllable active) diffusion panel **106**, according to one embodiment, is shown in FIG. 1. When illuminating a subject **112** with a light source **104** for the purpose of photography, videography, motion picture capture, or theater, it is often desirable for the light source **104** to deliver light that is "soft" in nature/character. A light source that delivers such light is often referred to as a "soft source" and is an illumination that appears to emanate from a large area, thereby casting shadows that have gradual transitions from light to dark, or "soft shadows". In contrast, a "hard source" is an illumination that appears to emanate from a point source such as a single bulb or filament, thereby casting "hard shadows" that have a distinct and deliberate transition from light to dark.

Most of the illumination sources used are point source type lights such as filament-based incandescent bulbs. Such lights cast harsh or distinct shadows. Various methods of light dif-

fusion may be used to help soften the light source as its light appears to the subject. One method to soften the light is to place a relatively large piece of semi-transparent material between the hard light source and the subject to diffuse the hard light. The diffusion material is illuminated on one side by the hard light source and appears to glow relatively uniformly on the opposite side which faces the subject. The subject then appears to be illuminated by a soft light source effectively as large as the illuminated surface of the diffusion material.

Choosing among different diffusion materials most commonly involves choosing material that has particular transparency characteristics. A material with high transparency will make a hard source only slightly softer (if at all) while a more opaque material will be the most effective at softening a hard source. Each subject or lighting situation may require a unique level of diffusion to give “just the right look”, and no single diffusion material having a particular transparency may provide the “right” amount of diffusion for every situation.

Consequently, throughout a typical filming shoot the diffusion material (and thus the transparency of the material) is often changed multiple times before the desired level of diffusion appropriate to the subject is achieved. The process of selecting the correct diffusion requires having a wide selection of different grades of diffusion materials on hand, and the physical action of removing and replacing the diffusion material near the light source, which often is placed in locations (i.e. overhead structure **102**) requiring a ladder or other type of scaffold or lift for sufficient access for placement of the diffusion material.

As shown in FIG. 1, a active diffusion panel **106** having diffusion material that has an electrically adjustable level of transparency may be used to soften the otherwise hard light **108** from a point source light **104**. The light transmitted **110** to the subject **112** can be selectably changed in terms of its softness using a remote control **118** to vary the degree of transparency of the (active) material used in the diffusion panel **106**. The remote control **118** is preferably connected to the panel **106** by wires **116**, but in other embodiments the control **118** may wirelessly communicate with the (active) panel **106**. Using an active panel **106** that is adapted to provide a range of transparency from clear (or transparent) to substantially opaque eliminates the need for the user **120** or other lighting crew members to physically change the diffusion material to achieve different levels of diffusion and lighting at the subject. The active material in the panel **106** may be adjusted by the user (camera operator or other crew member) **120** at will during the film shoot to compensate for changing levels of natural light, changes in desired overall illumination, or simply to satisfy the visual goals of the photographer.

FIGS. 2a-2c illustrate different levels of diffusion that are preferably provided using an electrically adjustable diffusion panel **106**. Conventional diffusion paper ranges from ¼ stop diffusion paper to full or 1 and ¼ stop paper. Light diffusion or ¼ stop paper is more transparent and only slightly softens the shadows/shadow edges. Medium diffusion or ¾ stop paper softens the shadow edges more, causing shadow edges to fade. And heavy diffusion, such as “Lee Filters #216” (brand named) full stop paper causes shadow edges to fade and blend in so the shadows are nearly completely eliminated.

FIG. 2a illustrates the active panel **106** in a fully transparent mode **214**. In such a mode **214** the panel **106** allows the light **108** projected from light source **104** to appear to the subject **112** without any scattering. The shadows **220** from such setting of the adjustable panel **106** have sharp edges, and the light transmitted **202** is unsoftened. Viewed from the

subject **112**, the light source **104** behind the panel **106** may be represented as shown in view **208**, indicating that the light source **104** remains an unsoftened point source of light. In the view **208**, the panel material is fully transparent, without color. As the diffusion setting **214** is adjusted to provide some diffusion, the view **208** starts to take on, in preferred embodiments, a whitish or cloudy appearance.

FIG. 2b illustrates a medium diffusion setting **216**, where the transmitted light **204** is diffused (or scattered) to a medium setting **216** whereby the incident light **108** is scattered somewhat as it passes through the panel **106**. With such setting **216**, the shadow **222** is softened so as to lose its distinct edges, and viewing the panel **106** from the view point of the subject **112** may be represented as shown in view **210**, indicating that the light source behind the panel **106** has become softened and made less distinct. With the medium setting **216** the panel **106** material in view **210** takes on a whitish appearance, and the detail of the light source **104** is lost due to the scattering of light allowed through the diffusion material.

