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(54) Title: AN LED BASED LIGHTING SYSTEM PROVIDING INDEPENDENTLY CONTROLLABLE LIGHT DISTRIBUTION PATTERNS

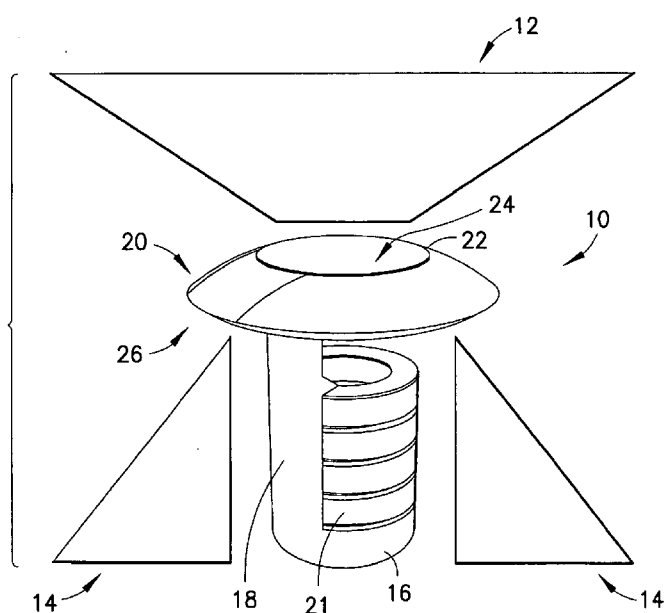


FIG. 1

(57) Abstract: An LED based lighting fixture providing independently controllable light distribution patterns, e.g., ambient lighting and task lighting, is provided. The light fixture of the present disclosure provides a 'dome' type LED based light fixture to replace the functionality of a traditional incandescent table lamp to provide much higher energy efficiency, improved lighting quality, control and utility, and capability for 'off-grid' operation. A lighting system of the present disclosure provides a self-contained, portable light pod which is designed primarily to be supported by off-grid renewable energy sources (e.g. solar, wind, etc.) and has a self contained battery to permit portable operation. The light pod of the present disclosure may be used in combination with a semi-stationary lighting fixture.



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**AN LED BASED LIGHTING SYSTEM PROVIDING INDEPENDENTLY
CONTROLLABLE LIGHT DISTRIBUTION PATTERNS**

[0001] PRIORITY

[0002] This application claims priority to an application entitled "AN LED BASED LIGHTING FIXTURE PROVIDING INDEPENDENTLY CONTROLLABLE LIGHT DISTRIBUTION PATTERNS" filed in the United States Patent and Trademark Office on February 15, 2008 and assigned Serial No. 61/029,090 and an application entitled "AN LED BASED LIGHTING SYSTEM FOR DISTRIBUTED PORTABLE LIGHTING" filed in the United States Patent and Trademark Office on February 15, 2008 and assigned Serial No. 61/029,100, the contents of which are hereby incorporated by reference.

[0003] BACKGROUND

[0004] Field

[0005] The present disclosure relates generally to lighting, light fixtures and lamp assemblies, and more particularly, to an LED based lighting fixture providing independently controllable light distribution patterns, e.g., ambient lighting and task lighting. Furthermore, the present disclosure relates to an LED based lighting fixture to replace incandescent table lamps having "on-grid" and "off-grid" capabilities, i.e., battery operated, with a solar power charging option. Additionally, the LED based lighting system of the present disclosure provides an LED based portable lighting device as an alternative solution to traditional residential portable lighting.

[0006] Description of the Related Art

[0007] Incandescent light bulbs are used in a large variety of lighting products. Although inexpensive to purchase, incandescent light bulbs have several drawbacks. First, incandescent light bulbs use a relatively large amount of power compared to other lighting products which increase energy costs. Second, incandescent light bulbs have a short life causing repetitive replacement costs.

[0008] Recently, a trend in the lighting industry is to develop light emitting diode (LED) based products that can replace current incandescent based light fixture products. LED technology offers more energy efficiency than traditional incandescent bulbs and has 20-30 times the reliability.

[0009] Major strides have been made in the refinement of light emitting diode (LED) technology over the past decade. LEDs are 3-5 times more energy efficient than incandescent lighting and is expected to double in efficiency over the next ten years. LED technology has recently started to be used in products for general purpose illumination (as opposed to traffic lights, emergency vehicle lights, LCD backlighting and signage). Some examples include: task lights, lamps, architectural spotlights, cove lights, recessed downlights, streetlighting, LED replacement MR and PAR lamps, transportation (e.g. auto tail lights, boat/plane cabin lights), flashlights and interior/exterior spotlight fixtures.

[0010] There are major global concerns for reducing energy consumption due to both cost and effect on global warming. Incandescent light is highly inefficient, needlessly consuming large amounts of energy with 95% of it converted into heat and only 5% becoming light. With lighting representing 22% of all electricity consumed in the U.S., and incandescent light bulbs consuming 42% of the nation's

electricity used for lighting, it is fair to conclude that incandescent light is significantly contributing to the impending threat on the world's energy supply. It is estimated that 90% of residential lighting energy (vs. commercial sites) is consumed by inefficient incandescent/halogen technology.

[0011] In addition to energy efficiency, LEDs offer the following benefits over a traditional incandescent based lamp: 25 times the service life (50,000 hours or more); enhanced safety, no hot bulbs that can burn a person or cause fire; can vary color temperature of the light to suit different environments and applications; can dim light with no change to color temperature; low power and operating voltage is better suited for battery operation; solid state technology resists shock and vibration; and small point light sources give greater fixture design flexibility.

[0012] Thus, a need exists for a lighting fixture which conserves energy while providing a uniform light distribution of a conventional incandescing light bulb. A further need exists for a portable lighting device capable of being powered by renewable energy sources.

[0013] SUMMARY

[0014] An LED based lighting fixture providing independently controllable light distribution patterns, e.g., ambient lighting and task lighting, is provided. The light fixture of the present disclosure provides a "dome" type LED based light fixture to replace the functionality of a traditional incandescent table lamp to provide much higher energy efficiency, improved lighting quality, control and utility, and capability for "off-grid" operation.

[0015] The LED based lighting fixture of the present disclosure takes advantage of the benefits of LED technology in an entirely new and unique form. Using highly optimized system integration and advanced ergonomic design, the lighting fixture sets a new standard for residential table/counter top lighting, replacing old incandescent “bulb and lamp shade” technology. It offers much higher energy efficiency, off grid operation when utility power is interrupted or generally unreliable and variable color temperature control to improve lighting quality matched to user environment or activity. The LED based lighting fixture of the present disclosure also has detachable lighting elements to provide portable lighting in multiple locations when grid-power is unavailable.

[0016] An LED based lighting system to provide warm, comfortable ambient lighting within a home as a high efficiency, full featured, portable alternative to traditional incandescent or CFL type lamps or light fixtures is provided. The lighting system of the present disclosure provides a self-contained, portable light pod which is designed primarily to be supported by off-grid renewable energy sources (e.g. solar, wind, etc.) and has a self contained battery to permit portable operation. The light pod can also be recharged from a power grid during low demand periods. The light pod of the present disclosure may be used in combination with a semi-stationary lighting fixture (also known as a ModuLight lighting fixture). Single or multiple light pods can be controlled and programmed from an optional remote control device.

[0017] The light pod of the present disclosure is intended to represent a new generation in consumer lighting for table, desk, counter-top and hand-held type

applications. It is based on LED technology as well as advanced system and industrial design to offer, high quality “ambient” and “task” lighting, high efficiency and high reliability. It is designed to provide excellent ambient lighting for a room employing a warm color temperature (~2800K) and provide highly effective task lighting at different color temperatures (e.g. ~3800K) better suited to the human eye response for reading, writing and other tasks. It also offers new functions, features and levels of performance that were not possible with conventional incandescent bulb technology. This includes electronic color temperature control, dimming and time-day-programming from a remote control device.

[0018] The light pod of the present disclosure is battery operated and intended to be recharged from renewable energy sources, such as a photovoltaic solar panel, or from the utility grid power, during non-peak load periods. The battery cells employ Lithium Ion technology to support a maximum number of recharge cycles (as would occur with daily recharging from a solar panel) and high power density (small battery size). The batteries can be easily removed for recycling at product end-of-life. The light pods may be recharged when placed back in an accessory base.

[0019] The light pod contains very high brightness Warm (~2800K) and Neutral (~3800K) white LED light sources, a battery, a processor and a high efficiency electronic drive circuit to maximize battery life. The light pod includes an annular, hollow body which is a semi-transparent diffuser that creates the desired light distribution. The annular body is coupled to an opaque base which is

configured to enable the light pod to stand securely on a flat surface and facilitates gripping of the light pod by a user.

[0020] The light pod is also designed to be hand-held, with some of the light more highly directed for specific user tasks. Each light pod has a two channel LED driver circuit to provide constant current to the LEDs. The driver is a “boost” type that permits maximum energy extraction from the battery of the light pod to maximize battery life and light on-time duration.

[0021] The light pods are also designed to be used with a semi-stationary lighting fixture (e.g., a ModuLight lighting fixture). A battery charging system of the lighting fixture is capable of charging a plurality of light pod battery packs in parallel and simultaneous with the charging of the main internal battery of the lighting fixture, from 12VDC input power. The charging system is designed to fully recharge all batteries within a 12 hour period. The charging system has a low voltage disconnect to prevent the batteries from being damaged if the voltage gets too low. A solar charging system (e.g., photovoltaic panel and storage battery) accessory is also provided to charge the light pods individually, or as a group.

[0022] BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The above and other aspects, features, and advantages of the present disclosure will become more apparent in light of the following detailed description when taken in conjunction with the accompanying drawings in which:

[0024] Figure 1 is perspective view of a lighting fixture in accordance with the present disclosure;

[0025] Figure 2 is a side view of the lighting fixture in accordance with the present disclosure illustrating the pivoting of a lighting director to effect a change in the light distribution pattern;

[0026] Figure 3 is a perspective view of a light pod in accordance with the present disclosure;

[0027] Figure 4 is a front view of the lighting fixture illustrating an operating interface;

[0028] Figure 5A is a top view of a diffuser employed in the lighting director, Figure 5B is a cross sectional view of the lighting director using a direct illumination method, Figure 5C is a top view of an array of LEDs for ambient lighting and Figure 5D is a bottom view of an array of LEDs for task lighting in accordance with the present disclosure;

[0029] Figure 6 is a cross sectional view of the lighting director illustrating a light distribution pattern for ambient light in accordance with an embodiment of the present disclosure;

[0030] Figure 7 is a cross sectional view of the lighting director illustrating a light distribution pattern for task light in accordance with an embodiment of the present disclosure;

[0031] Figure 8 is a cross sectional view of the lighting director illustrating a light distribution pattern for ambient light and task lighting in accordance with an embodiment of the present disclosure;

[0032] Figure 9 is a cross sectional view of the lighting director illustrating the pivoting of the lighting director in accordance with an embodiment of the present disclosure;

[0033] Figure 10 is a perspective view of a solar panel accessory for use with the lighting fixture in accordance with the present disclosure;

[0034] Figure 11A is a top plan view of the lighting director with photovoltaic cells disposed thereon and Figure 11B is a cross section view of the lighting fixture positioned so the photovoltaic cells disposed on the lighting director will receive sunlight;

[0035] Figures 12A-D are several views illustrating an alternative embodiment of a lighting fixture in accordance with the present disclosure, where Figure 12A is a perspective view of a lighting director illustrating key optical components, Figure 12B is a detailed cross sectional view of the fixture, Figure 12C is a cross sectional view of the lighting director using a reflector method for creating diffuse, uniform light illustrating the LED light sources relative to the optical elements and Figure 12D is a cross sectional view of the lighting director illustrating a light distribution pattern for ambient light in accordance with a secondary, reflective illumination, embodiment;

[0036] Figure 13 is an alternative embodiment of a lighting director for creating task lighting using an array of LEDs combined with a light guide;

[0037] Figure 14 is an another embodiment of a lighting fixture in accordance with the present disclosure where a plurality of light pods are arranged at a base of the fixture;

[0038] Figure 15 is a further embodiment of a lighting fixture in accordance with the present disclosure where a single light pod unit is centered in the base of the fixture;

[0039] Figure 16 is another alternative embodiment of a lighting fixture in accordance with the present disclosure where a removable light pod is part of the dome of the fixture;

[0040] Figure 17 is another embodiment of a lighting fixture in accordance with the present disclosure where the fixture may be removed from the base and laid on its side or with the lighting director or dome facing a surface to direct the light at any angle;

[0041] Figure 18 illustrates other embodiments for mounting of the lighting director to a table, ceiling or wall;

[0042] Figure 19 is a front view of a light pod in accordance with the present disclosure illustrating lighting components;

[0043] Figure 20 is a side and front view of a light pod in accordance with the present disclosure illustrating lighting distribution;

[0044] Figure 21 shows several views illustrating a luminance profile of a light pod in accordance with the present disclosure;

[0045] Figure 22 illustrates various charging stations for the light pod in accordance with the present disclosure;

[0046] Figure 23 is a diagram of the electronic architecture of the light pod in accordance with the present disclosure; and

[0047] Figures 24A-D are several views illustrating various mounting options for the light pod in accordance with the present disclosure.

[0048] DETAILED DESCRIPTION

[0049] Preferred embodiments of the present disclosure will be described hereinbelow with reference to the accompanying drawings. In the following description, well-known functions or constructions are not described in detail to avoid obscuring the invention in unnecessary detail.

