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(54) **LED LAMP FAILURE ALERTING SYSTEM**

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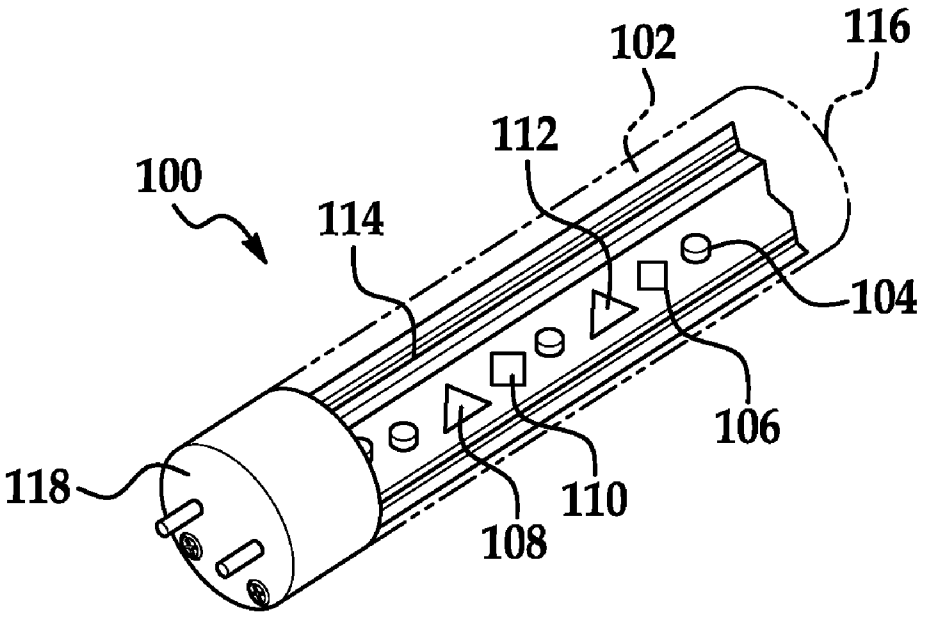
(57) **ABSTRACT**

A lighting system includes at least one LED and at least one regulator in communication with the at least one LED. The at least one regulator is configured to supply a substantially constant current to the at least one LED while allowing a light output from the at least one LED to degrade over time towards a target minimum light output, and once the light output of the at least one LED is below the target minimum light output, increase current to the at least one LED to maintain the light output at the target minimum light output.