FIG. 2c illustrates a heavy diffusion setting **218**, where the transmitted light **206** is now diffused (or scattered) to a heavy setting **218** whereby the incident light **108** is heavily scattered as it passes through the panel **106**. With such setting **218**, the shadow **224** is softened so as to be nearly eliminated, and viewing the panel **106** from the view point of the subject **112** may be represented as shown in view **212**, indicating that the light source behind the panel **106** has become nearly undefined. With the heavy setting **218** the panel **106** material in view **212** takes on a more uniformly whitish appearance, and even the outline of the light source **104** is lost due to the scattering of light allowed through the diffusion material. Adjusting the diffusion of panel **106** to an even heavier (i.e. more diffused) setting preferably causes the panel **106** to become opaque, presenting a view to the subject **112** of a solidly (uniformly) whitish panel. At such a setting, the opaque panel fully blocks the subject **112** from view of the light source **104**.

In preferred embodiments, the diffusion provided by panel **106** may be adjusted using a remote control **118** from completely transparent (no diffusion/scattering of the incident light from the light source **104**) to fully opaque (complete scattering of the incident light from the light source **104**), with the adjustment of diffusion being continuous so that the user **120** may select from any amount of transparency using the control **118**, from full transparency to no transparency and any selection of transparency therebetween. In other embodiments, the diffusion provided may be adjusted between nearly transparent to nearly opaque, with any selection of transparency therebetween. In still other embodiments, the diffusion may be adjusted so as to correspond with diffusion papers or filters or scrims available in the film and video industry. For example, the diffusion setting **214** may correspond with ¼ stop diffusion papers commonly available, setting **216** may correspond with ¾ stop papers available, and setting **218** may correspond with full stop papers available. In one embodiment, the control **118** may include detents at various commonly used settings or settable/resettable/programmable presets for the convenience of the user **120** to return to desired diffusion settings.

Although any type of light source may be used, the light source **104** is preferably a cool light source such as LED or fluorescent lighting. Commonly used incandescent or other hot type lighting may be used with sufficient shielding incorporated into panel **106**, with sufficient spacing between the light source **104** and the panel **106**, and/or with use sufficient cooling means (such as fans, heat sinks, favorable ambient/

cooling temperatures, etc.). Preferably, LED lighting such as lighting provided by Zylight LLC (www.zylight.com) is used for the light source **104**. Suitable lighting is also described in the application for U.S. letters patent, application Ser. No. 11/423,443 filed on Jun. 11, 2006, which is hereby incorporated by reference herein in its entirety, and which describes wirelessly controllable and wirelessly networked LED lighting modules.

Referring to FIG. 3, multiple remotely controllable diffusion panels **104** may be used together. For example, a typical film or video production set may include the lighting set up **300** shown in FIG. 3, including a key (or primary) light source **104**, a fill light **302**, a back light **304**, and a background light **306**. In preferred embodiments, each of the active diffusion panels **106** may be remotely electrically controlled so as to provide desired levels of diffusion. The panels **314** and **308** may be set, for example, to medium-to-heavy diffusion settings for transmitting diffused light **322** and **318**, respectively. The panels **310** and **312**, similarly, may be set, for example, to lower diffusion/greater transparency settings for transmitting diffused light **320** and **316**, respectively.

Referring to FIG. 4, the components **400** of an exemplary adjustable diffusion panel **106** preferably include active material **408** that provides a range of electrically selectable degrees of transparency, frame fastening material **402** for affixing the active material **408** to a rigid or semi-rigid frame **404**, and a controller **414** having circuitry adapted to control an electrical potential applied to the material **408** causing the material to change its transparency in response to the electrical potential selected by the user of the controller **414** and thereby applied to the active material **408**. In one embodiment the controller includes a 9 volt battery, a potentiometer or other potential changing selection knob **416**, wires **412** for delivering an electrical potential (i.e. voltage) to the material **408** via a connection **410**. Preferably the material **408** and frame fastening material **402** (which may be a magnetic backed material, Velcro type material, or other material preferably easily removable from rigid or semi-rigid frame **404**) are rollable **406** so as to facilitate easy mobility from shoot to shoot. Other structures may be used in place of the frame **404**, and other shapes of the frame **404** may be used.