[0050] Referring to Figure 1, an LED based lighting fixture 10 providing independently controllable light distribution patterns, e.g., ambient lighting and task lighting is provided. The lighting fixture 10, also known as the ModuLight lighting fixture, represents a new generation in consumer lighting for table, desk and counter-top type applications, in place of traditional incandescent table and desk lamp products. The lighting fixture 10 is based on LED technology as well as advanced system and industrial design to offer, high quality “ambient” 12 and “task” lighting 14, high efficiency and high reliability. The lighting fixture 10 is designed to provide excellent ambient lighting 12, also referred to as up or indirect lighting, for a room employing warm color temperature (~2800K) and provide highly effective task lighting 14, also referred to as down lighting, at different color temperatures (e.g. 2800 - 3800K, adjustable) better suited to the human eye response for reading, writing and other tasks. It also offers new functions, features and levels of performance that was not possible with conventional incandescent bulb technology. This includes electronic color temperature control, dimming, variable light

distribution control, time-of-day programming of light intensity and color temperature and remote control operation.

[0051] The lighting fixture 10 generally includes a base 16 for supporting the fixture on a surface, a support arm 18 coupled to the base 16 for supporting a dome shaped lighting director 20. A plurality of detachable light pods 21, also referred to as PodLights, are disposed along the support arm 18. The lighting fixture 10 is designed to replace the functionality of a traditional table lamp and/or desk lamp containing a 40 Watt – 75Watt incandescent bulb, while using 40% to 60% less energy. It generates, overall, 30 lumens/Watt or greater of usable light, more than twice the efficiency of the incandescent table lamp it replaces. In one embodiment, the lighting fixture 10 is approximately 12.5" in overall height with a dome diameter of 12" and base diameter of 7". The lighting fixture 10 is ergonomically designed to a suite wide range of living environments and decor.

[0052] The adjustable lighting director 20 is designed to attain high levels of system energy efficiency by directing the LED produced light in the intended directions while minimizing optical losses as light is diffused and reflected through various optical devices employed. The lighting director 20 includes an array of warm white LEDs 24 to support ambient lighting and an array of neutral white LEDs 26 to support task lighting functions. The convex shaped lighting director 20 includes a high efficiency diffuser 22 (~85%) to create a wide upward ambient light pattern 12 with minimal light loss. The outer portion of the lighting director 20 supports the array of neutral white LEDs 26 and a reflective optical system to direct the light downward to illuminate the table, counter or other surface area. As shown

in Figure 2, the lighting director 20 pivots along its vertical support arm 18, the details of which will be described below, to allow the user to optimally direct light for the room conditions or activities being performed.

[0053] The lighting fixture 10 employs high power, high efficacy LED devices with multiple color temperatures selected for a comfortable aesthetic illumination effect as well as being optimized for human eye sensitivity, perception based on industry and academia research. "Warm" (~2800K) white LEDs are employed for general room ambient illumination, with optimized color rendering for interior furnishings, skin tone and dining. Generally, this color temperature provides a level of comfort and warmth that people are used to experiencing in a home atmosphere. "Neutral" (~3800k) white LEDs are combined with "Warm" (~2800K) white LEDs for the task (downward) lighting function. This allows the user to adjust the color temperature from 2800K to 3800K or anywhere in between. The cooler color temperatures are better suited to performance of tasks such as reading, writing and care giving. The detachable light pods also have a fixed or adjustable color temperature between 2800K and 3800K.

[0054] The lighting fixture 10 includes a plurality of detachable light pods 21, i.e., PodLights, to support light distribution for multiple rooms/locations when grid power is interrupted, generally unavailable or as a means of creating portable ambient light without drawing "on grid" power for the purpose of energy conservation. These pod lights 21 may also be provided as a separate, stand-alone device independent of the lighting fixture 10, thereby recharged from a solar accessory, wall transformer or other energy source, as will be described in detail

below. Individual pods 21 removed from the fixture 10 are illustrated in Figure 3. Each of the three light pods 21 contains a very high brightness white LED light source that can vary in color temperature, battery and high efficiency electronic drive circuit to maximize battery life. The light pod also contains a microprocessor and RF interface to be controlled from a remote control device. Each light pod 21 activates automatically when removed from the base 16 of fixture 10 and has its own on/off switch 28 and other controls for color and dimming (i.e., user controls). The translucent light pod 21 includes an enclosure which is designed to stand securely on a flat surface and provide a wide ambient light pattern to illuminate a room at low light levels. Furthermore, as can be seen from Figure 3, the enclosure is configured to match the shape of the base 16 of the fixture with one end 30 configured to mate with the support arm 18. The light pod 21 is also designed to be hand-held having a central aperture 32, with some of the light more highly directed for specific user tasks.

[0055] The lighting fixture 10 has an internal central digital processor or controller located in base 16 for receiving user inputs from interface 34 (or from a remote control) for on/off control, color temperature control, light distribution control and dimming (see Figure 4). In addition, a programmable remote control allows light levels and color temperature to be controlled remotely from the lighting fixture and allows time-of-day programmability. The controller also can detect absence of external power and battery charge status. There are high efficiency electronic LED driver circuits to provide a constant (e.g., 350mA) current to permit consistent LED operation within their specification requirements. The controller and driver circuits

are designed to draw minimal current during quiescent (“off”) operation and during normal operation “on”. It is important to minimize the amount of power used when the product is “off”, as this will affect overall system efficiency as measured by the Department of Energy (DOE) Energy Star guidelines and guidelines of other agencies.

[0056] Color temperature control, dimming and variable light distribution is performed using a Pulse Width Modulation (PWM) technique, whereby the LED on-time duty cycle for each LED white color is varied following a stored program based on user input commands. When color temperature is being changed by the user, the duty cycle of the appropriate LED color (warmer or cooler) is increased and the other color decreased based on a preprogrammed schedule. Dimming is accomplished by lowering the duty cycle on all color LEDs equally so that color temperature is maintained while brightness is reduced to the commanded level. Lighting distribution is controlled (ambient vs. task) by raising or lowering the duty cycle of those LEDs supporting the corresponding lighting function.

[0057] The controller also drives a user indicator 36 (see Figure 4) providing feedback of “efficiency setting”. Basically, the less power being used by the lighting fixture’s LEDs, based on the user settings for color temperature, dimming and distribution, the higher the efficiency indication.

[0058] The lighting fixture 10 is powered from line voltage utility power grid, a solar panel/battery accessory, internal batteries or battery energy from the light pods. The internal or light pod batteries may be charged from the grid, when available, or via a solar panel accessory designed to fully recharge the batteries

within a 12 hour period, depending on available sunlight. The battery cells employ Lithium Ion technology to support a maximum number of recharge cycles (as would occur with daily recharging from a solar panel) and high power density. The battery system is composed of battery cells in the solar panel accessory system or in the base 16 of the fixture 10 and one in each of the removable light pods 21. When the light pods 21 are attached to the fixture 10, their internal LEDs remain off, and their battery energy is made available to support operation of the main LEDs in the lighting director 20 of the fixture 10. In this configuration, the lighting fixture 10 is designed to operate from 4 to 6 hours from battery power. When the light pods 21 are removed, assuming external power is still not available, the lighting fixture 10 will operate on the number of batteries remaining. If all three light pods 21 are removed, the light fixture 10 operates solely off its main battery pack in its base 16 (if installed) or from the battery of the solar power system. The battery charging system is capable of charging few or many cells simultaneously, depending upon the number of light pods 21 installed.

[0059] The lighting fixture 10 has mechanical provisions to dissipate the heat generated from the LEDs. This heat must be effectively removed to permit the LEDs to stay at 80C or lower junction temperatures to support their long projected life and lumen maintenance. The LEDs of arrays 24, 26 are mounted to metal core printed circuit boards which provides for heat dissipation and also has physical connection to other thermally conductive materials in the dome or lighting director for heat dissipation. The surface area of these thermally conductive components aids in heat dissipation to the ambient air environment. Furthermore, the lighting fixture is

designed with a number of features that make it a “green” or “sustainable” product (e.g., minimizing depletion of limited natural resources): it consumes less energy than the incandescent bulb it replaces; it can be run from solar power exclusively, if desired; it is designed with control features that permit the user to easily reduce power consumption (e.g. dimming); and it is constructed with materials and assembly methods that can easily break the unit down for recycling.

[0060] Referring to Figure 5, the lighting director 20 will be described in more detail where Figure 5A is a top view of a diffuser 22 employed in the lighting director 20, Figure 5B is a cross sectional view of the lighting director 20, Figure 5C is a top view of an array of LEDs 24 for ambient lighting and Figure 5D is a bottom view of an array of LEDs 26 for task lighting. The lighting director 20 is configured as a dome shaped head assembly including warm white and neutral white LED light sources, optimally positioned to efficiently emit light to create the desired ambient and task lighting pattern, reference numerals 12 and 14 as shown in Figure 1 respectively. The lighting director 20 includes a dome or reflector 38. In one embodiment, this convex shaped “ring” structure 38 is made of plastic that is either opaque or translucent. It acts as a support structure for the LED arrays 24, 26 and diffuser lens 22 as described later. The dome or reflector 38 provides the mechanism to attach to the main vertical support arm 18 of the fixture 10. The translucent dome/reflector 38 may optionally have a color or artistic design impregnated into the plastic to give it a pleasing aesthetic appearance. Some light generated within the assembly may pass through this ring structure to enhance its appearance or to change the color characteristics of the transmitted light (e.g. a

yellow colored ring may make light more amber in color). The inside of the ring may also act as a reflector, directing light generated from the LEDs in a downward direction toward a table, counter or desk, for example.

[0061] The dome/reflector ring 38 will support the high efficiency diffuser lens 22. The shape of the ring 38 blends with the shape of the high efficiency diffuser lens 22 to support the desired ambient light distribution and its shape also influences its performance as a reflector in creating the desired downward light pattern. It also provides structural support for the warm white LED array 24 and neutral white LEDs 26. The ring 38 is designed to hide the assembly detail of the LED mounting provisions and to prevent direct glare from the LEDs to the user. This ring may optionally have open venting slots 40 toward the top, near the diffuser 22, to allow convective airflow to escape upward from the dome as an aid in cooling the LED devices.

[0062] The main function of high efficiency diffuser lens 22 is to direct the light from the warm white LED array 24 to create the desired ambient (upward) light pattern. The lens 22 is optically matched to the characteristics of array 24 (e.g., LED arrangement, light emission properties, distance from lens, etc.) for greatest efficiency and to achieve the desired light pattern in a uniform manner. The lens 22 is made of a transparent plastic (or glass) material that has diffusing properties to generate the desired wide ambient light pattern. It may employ microlens type, molded diffusing features, internal diffusing materials or other methods to direct the transmitted light. It is designed to have an efficiency of 85% or greater to minimize light loss and maximize energy efficiency of the fixture 10. The diffusing properties

of the lens 22 may vary along its radius (from center to edge) to create the desired light pattern and uniformity. Its diffusing properties will normally be uniform around its circumference, but may optionally be designed to direct light in given direction (e.g. away from the fixture's support arm 18 and toward the center of a room).

[0063] The warm white LED array 24 is composed of an array (e.g., 3 or more) of LEDs 42 that emit light in generally a Lambertian pattern and with a Correlated Color Temperature of 2800K, on average. The high efficiency diffuser lens 22 is the primary optical device to direct the light generated by these LEDs 42 as shown in Figure 6. This lighting is intended to illuminate the room via indirect reflection from ceiling and walls (see Figure 8), illuminate decorative items within a room and provide a level of lighting that permits a person to safely navigate within a room. A smaller portion of the generated light may also be reflected downward from the ring structure 38 (e.g., light rays 44 shown in Figure 6) and mix with the light generated from the downward facing LEDs 26. Examples of these LEDs 42 are Nichia 1 Watt or Cree 1 Watt warm white LEDs. The array of LEDs is disposed on a circular metal core (e.g., aluminum) printed circuit board (PCB) 46 to support electrical connection and mechanical mounting of the LEDs, including heat removal to minimize LED junction temperature. The PCB 46 may be constructed of materials other than metal. Other electronic components may be mounted on the PCB 46 to control the current to the LEDs 46. Additional heat sinking structural elements (e.g. fins that increase surface area) may be provided to increase thermal management effectiveness. The PCB 46 is connected to the dome/reflector 38 by means of LED PCB support structure 48. Alternatively, there may be a structural

connection to the support arm 18 of the fixture 10 to also transfer and then dissipate heat to the environment.

[0064] The warm/neutral white LED array 26 includes an array (e.g., 4 or more) of LEDs 50 that emit light in generally a Lambertian pattern and with a Correlated Color Temperature of 2800K to 3800K. These LEDs 50 may be mounted on a PCB ring 52 as show in Figures 5B and 5D or individually mounted to the dome/reflector 38. These LEDs 50 may have an additional lens attached to them to create the desired downward light distribution pattern. This lighting is intended to illuminate the surface or a desk, table, countertop or other flat surface as an aid in performing user tasks (reading, writing, childs' homework, care giving, etc.) as shown in Figures 7 and 8. It's color temperature (2800K to 3800K) is based on industry/university research whose findings indicate this is a preferred range by users for these types of tasks.