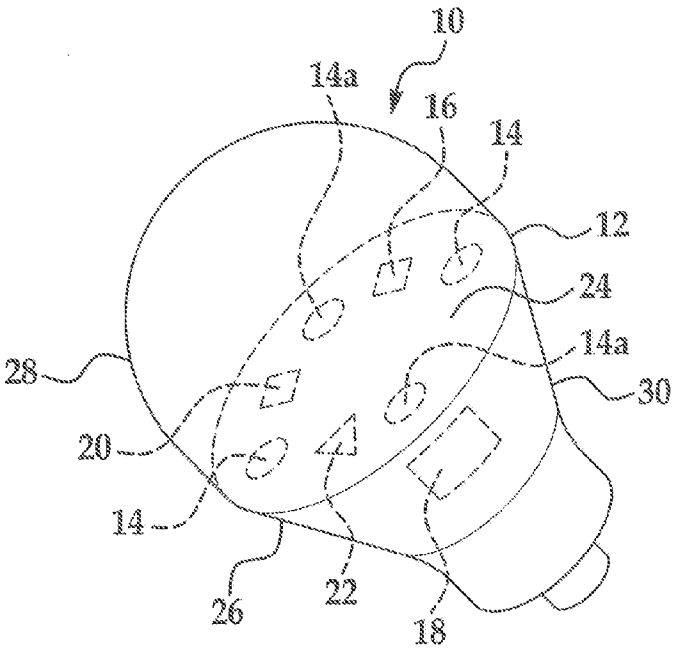


FIG. 1

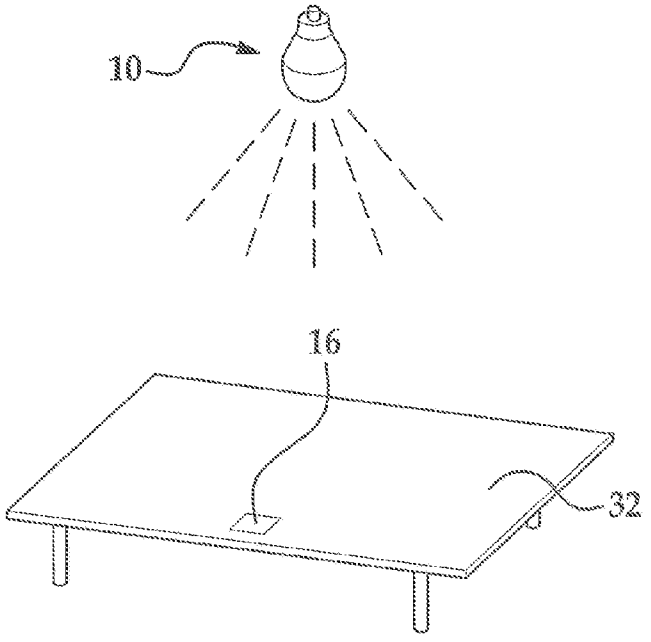


FIG. 2

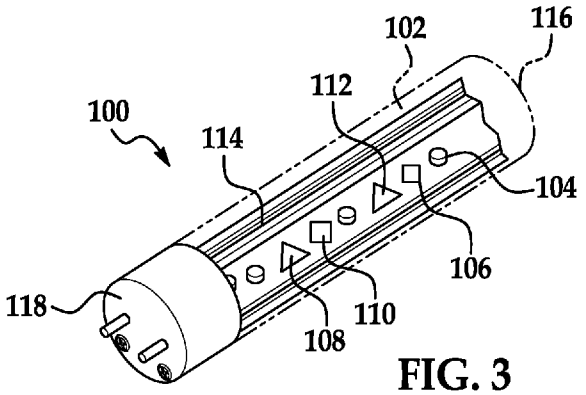


FIG. 3

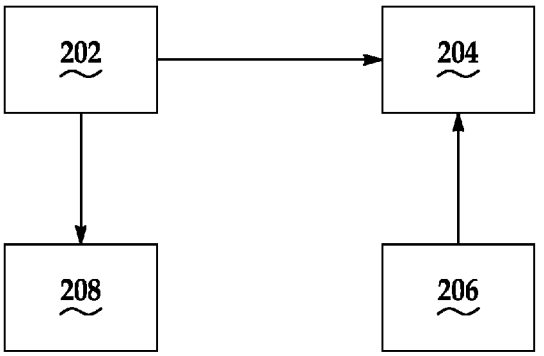


FIG. 4

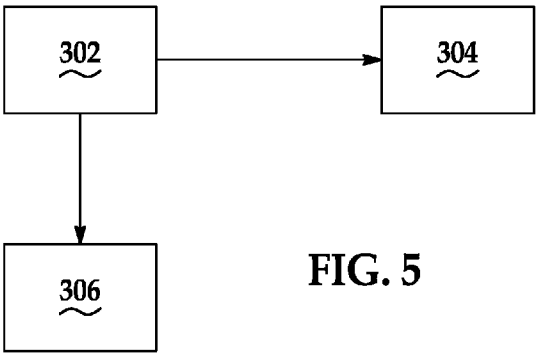


FIG. 5

LED LAMP FAILURE ALERTING SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a divisional of U.S. patent application Ser. No. 14/202,443 filed Mar. 10, 2014, which is a continuation of U.S. patent application Ser. No. 12/202,662 filed Sep. 2, 2008, now U.S. Pat. No. 8,674,626, issued on Mar. 18, 2014, the disclosure of which is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates in general to light fixtures utilizing light emitting diodes, and more particularly, to failure alerting systems for the light emitting diodes.

BACKGROUND

[0003] Light emitting diode (LED) lighting fixtures are useful for a variety of applications. Examples of these applications include commercial and household interior lighting, exterior and egress lighting, emergency lighting, automotive lighting and instrument lighting. LED lighting fixtures promise to provide improvements over existing lighting technologies. One significant improvement is a longer operating life. This improvement, however, raises different challenges than other lighting technology. Whereas other sources of light, such as fluorescent and incandescent, have a failure mode of relatively sudden and complete shut-off, LEDs typically continue to fade over time without shutting off completely. This tendency has been recognized by the solid-state lighting industry in the form of lifetime measurement criteria that defines LED life as "L70", the hours of service at which the LED will output 70% of its original and/or rated output at the original/rated power draw.