Preferable sizes include a 2 foot by 2 foot diffusion panel **106**, a 3 foot by 3 foot version, and a 4 foot by 4 foot version. Other sizes may be fabricated. Generally, any size and any shape (square, rectangular, irregular, circular, etc.) may be used. Preferably the surface area of the material **408** is large relative to the light source **104** for most applications. An electrically adjustable active diffusion panel **106** may also be used, however, with panel lights (such as the IS3 by Zylight LLC) in soft box or other applications.

The active material **408** may comprise any material whose transparency may be electrically adjusted from transparent (or nearly transparent) to opaque (or nearly opaque). In preferred embodiments, the material **408** comprises a polymer dispersed liquid crystal (PDLC) film between layers of flexible, transparent plastic that include a thin layer of conductive, transparent material. The conductive material form transparent electrodes with liquid crystal droplets trapped therebetween, and the liquid crystal droplets align together in varying degrees in response to a voltage applied across the electrodes. With greater voltage, more of the liquid crystals align thus increasing the material's effective transparency.

FIG. 5a illustrates a cross-section **500** of material **408**, according to one embodiment, where the material **408** is in an "off" state, and FIG. 5b illustrates a cross-section **502** of material **408** where the material **408** is in an "on" state.

As shown in FIG. 5a, with no applied voltage **512**, transparent electrodes **520** and **522** do not cause any alignment of the liquid crystal droplets **526**, **528**, and **524**. Therefore, because each of the liquid crystals transmits light in one direction **530** and blocks light in a perpendicular direction **532**, the cross-section **500** causes incident light **508** to scatter **510** rather than allow transmittance of the light **508** through the PDLC matrix.

As shown in FIG. 5b, the cross-section **502** allows incident light **506** to pass through the PDLC matrix as transmitted light **504** due to the alignment of the liquid crystals **534**, **536**, and **540** in response to a voltage **514** applied to the transparent electrodes **518** and **516**. The degree of transparency depends upon the voltage applied and degree to which the liquid crystal droplets align together. As shown, the liquid crystals **534**, **536**, and **540** are all aligned so as to allow incident light to pass through. As the voltage is varied, the alignments are changed causing the material to scatter incident light and take on a milky white or cloudy appearance. For example, reducing the voltage applied to electrodes **518** and **516** preferably causes the liquid crystal **540** to spin out of alignment such that the direction **538** is no longer aligned with the incident light **506** and the direction **542** begins to block the incident light **506**.

Although the material **408** in preferred embodiments is constructed as shown and operates as described in FIGS. 5a and 5b, other arrangements, materials, and configurations may be used that provide the desired electrically adjustable transparency adapted for a diffusion panel **106** as shown and described herein.

The terms and expressions which have been employed in the forgoing specification are used therein as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding equivalence of the features shown and described or portions thereof, it being recognized that the scope of the invention is defined and limited only by the claims which follow.

What is claimed is:

1. An electrically adjustable optical diffusion panel adapted for luminaires used in a film or video production, the diffusion panel comprising:

(a) a rigid or semi-rigid frame having a horizontal length and a vertical height defining a plane and enclosing a perimeter of an active diffusion two-dimensional planar area through which incident light from a film or video production light source passes, transversing the planar active diffusion area enclosed by the perimeter frame to become transmitted light thereafter;

(b) diffusion material separable by hand from said frame and affixed to frame fastening material substantially aligned with said perimeter of said frame, and said diffusion material covering said active diffusion area, said diffusion material having its transparency continuously and variably changeable between a substantially transparent state and a substantially opaque state in response to an electric potential applied to electrodes of said diffusion material, said electrodes comprising inseparable layers of conductive, transparent material covering and co-planar with said active diffusion area and having liquid crystal trapped therebetween, wherein said diffusion material with said frame fastening material is repeatably detachable from said frame and flexible enough to allow said diffusion and frame fastening material to be rolled into a tube and thereafter unrolled and re-attached to said frame without degradation to the transparency range of said diffusion material; and

(c) a controller electrically interconnected with said electrodes, said controller having a battery and circuitry adapted to provide said electric potential to said electrodes.

2. The diffusion panel of claim 1 wherein said substantially transparent state provides a substantially clear panel through which said light source is visible to a subject of said film or video production and shadows cast by said light source have sharp definition.

3. The diffusion panel of claim 1 wherein said substantially opaque state provides a substantially opaque panel through which said light source is not visible to a subject of said film or video production and shadows cast by said light source have indistinct definition.

4. The diffusion panel of claim 1 wherein said diffusion material provides transparency equivalent to $\frac{1}{4}$ stop, $\frac{3}{4}$ stop, and full stop diffusion paper in response to a user of said panel selecting said electric potential with said controller so as to vary said transparency to be equivalent to said $\frac{1}{4}$ stop, $\frac{3}{4}$ stop, and full stop diffusion paper.