[0065] In one embodiment, the LED array 26 is disposed on an annular metal core (e.g., aluminum) printed circuit board (PCB) 52 to which the LEDs 50 mount to support electrical connection and mechanical mounting of the LEDs, including heat removal to minimize LED junction temperature. The PCB 52 may be constructed of materials other than metal. Other electronic components may be mounted on this array 26 to control the current to the LEDs 50. Additional heat sinking structural elements (e.g. fins that increase surface area) may be provided to increase thermal management effectiveness. The array is connected to the dome/reflector 38 by secondary support struts 54. Alternatively, there may be a structural connection to the support arm 18 of the fixture 10 to also transfer and then dissipate heat.

[0066] The light director 20 is mounted to the fixture's support arm 18 as shown in Figure 9. A pivot mechanism 56 is provided to allow the lighting director 20 to be rotated upward up to a predetermined number of degrees to change the light distribution pattern relative to the room ceiling/wall surfaces or tabletop surfaces as a user may desire depending on the fixture's location in a room and the user's preferences.

[0067] The lighting fixture 10 is designed to be powered from 12VDC which makes it compatible with a number of power supply sources including external batteries (e.g. truck or RV battery) as well as solar panel devices which typically output 12VDC. Referring to Figure 10, a solar panel accessory 60 is provided with the fixture 10 to enable it to operate totally independent of grid power when either interrupted (e.g., a power failure), not reliable (e.g., rolling blackouts due to limited utility power generation capacity), no grid connection available (e.g., in developing countries) or user doesn't want to use the grid (e.g., save on energy bills/environment). The solar panel 60 uses an array of photovoltaic technology to produce the required number of watts of power (or amps) that will recharge the fixture's batteries within a 12 hour period on average, considering sunlight levels available at various latitudes. The solar panel accessory 60 is sized to allow the fixture 10 to provide 4 to 6 hours of operation each day, when recharged solely from the solar panel. In one embodiment, the solar panel accessory 60 includes at least one battery cell which is charged while the fixture is uncoupled to the solar panel accessory 60. In this embodiment, the fixture 10 will be energized immediately upon

coupling to the solar panel accessory 60 and can be used while the battery cells in the fixture are being charged.

[0068] The solar panel accessory 60 is designed to be aesthetically pleasing in appearance yet provide good support functionality to allow it to be aimed through a window or placed in an outdoor location and optimally positioned for maximum sunlight absorption. An indicator and/or feedback feature allows the user to adjust the solar panel's orientation for the present sun angle. A length of cable 62 is provided so that the solar panel can be semi-permanently located and still maintain connection to the fixture 10. A spring loaded coiling device 64 allows the cable to be conveniently retracted and stored within the solar panel accessory when not being used.

[0069] In one embodiment, an array of Photovoltaic cells 66 is mounted on the top side of the dome/reflector 38 as shown in Figure 11A. The dome/reflector's pivot mechanism will allow the light director 20 to be tilted toward the sun through a window or skylight for day recharging of internal batteries as shown in Figure 11B.

[0070] Other Embodiments

[0071] Figures 12A-D illustrates several views of an LED lighting fixture 100 employing a reflector method. In this embodiment, the lighting director includes a Lambertian reflector 108 for reflecting light downward for task lighting and a Lambertian diffuser 112 for diffusing light through the top of the fixture for ambient light. Internal to the lighting director is a printed circuit board (PCB) 114 for supporting a plurality of Lambertian LEDS 102. It is to be appreciated that the PCB 114 may include one or more boards. A top surface of the PCB 114 includes at

least one LED 102 and a Lambertian reflecting mask 116 and a bottom surface includes at least one LED and a metalized flat mask 104. Mounted below the PCB 114 is a metalized conical reflector 106 for reflecting light generated by the LEDs mounted on the bottom surface of the PCB 114.

[0072] The LEDs 102 mounted on the top surface of the PCB 114 generate light which passes through the diffuser 112. The LEDs to support task lighting include warm white and neutral white LEDs 102 and are mounted on the metal core printed circuit board 114 facing downward. The LED light is reflected from the metalized conical reflector 106 and then off the Lambertian reflector 108 as shown in Figure 12D. These two optical mechanisms mix the light emitted from the LEDs to enable a high level of spectral and spatial uniformity when directed to a table or desk surface. The warm/neutral white LED array 102 includes an array (e.g., 4 or more) of LEDs that emit light in generally a Lambertian pattern and with a Correlated Color Temperature of 2800K to 3800K.

[0073] In another embodiment as shown in Figure 13, the task lighting is produced by a circular array of LEDs couple with a light guide. A circular array of LEDs 152 is disposed around the outer circumference of the dome shaped lighting director 150. A light guide 154 captures the emitted LED light and directs it downward to produce the desired task lighting pattern. For ambient lighting, a second array of LEDs 156 will be employed with a reflector 158 and diffuser 160 similar to the embodiments described above.

[0074] In an alternative embodiment of the lighting fixture 200 as shown in Figure 14, the removable light pods 202 are located in three or more "wedges" of a

horizontal base (e.g. three 120 degree sectors). The outside perimeter 204 of the light pod 202 supports a linear array of LEDs, battery and electronics. A wedge section may employ a hollow diffuser or light guide 206 to distribute the light.

[0075] In another alternative embodiment, the removable light pod 210 is a single element mounted in the middle of the fixture base 212 as shown in Figure 15. This pod may also direct light upward to become a light source for the ambient lighting function of the lighting fixture.

[0076] In a further embodiment shown in Figure 16, a single removable light pod element 220 is located in the dome structure 222 to support the main ambient light function but also be removable for portable distributed lighting. In one embodiment, light pod 220 will supplement the ambient light generated by fixture as described above. In another embodiment, the light pod 220 will be the only source for ambient light.

[0077] Referring to Figure 17, the lighting director 230 and support structure 232 are designed to be removed from a fixed base 234 and can be laid on its side or pivoted on its dome to direct lighting in a desired direction.

[0078] It is further contemplated that the lighting director be a standalone device to be mounted in various configurations. Figure 18 depicts other possible methods for mounting the lighting director on a table, from a ceiling, or on a wall.

[0079] With reference to Figures 19-24, a light pod in accordance with the present disclosure will be described.

[0080] As shown in Figure 19, the light pod 21 includes an annular, hollow diffuser/body 302 coupled to a base 304. The body 302 is constructed of a high

efficiency diffusing plastic material that distributes the light energy from two or more “warm” white LEDs (~2800K) 306 and two or more “neutral” white LEDs (~3800K) 308. The LEDs duty cycle are controlled to permit only warm white light to be generated, or only neutral white light to be generated or mixed proportions of one another so that any color temperature between about 2800K to about 3800K can be produced. This permits the user to optimally adjust the color temperature to the environment and task. The LEDs 106, 108 are 0.5 watt or 1.2 watt each, but could have other power levels.

[0081] The diffuser/body 302 has internal reflective properties to carry the light from the base 304 around and toward the top of the light pod 21, that is, the internal surfaces of the hollow body are reflective and semi-transparent. While some light is reflected inside the cavity of the diffuser/body 302, the majority is transmitted through the diffuser/body 302 to the outside environment as shown in Figure 19. The material of the diffuser/body has diffusing properties to disperse the light in many different directions, to provide room ambient lighting and to reduce direct “hot spots” and glare from LEDs 306, 308. The inside surface 310 of the diffuser/body 302 is configured to be more reflective than the other three sides of the diffuser/body 302, in this manner, light is minimally transmitted into the center “hole” of the light pod 21 where it has little use. The surface 310 is employed to reflect light back toward the outside surface of the diffuser/body 302 for transmission into the room.

[0082] The base 304 is made of an opaque material and contains the LEDs 306, 308, drive electronics, battery, processor and user controls. The base 304 is a generally rectangular volume with at least one flat surface 312 for supporting the

light pod 21 in an upright position on a surface with the body 302 being perpendicular to the surface. The base 304 is designed to be comfortable for hand-held use or to sit securely on any flat surface, and to interface with various power and mounting accessories as will be described below. The base 304 provides heat transfer (thermal management) for the LEDs and other internal electronic and battery components to the external environment. Internal mechanical provisions and mating with base 304 of the internal electronics provide for heat conduction and convection to the external environment. The LEDs 306, 308 are mounted to the base 304 via metal core printed circuit board (PCB) to transfer heat from the LED junction to the base 304 and then to the external environment.

[0083] The light pod 21 is designed for indoor applications and is drop resistant (e.g., a 3 foot drop). To the extent possible, the light pod 21 will be made from recyclable materials and its components will be easily separable at end-of-life.

[0084] The light pod 21 produces approximately 150 to 350 lumens of flux (i.e., total light output.) The Color Rendering Index is > 80 , to provide good rendering of people and objects in a residential setting. Optional versions of the light pod 21 may have colored LEDs (e.g. amber, red, blue or any other color through RGB color mixing methods). The light distribution pattern is depicted in Figure 20. The light pod 21 emits light mainly from the outside three surfaces of the body 302 (e.g., a top circumferential surface 314, an annular, front surface 316 and annular back surface 318) to support a wide area distribution ambient lighting function. The light pod 21 emits a more concentrated amount of light near the base 304 as indicated by the more closely spaced arrows. This is to support illumination

of table top objects when the light pod 21 is sitting on a table (or other surface). When the user is holding the light pod 21 while moving about, the same concentrated light pattern can be steered toward intended targets of interest.

[0085] Figure 21 depicts the general luminous intensity (candela) profile of the emitted light. As can be seen, more light is emitted along the lateral axis of the light pod 21, allowing the user to steer more concentrated light in the desired direction or to be of better utility when used in a hand-held manner.

[0086] The light pod 21 can be powered from a plurality of power sources including internal batteries, a 120VAC-to-12VDC power supply (e.g. wall cube), a vehicle 12VDC source or a solar panel/battery accessory, etc.. When not operating on batteries, the light pod 21 can be inserted in a charging base – single 322 or ganged 324 (as illustrated in Figure 22) to be directly powered or recharged from another energy source as listed above. The light pod 21 is also designed to be recharged in the lighting fixture 10 (when inserted) via a docking or mating connector, as will be described below.

[0087] The light pod 21 and charging accessories are designed to fully recharge the internal batteries of the light pod in a 12 hour period. The batteries and recharge circuitry are designed for frequent recharging cycles to maximize their useful life before replacement. The light pod is designed to draw minimal power in its “off” state to preserve battery power and to minimize draw on other power sources (e.g. grid).

[0088] The electronics architecture of the light pod 21 is illustrated in Figure 23. The electronics architecture generally includes a battery system 330, charge

circuit 332, two LED driver circuits 334, 336, a processor 338 and user controls 340. In one embodiment, the light pod will include an RF link 342 for remote control operation.

[0089] The battery system 330 is made up of one or more lithium ion rechargeable cells. The battery system 330 is replaceable in the event that it loses capacity through extended use or to remove for product disposal and recycling. The battery is located in the base 304 to keep the light pod's center of gravity toward the base for secure and stable placement on a flat surface.

[0090] A recharging circuit 332 measures the voltage of the battery pack and controls the recharge energy applied to ensure full recharge in 12 hour period and removing recharge energy once the battery is fully recharged (e.g., to prevent overcharge). The recharging circuit 332 will also command "off" the light pod if the voltage gets too low, which could cause damage to the battery cell. The recharging circuit 332 also provides charge status information to a main processor to provide user indications ("charged", "charging", "battery low", etc.).

[0091] The base 304 further includes a docking or mating connector 333 coupled to the charging circuit 332. The docking or mating connector 333 will couple to a complementary connector on the lighting fixture 10 described above or connect with the various charging accessories of Figure 22. When coupling to the lighting fixture 10, the charge circuit 332 will recharge the battery cells 330 with power or energy received via the docking or mating connector 333 from the lighting fixture 10.

[0092] The electronic architecture further includes LED drivers 334, 336 coupled to the LEDs 306, 308. The LED drivers 334, 336 are electronic circuits that

uses a "boost" style switching regulator to maximize the energy extraction from the battery (even as its voltage falls off) and to provide a constant current (e.g. ~350mA) to the LEDs 306, 308. The LEDs require a constant current to achieve intended light output and to ensure LED reliability.

[0093] The light pod 21 includes two driver channels 334, 336, one for warm white (WW) LEDs and one for neutral white (NW) LEDs, respectively. Each driver channel is controlled by processor 338. The processor 338 can activate one driver or the other, or both in combination using Pulse Width Modulation (PWM) signals to vary the duty cycle between colors to shift the combined color temperature anywhere between about 2800K to about 3800K as commanded by the user. In addition, this same PWM technique can be used in both channels to dim the light from 100% power linearly down to 0%, at a constant color temperature.

[0094] The processor 338 accepts user inputs from the on-board user controls 340, mounted in the base 304 or from an optional remote control via the RF Link 342. The processor 338 controls light on/off, color temperature and dimming. An optional remote control may be provided that can control a single or up to 10 light pods individually using an addressing mechanization. The RF signal will be in the 900 MHz or 2.4 GHz range to permit non-line of sight short range and low power control within a home. 802.11 or "Zigbee" communications protocols may be employed. The remote control will allow the user to program (programming stored in the remote control) the following for each light pod: set "on"/"off" times; set color temperature value; set dimming (intensity) value; set "energy save" mode; manual on/off control; manual color temperature control; manual dimming control; manual

Energy Savings mode, etc. The remote control will have the capability to display current settings and options of the light pods it is controlling.

[0095] Referring to Figure 24, the light pod will have mechanical features that permit it to be mounted on a flat surface (Figure 24A), from walls (Figure 24B), ceilings (Figures 24C and D) and other surfaces. This may be done with attachment points on the base 304 or with an adapter mechanism.

[0096] While the disclosure has been shown and described with reference to certain preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the disclosure.

WHAT IS CLAIMED IS:

1. A lighting fixture comprising:
 - a base for supporting the fixture on a surface;
 - a support arm coupled to the base for supporting a lighting director;
 - the lighting director including a plurality of LEDs, the plurality of LEDs configured for providing independently controllable light distribution patterns; and
 - at least one detachable light pod disposed along the support arm, the at least one detachable light pod including at least one LED.
2. The lighting fixture of claim 1, wherein the independently controllable light distribution patterns include an ambient light pattern and a task light pattern.
3. The lighting fixture of claim 1, wherein the support arm pivotally supports the lighting director.
4. The lighting fixture of claim 1, wherein the at least one detachable light pod is automatically activated when detached from the fixture.
5. The lighting fixture of claim 1, further comprising a first rechargeable power source for powering the plurality of LEDs in the lighting director.

6. The lighting fixture of claim 5, wherein the at least one detachable light pod comprises a second rechargeable power source, wherein when the at least one detachable light pod is coupled to the fixture, the second rechargeable power source provides power to the plurality of LEDs in the lighting director.
7. The lighting fixture of claim 1, wherein the lighting director further comprises:
 - a first array of LEDs configured for producing light in a longitudinal direction away from the light director; and
 - a second array of LEDs configured for producing light in a direction opposite of the light produced by the first array.
8. The lighting fixture of claim 7, wherein the first array of LEDs are mounted on a circular printed circuit board having a first diameter and the second array of LEDs are mounted on a ring-shaped circuit board, wherein the inner circumference of the ring-shaped circuit board has a second diameter greater than the first diameter.
9. The lighting fixture of claim 7, further comprising a diffuser disposed over the first array of LEDs to diffuse light emitting from the first array and to reflect light in the direction opposite of the light produced by the first array.
10. The lighting fixture of claim 7, wherein the lighting director comprises a dome-shaped reflector having an inner and outer surface, the dome-shaped reflector configured to support the first array of LEDs and the second array of LEDs.

11. The lighting director of claim 10, wherein the dome-shaped reflector comprises an array of photovoltaic cells disposed on at least a portion of the outer surface.

12. The lighting fixture of claim 1, wherein the lighting director further comprises:
a printed circuit board having a first surface and second opposite parallel surface;

a first array of LEDs mounted on the first surface configured for producing light in a longitudinal direction away from the light director; and

a second array of LEDs mounted on the second surface configured for producing light in a direction opposite of the light produced by the first array.

13. The lighting fixture of claim 12, wherein the lighting director further comprises:

a domed-shaped reflector having an inner and outer surface, the dome-shaped reflector configured to support the printed circuit board, wherein light generated by the first array of LEDs is emitted through an aperture of the dome-shaped reflector.

14. The lighting fixture of claim 13, wherein the lighting director further comprises a conical reflector positioned below the second surface of the printed circuit board, wherein light generated by the second array of LEDs is reflected by the conical

reflector to the inner surface of the dome-shaped reflector and further reflected in the direction opposite of the light produced by the first array.

15. The lighting fixture of claim 14, wherein the lighting director further comprises a diffuser disposed in the aperture of the dome-shaped reflector.

16. The lighting fixture of claim 1, wherein the lighting director further comprises:
a circular reflector for supporting a first array of LEDs;
the first array of LEDs configured for producing light in a longitudinal direction away from the light director;

a second array of LEDs disposed along an outer peripheral circumference of the circular reflector; and

at least one light guide coupled to the second array of LEDs, the at least one light guide configured for capturing light emitted by the second array of LEDs and directing the emitted light in a direction opposite of the light produced by the first array.

17. The lighting fixture of claim 1, wherein the at least one detachable light pod further comprises:

a base for supporting a rechargeable power source and the at least one LED;
and

a annular, hollow diffuser body for distributing light generated by the at least one LED away from the at least one LED.

18. The lighting fixture of claim 17, wherein the diffuser body includes an inside surface for reflecting light from the at least one LED and at least one outer surface configured with a partially transparent material to allow the reflective light to pass through the outer surface.

19. The lighting fixture of claim 18, wherein the at least one detachable light pod further comprises:

at least two LEDs; and

a processor for individually controlling the at least two LEDs to maintain an adjustable color temperature.

20. The lighting fixture of claim 19, wherein the processor controls the at least two LEDs using pulse width modulation (PWM) signals.

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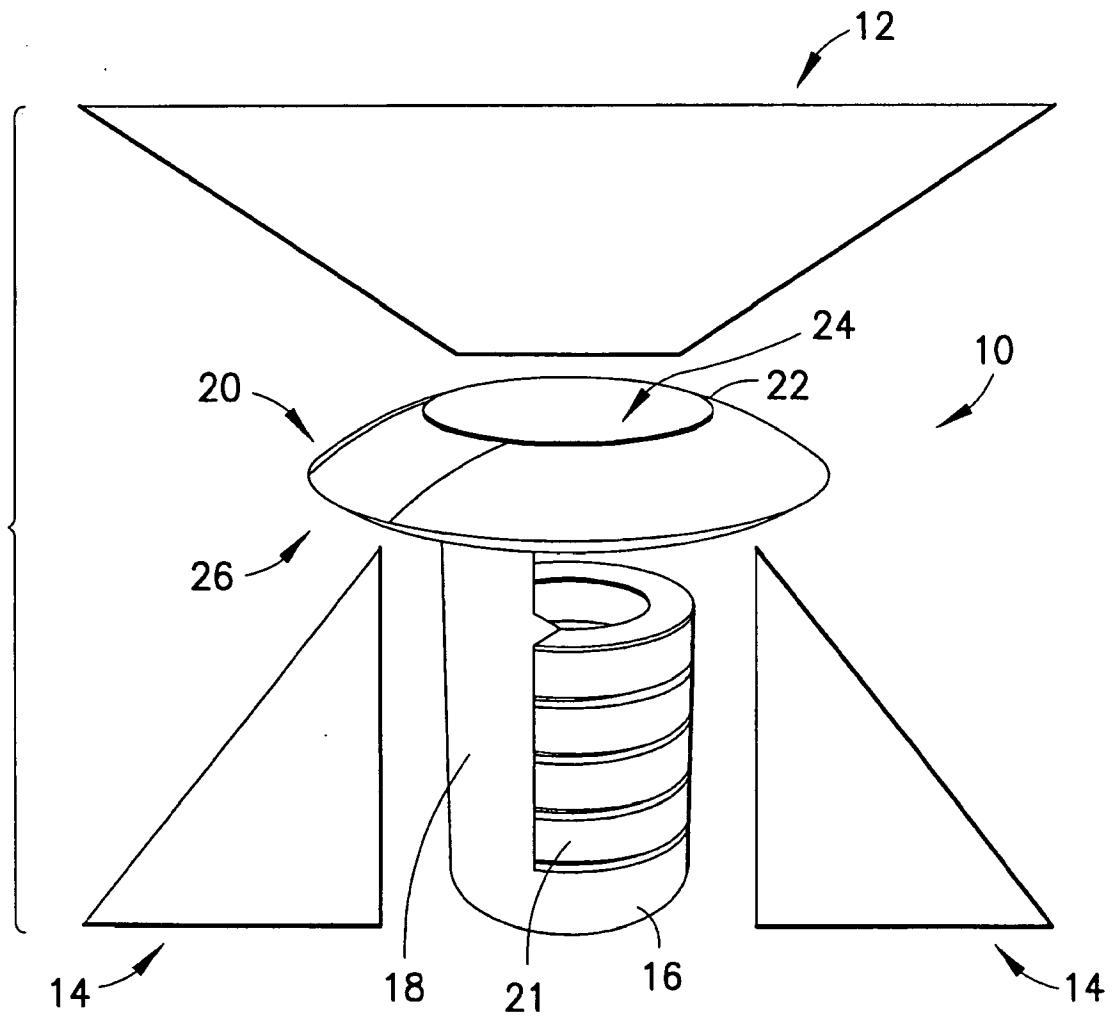
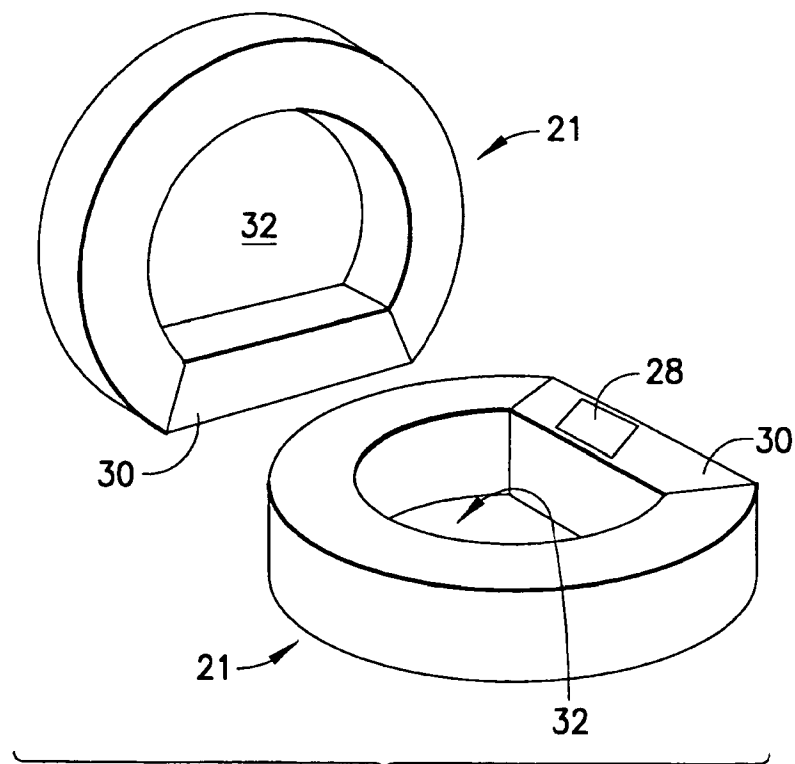
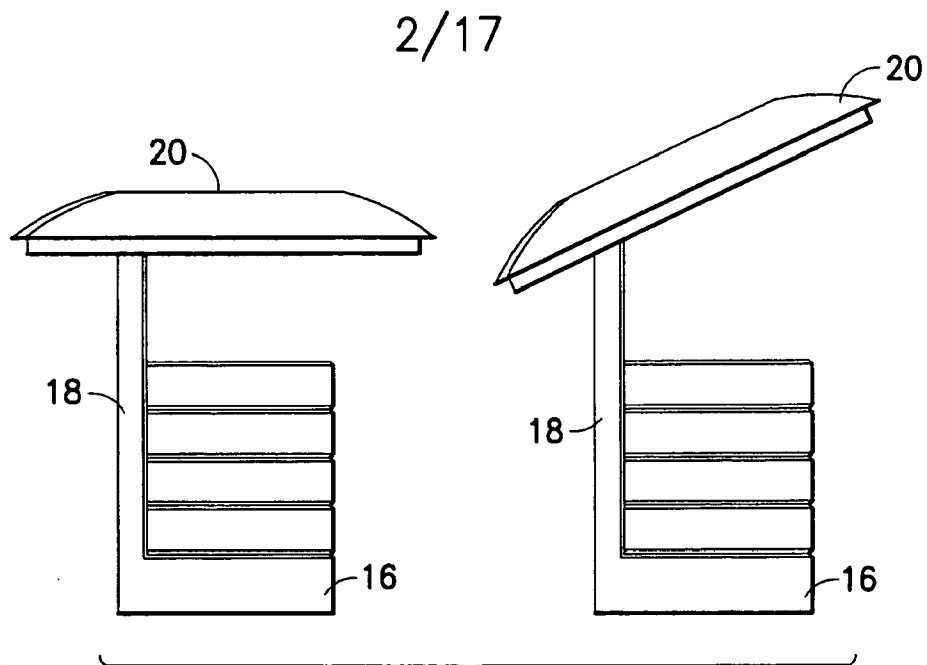


FIG.1



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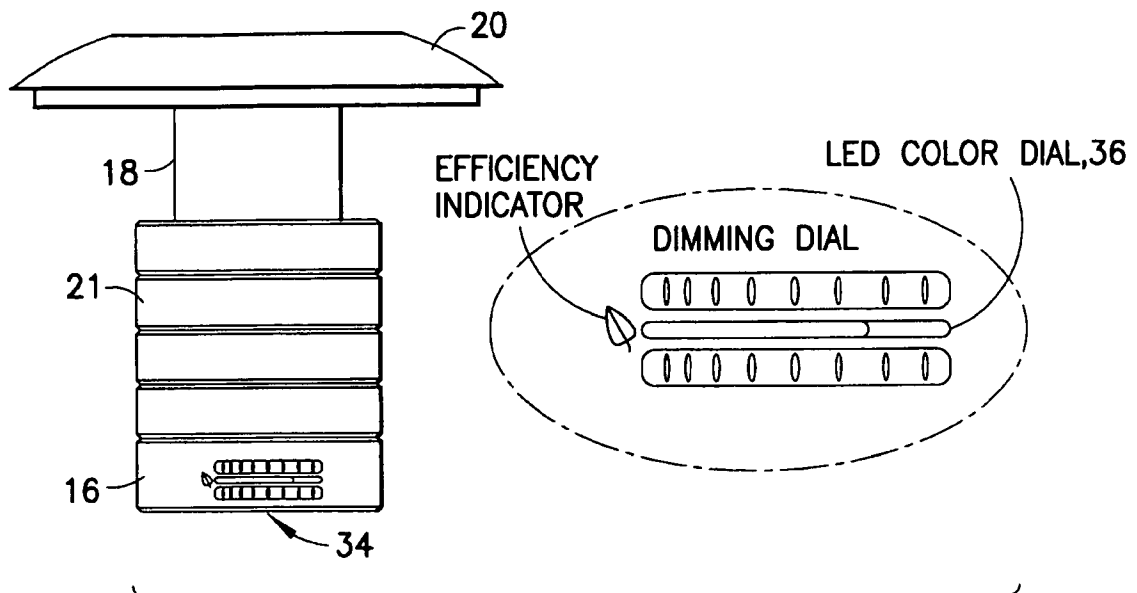