5. The diffusion panel of claim 4 wherein an exterior visual appearance of said diffusion material when not in a fully transparent mode is milky white.

6. The diffusion panel of claim 1 wherein said controller is a remote handheld sized device tethered to said electrodes and having a voltage control rotary knob.

7. The diffusion panel of claim 1 wherein said controller is a handheld sized device and said battery is a standard 9 volt battery.

8. The diffusion panel of claim 1 wherein said diffusion material comprises a polymer dispersed liquid crystal layer having a front surface area and a rear surface area, transparent conductive layers on both of said front and rear surface areas, and electrical connections between said conductive layers and said controller circuitry.

9. The diffusion panel of claim 8 wherein said liquid crystal layer becomes more transparent as voltage is increased across said electrical connections between said conductive layers.

10. The diffusion panel of claim 8 wherein said liquid crystal layer becomes substantially opaque when voltage is zero across said electrical connections between said conductive layers.

11. The diffusion panel of claim 1 further comprising circuitry adapted to wirelessly receive signals and change said electric potential applied to said electrodes in response thereto.

12. A method of diffusing light incident to a subject of a film or video production comprising the steps of:

- (a) placing a diffusion panel between a light source and said subject, said diffusion panel comprising an electrically adjustable optical diffusion panel as in claim 1;
- (b) energizing said light source so as to direct incident light therefrom through said diffusion panel; and
- (c) electrically adjusting the transparency of said diffusion panel by changing said electric potential using said controller.

13. The method of claim 12 wherein using said controller comprises rotating a knob on said controller, said controller comprising a remote handheld sized unit tethered to said electrodes.

14. The method of claim 12 wherein said substantially transparent state provides a substantially clear panel through which said light source is visible to said subject of said film or video production and shadows cast by said light source have sharp definition.

15. The method of claim 12 wherein said substantially opaque state provides a substantially opaque panel through

which said light source is not visible to a subject of said film or video production and shadows cast by said light source have indistinct definition.

16. The method of claim 12 further comprising (d) detaching said diffusion material from said frame and rolling said material into a tube.

17. The method of claim 16 further comprising (e) unrolling said diffusion material and re-attaching said diffusion material to said frame, wherein said diffusion material continues to operate with its transparency changeable between said substantially transparent state and said substantially opaque state in response to said electric potential applied to electrodes of said diffusion material, as before said step of detaching and rolling said material into said tube.

18. An electrically adjustable optical diffusion panel adapted for luminaires used in a film or video production, the diffusion panel comprising:

- (a) a rigid or semi-rigid frame having a horizontal length and a vertical height defining a plane and enclosing a perimeter of an active diffusion two-dimensional planar area through which incident light from a film or video production light source passes, transversing the planar active diffusion area enclosed by the perimeter frame to become transmitted light thereafter;
- (b) diffusion material separable by hand from said frame and affixed to frame fastening material substantially aligned with said perimeter of said frame, and said diffusion material covering said active diffusion area, said diffusion material having its transparency continuously and variably changeable between a substantially transparent state and a substantially opaque state in response to an electric potential applied to electrodes of said diffusion material, said electrodes comprising inseparable layers of conductive, transparent material covering and co-planar with said active diffusion area and having liquid crystal trapped therebetween; and
- (c) a controller electrically interconnected with said electrodes, said controller having a battery and circuitry adapted to provide said electric potential to said electrodes,

wherein said substantially transparent state provides a substantially clear panel through which said light source is visible to a subject of said film or video production and shadows cast by said light source have sharp definition, wherein said substantially opaque state provides a substantially opaque panel through which said light source is not visible to a subject of said film or video production and shadows cast by said light source have indistinct definition,

wherein said diffusion material with said frame fastening material is repeatably detachable from said frame and flexible enough to allow said diffusion and frame fastening material to be rolled into a tube and thereafter unrolled and re-attached to said frame without degradation to the transparency range of said diffusion material, wherein said diffusion material provides transparency equivalent to $\frac{1}{4}$ stop, $\frac{3}{4}$ stop, and full stop diffusion paper in response to a user of said panel selecting said electric potential with said controller so as to vary said transparency to be equivalent to said $\frac{1}{4}$ stop, $\frac{3}{4}$ stop, and full stop diffusion paper, and

wherein said controller is a handheld sized device having a voltage control rotary knob.

19. The diffusion panel of claim 18 further comprising circuitry adapted to wirelessly receive signals and change said electric potential applied to said electrodes in response thereto.