FIG. 4

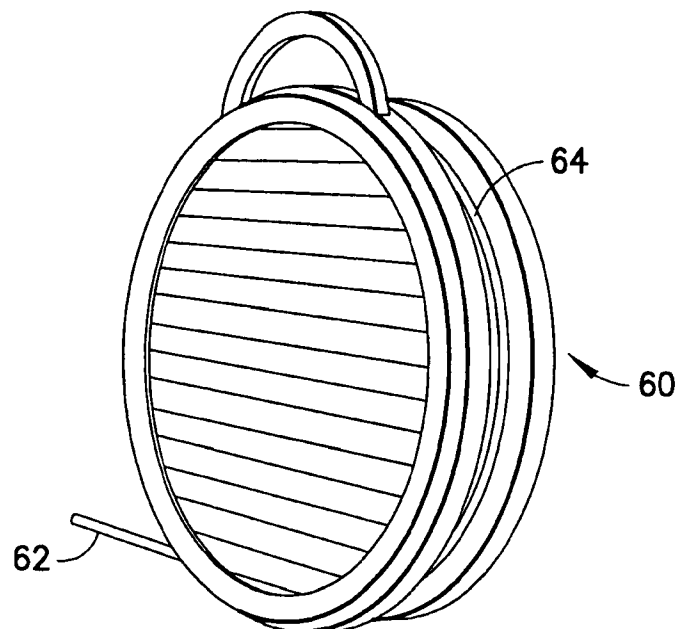


FIG. 10

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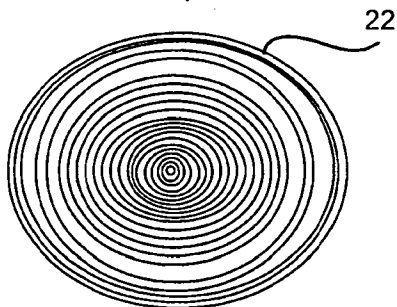


FIG. 5A

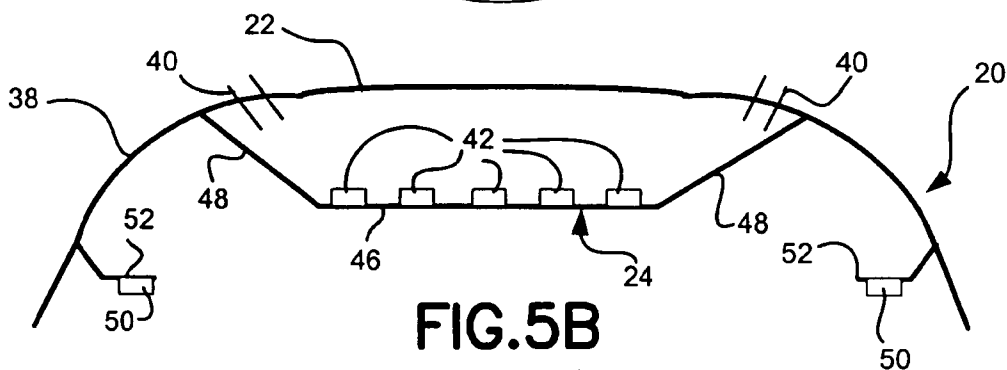


FIG. 5B

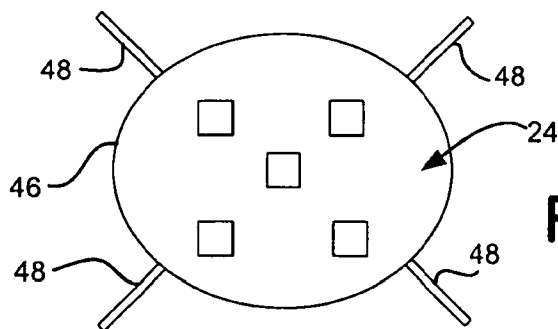


FIG. 5C

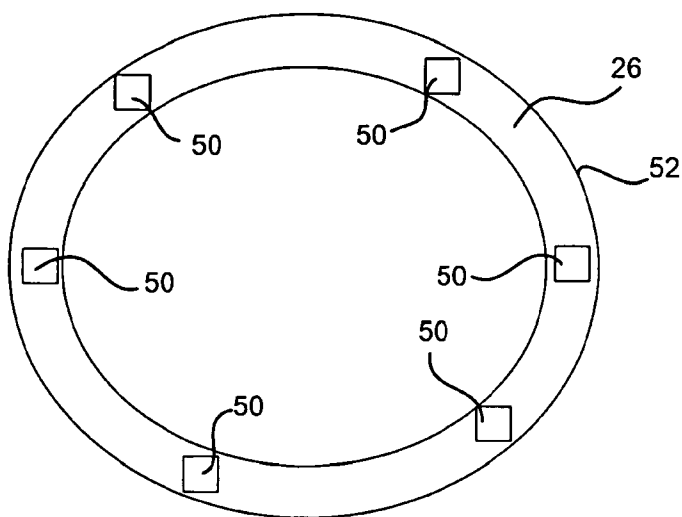


FIG. 5D

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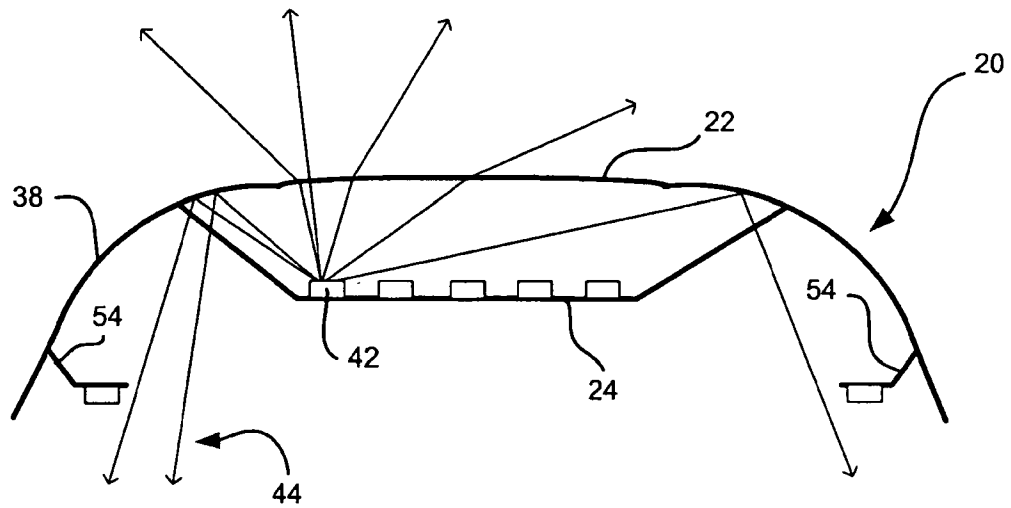


FIG. 6

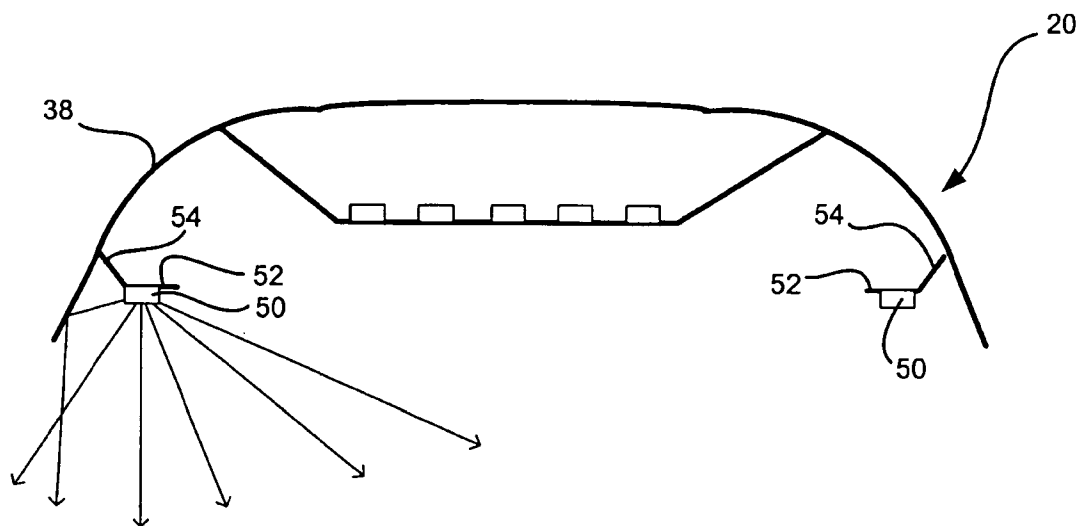


FIG. 7

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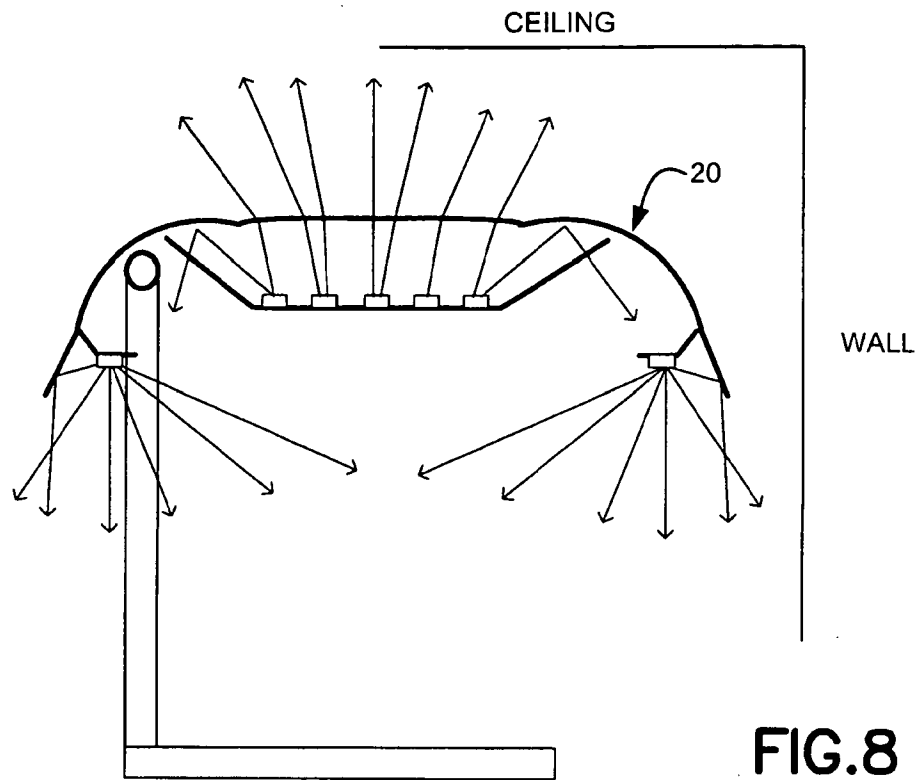


FIG. 8

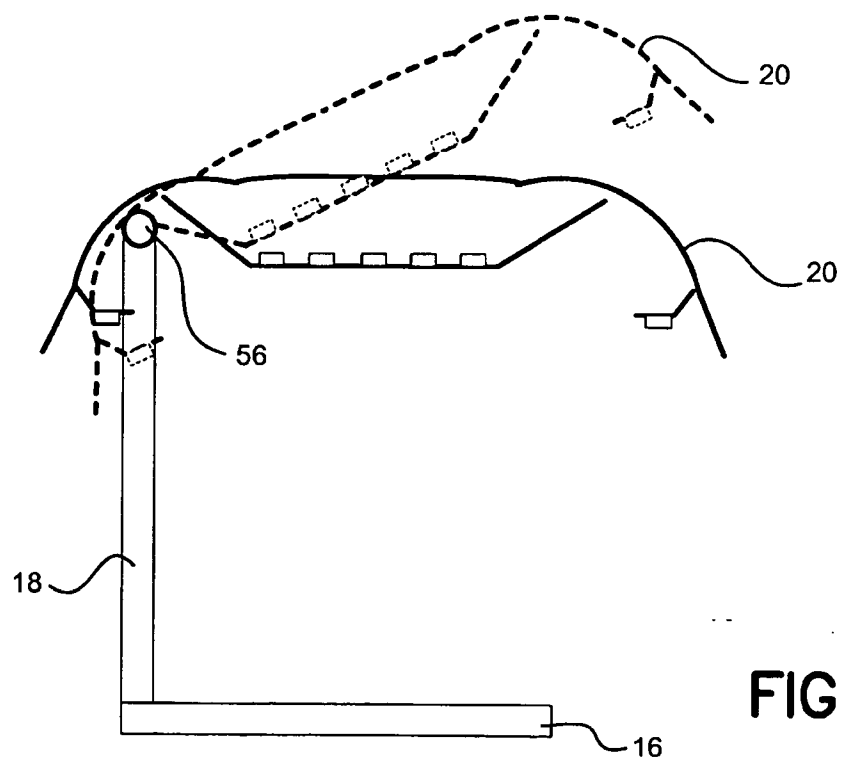
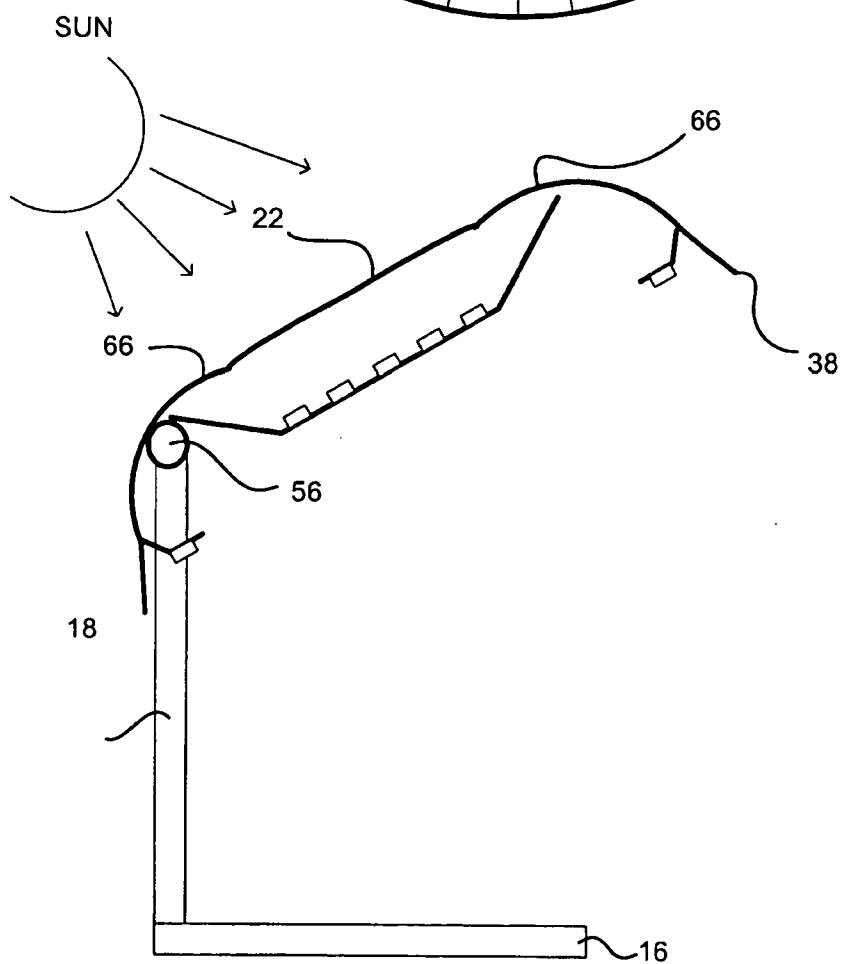
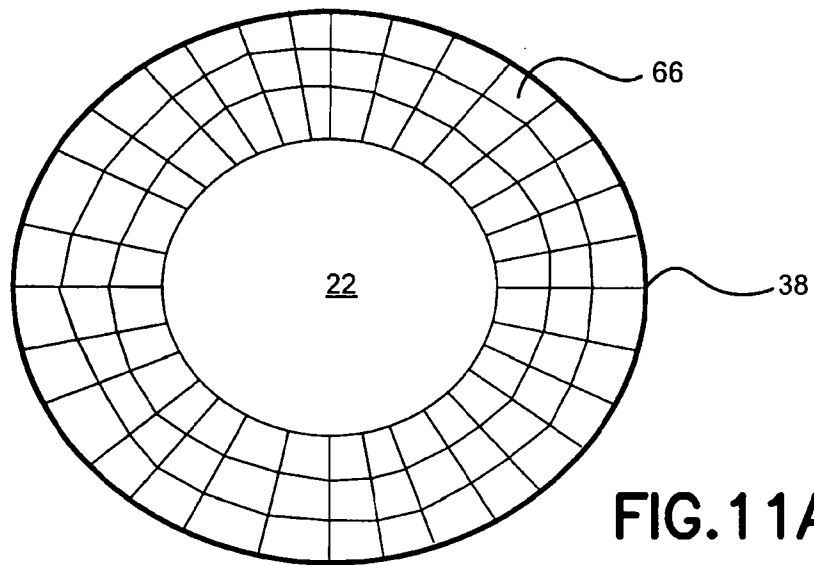
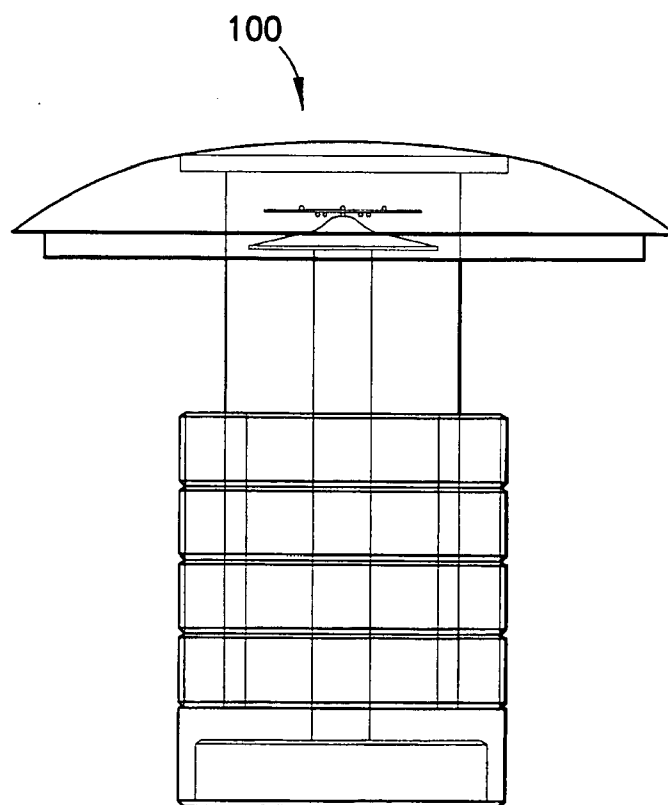
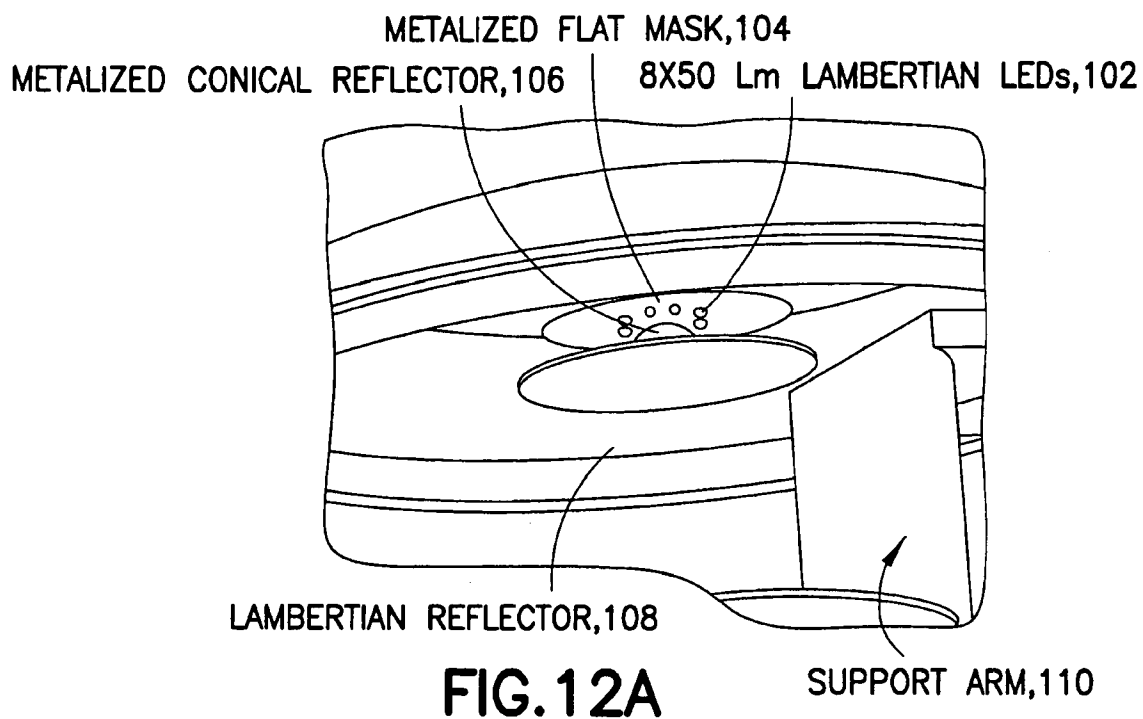


FIG. 9

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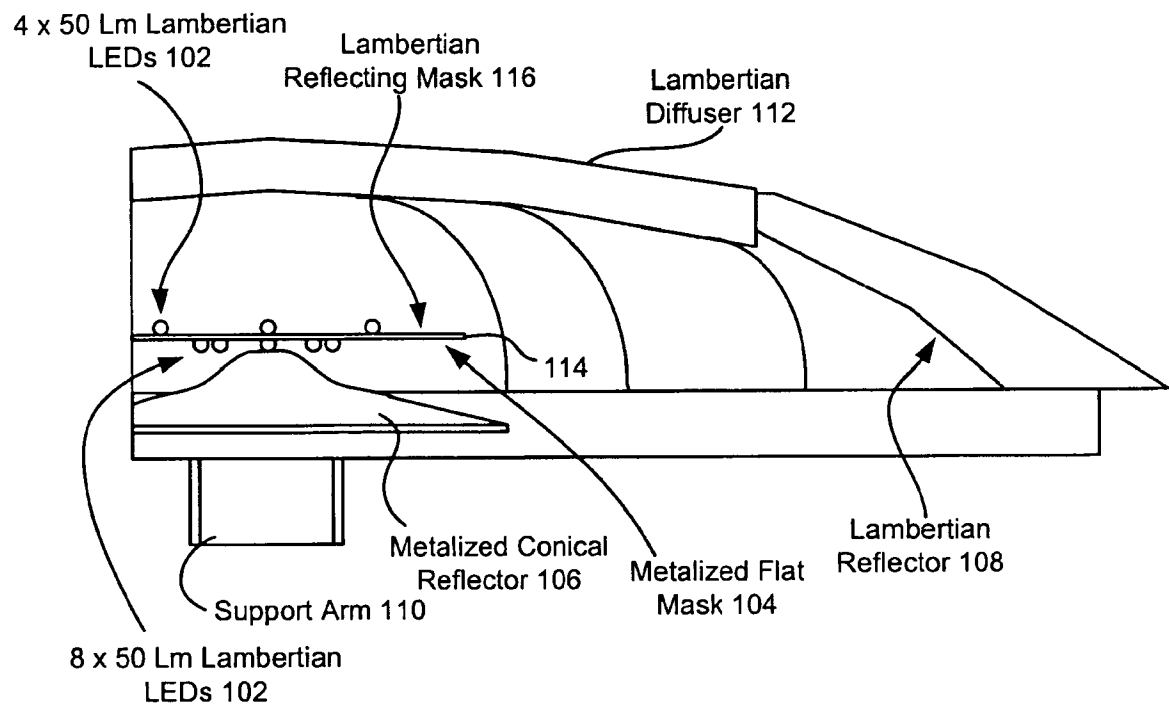


FIG. 12C

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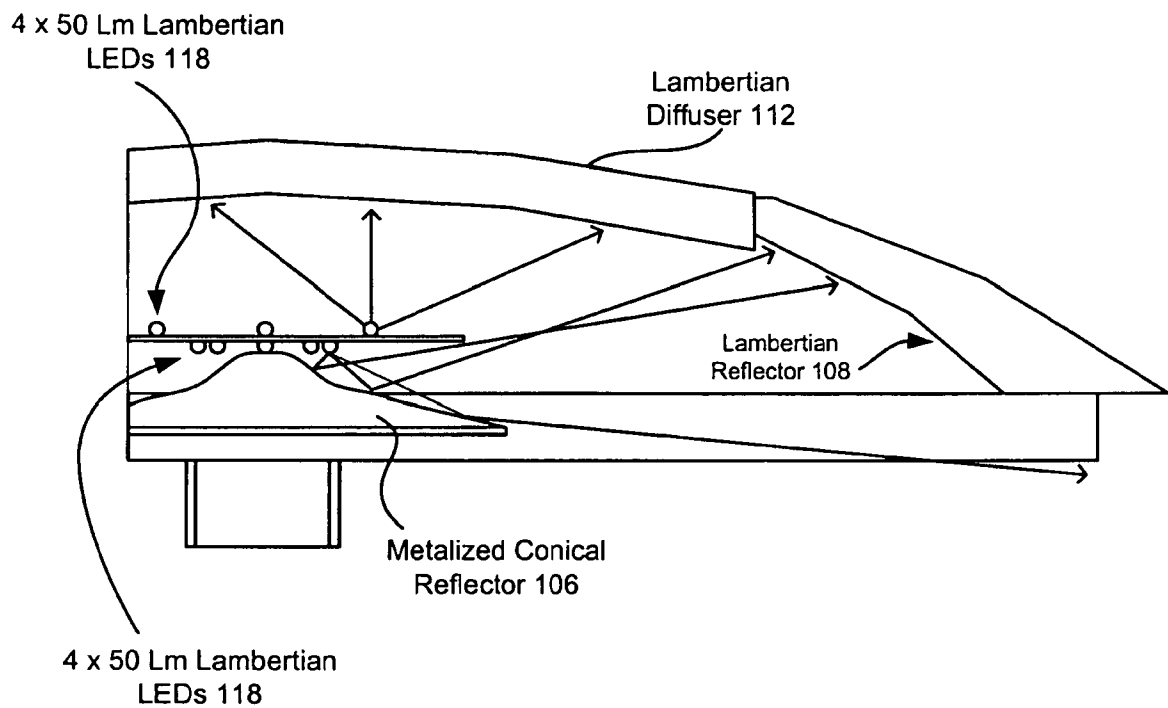


FIG. 12D

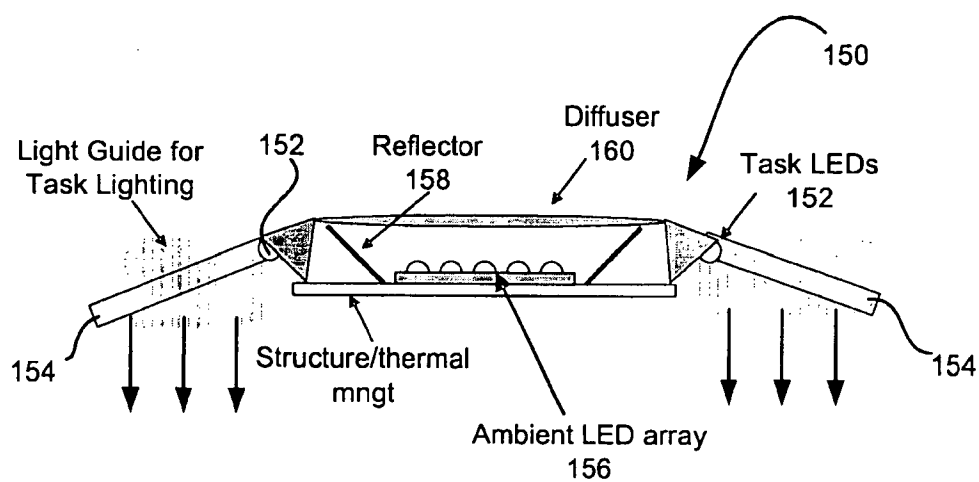
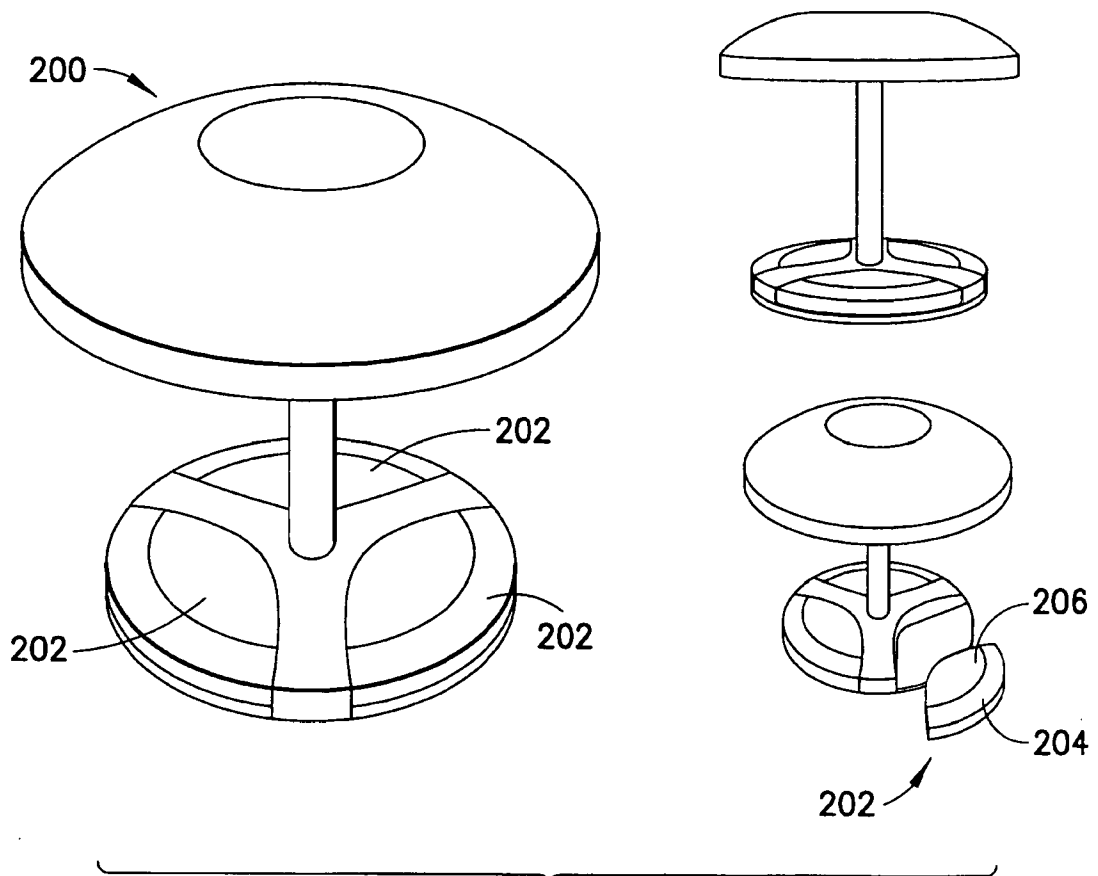
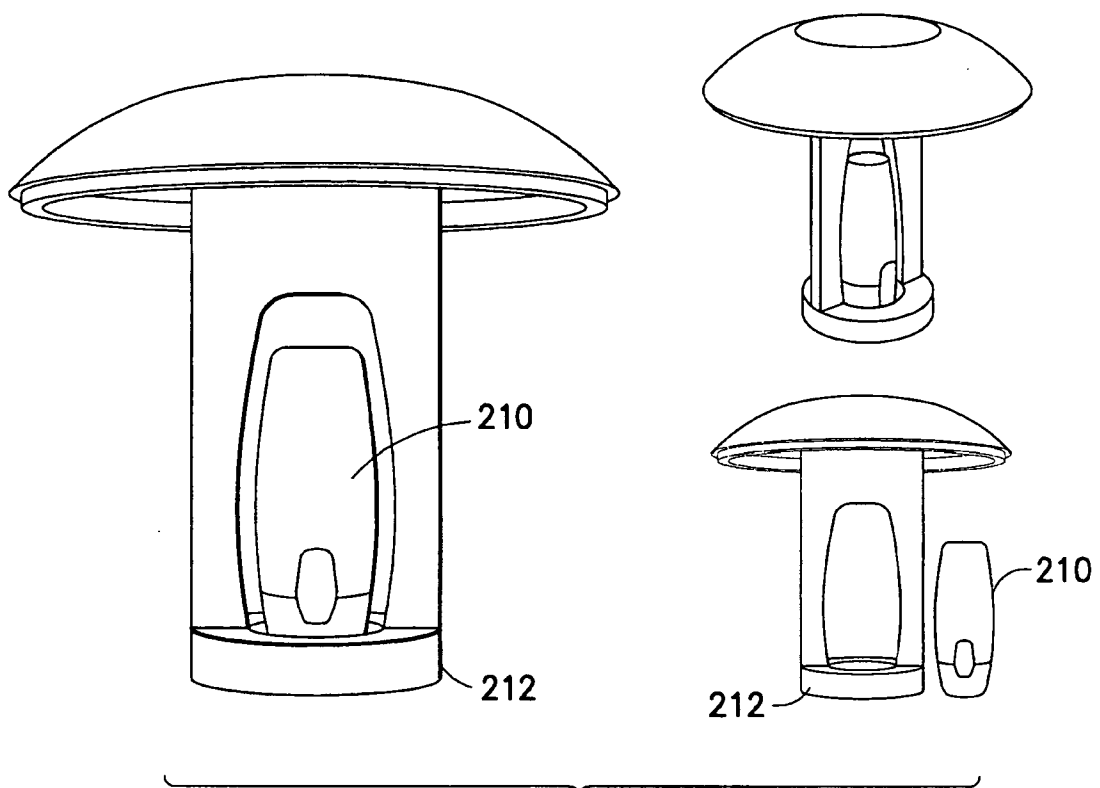


FIG. 13

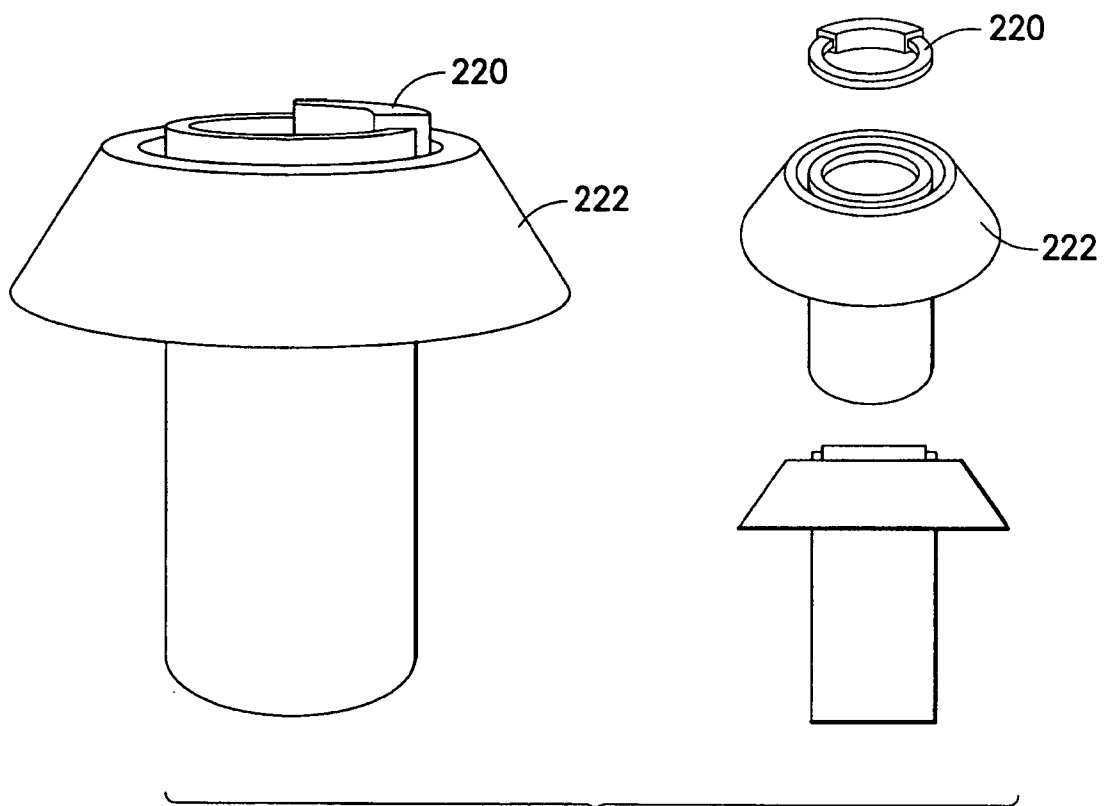
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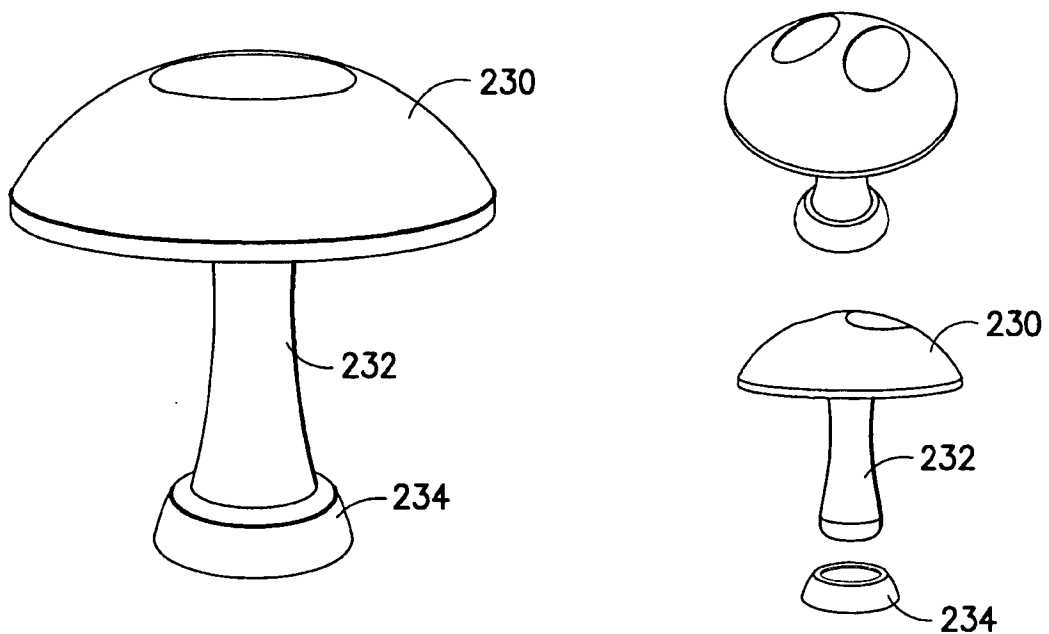
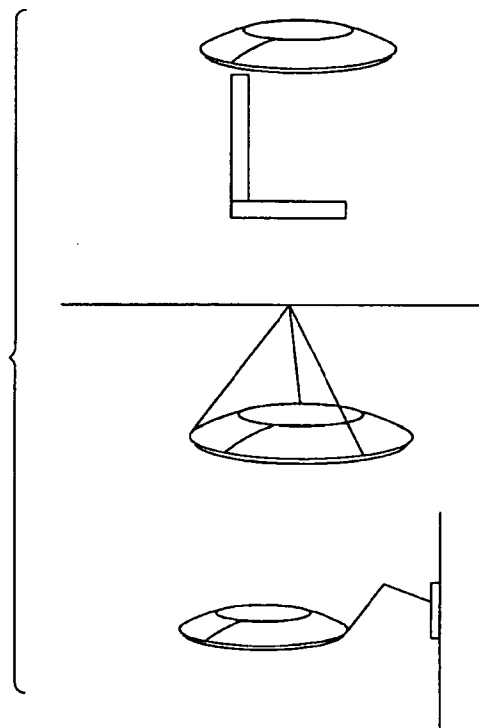


FIG. 17

FIG. 18



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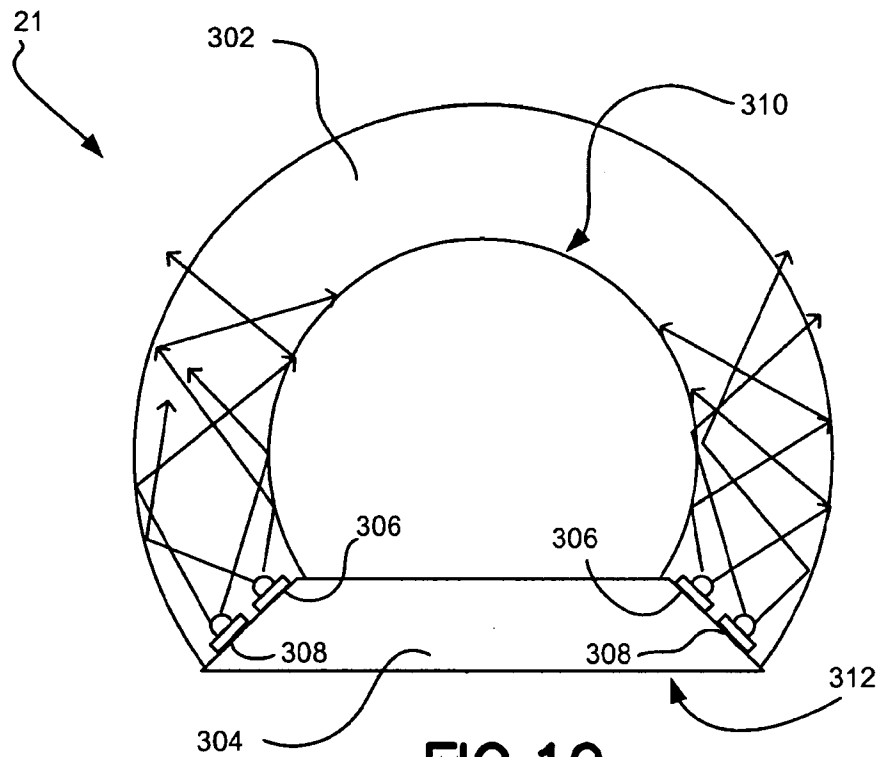


FIG. 19

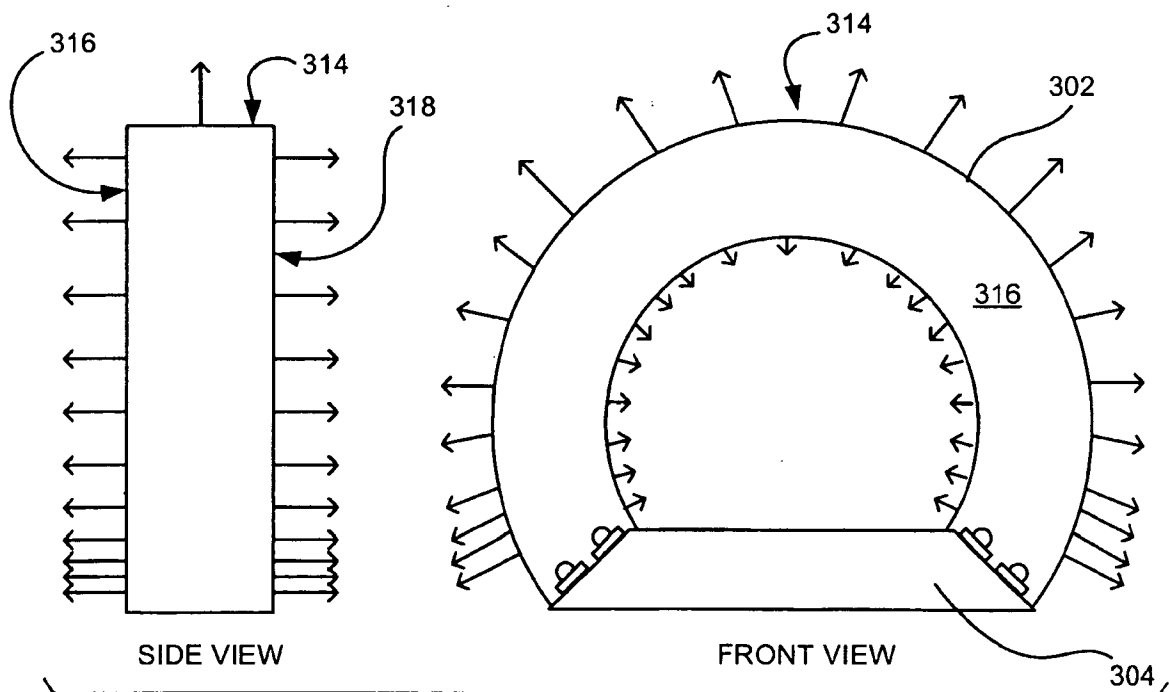


FIG. 20

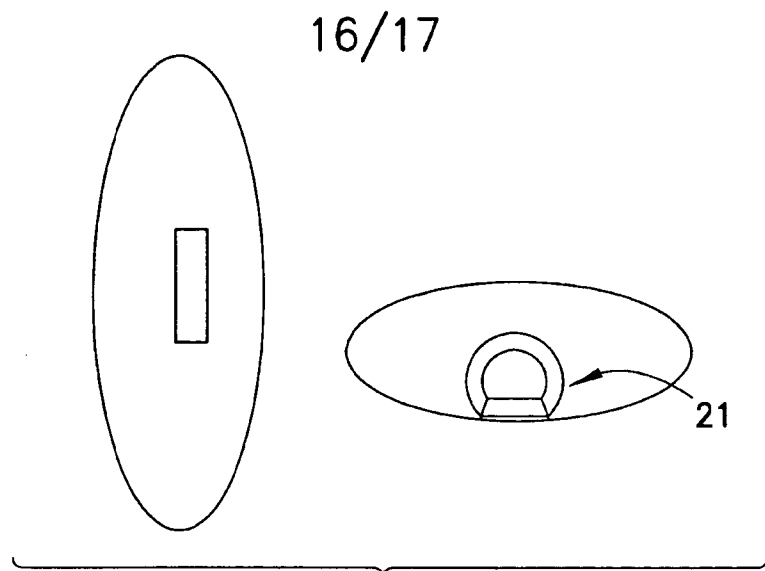


FIG.21

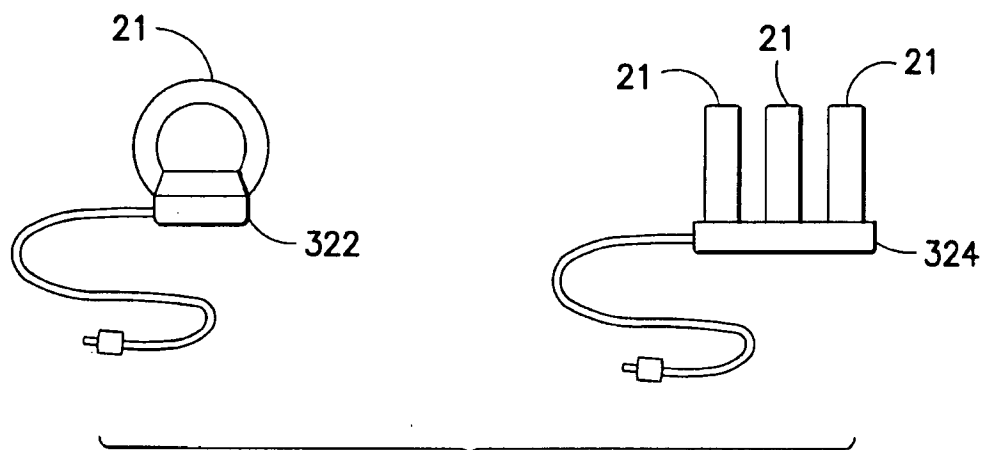


FIG.22

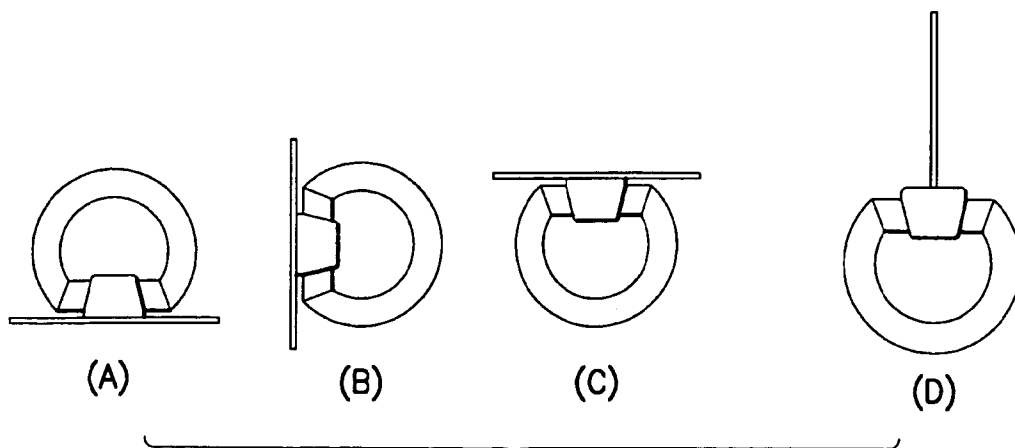


FIG.24

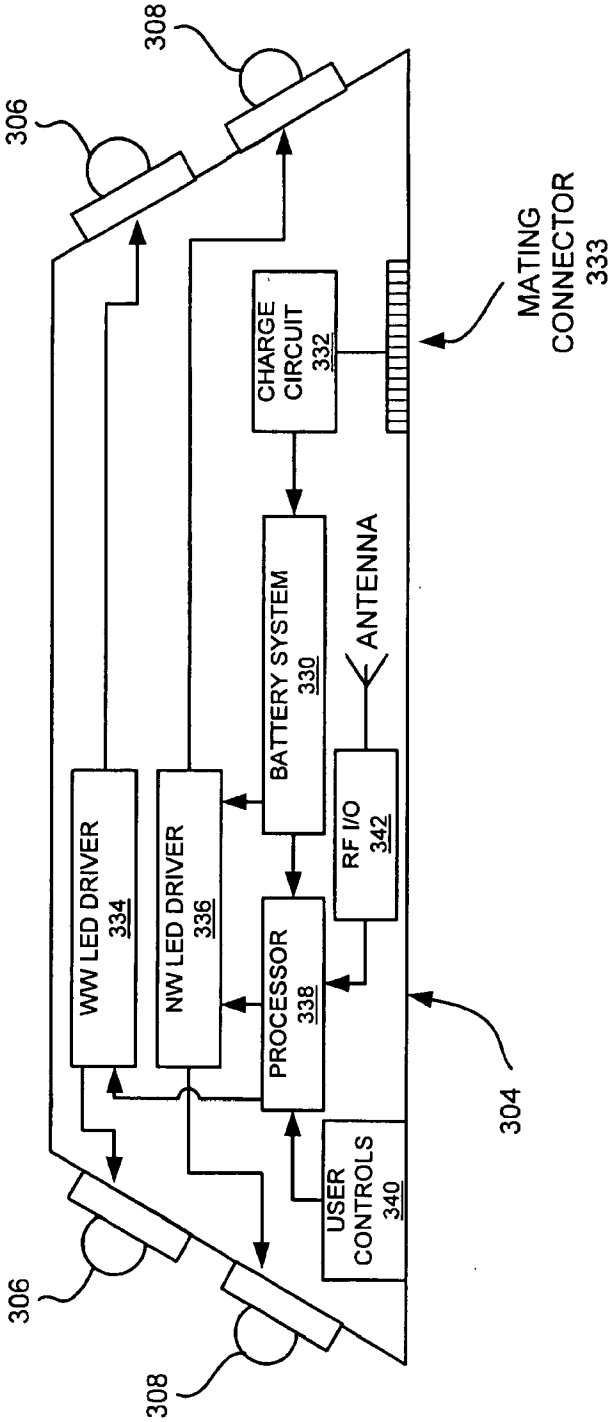


FIG.23