[0004] This failure mode can be perceived as a benefit, for example in the case of an LED lamp used to light an entrance over a dark set of stairs. An incandescent light will fail immediately when the filament burns out, leaving the entrance and stairs in the dark, while an LED lamp will typically continue to provide light at some level for a much longer period of time. However, the gradual dimming can be problematic. For example, at a given power draw, less light is output, resulting in an area that is less lit than intended. This can result in safety or security problems. More lights must be turned on or the lamps must be "undimmed" in order for the light levels to reach the level desired. The result is increased power consumption. Egress lighting requirements may require lighting designers to over-specify the amount of light in an area to ensure the required emergency egress light level is available in emergency evacuations over the lifetime of a building. This can cause regulatory barriers to the acceptance and implementation of LEDs into commercial and institutional buildings. In addition, due to the difficulty, time and expense of accurately determining when an LED light has permanently dropped below the acceptable light output limit, consumers may automatically replace LEDs upon expiration of the warranty. This may result in years of useful operational life being unnecessarily wasted, reducing the cost effectiveness of using LED lighting in the first place.

BRIEF SUMMARY

[0005] Disclosed herein are embodiments of LED-based lights and lighting systems. On such illustrative embodiment of lighting system comprises at least one LED and at least one regulator in communication with the at least one LED. The at least one regulator is configured to supply a substantially constant current to the at least one LED while allowing a light output from the at least one LED to degrade over time towards a target minimum light output, and once the light output of the at least one LED is below the target minimum light output, increase current to the at least one LED to maintain the light output at the target minimum light output.

[0006] Another embodiment disclosed herein is an LED-based light comprising at least one LED, a connector connectable to a light fixture, and a system for managing the at least one LED. The system is configured to detect a light output of the at least one LED, operate the at least one LED at a first power draw while allowing the light output from the at least one LED to degrade over time towards a target minimum light output, and once the light output of the at least one LED is below the target minimum light output, operate the at least one LED at an increased power draw to maintain the light output at the target minimum light output.

[0007] Yet another embodiment is an LED-based light comprising at least one LED, a lens at least partially enclosing the at least one LED, the lens at least partially forming a housing for the LED-based light, a connector attached to the housing and configuring the LED-based light for connection to a light fixture, and a system for managing the at least one LED. The system is configured to detect a light output of the at least one LED, operate the at least one LED to maintain the light output at a target minimum light output, and generate one or more signals indicating that the light output is low once the light output can no longer be maintained at the target minimum light output.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The description herein makes reference to the accompanying drawings wherein like reference numerals refer to like parts throughout the several views, and wherein:

[0009] FIG. **1** is a perspective view of an embodiment of an LED lamp with failure alerting system disclosed herein;

[0010] FIG. **2** is a schematic view of another embodiment of an LED lamp with failure alerting system disclosed herein;

[0011] FIG. **3** is a perspective view of yet another embodiment of an LED lamp with failure alerting system disclosed herein;

[0012] FIG. **4** is a schematic view of an embodiment of a failure alerting system for use with an LED lamp as disclosed herein; and

[0013] FIG. **5** is a schematic view of another embodiment of a failure alerting system for use with an LED lamp as disclosed herein.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0014] FIG. **1** illustrates one embodiment of an LED lamp **10** with a failure alerting system. The lamp **10** comprises an LED lighting unit **12** comprising at least one LED **14**, a photodetector **16**, a regulator **18**, a thermal sensor **20**, and a low light output indicator **22**.

[0015] In this illustrative embodiment, the photodetector **16** is configured to detect an actual light output from at least one LED **14**. The regulator **18** receives a signal from the photodetector **16** when the actual light output is below a target light output. When the signal is received, the regulator **18** increases a current to the one or more LEDs to maintain the target light output. The thermal sensor **20** senses an operating temperature of the at least one LED and controls the regulator **18** to increase the current and the target light output to ensure the operating temperature does not exceed a target temperature. In other words, the regulator **18** receives a thermal signal from the thermal sensor **20** and maintains the current and the target light output such that the operating temperature does not exceed a target temperature. The low light output indicator **22** receives a signal from the photodetector **16** when the actual light output remains below the target light output and produces a low light output signal.

[0016] The at least one LED **14** of the LED lamp **10** can be mounted on a circuit board **24**. The circuit board **24** may be made in one piece or in sections joined by electrical bridge connectors. An insulative board is typical, but other circuit board types, e.g., metal core circuit boards, can alternatively be used. Although the circuit board **24** shown in FIG. **1** is a circular surface, the circuit board **24** may be any shape desired or required depending on the overall shape and design of the lamp **10**.

[0017] The LEDs **14** can be mounted at predetermined intervals along or around the circuit board **24** to uniformly emit light from the lamp **10**. The spacing between LEDs **14** along the circuit board **24** is a function of the surface area of the circuit board **24**, the amount of light desired, the wattage of the LEDs **14**, and the viewing angle of the LEDs **14**. More than one LED is commonly referred to as a bank or array of LEDs. Within the scope of these embodiments, one or more banks or arrays of LEDs can be mounted on one or more circuit boards. The LEDs can emit white light and, thus, are commonly referred to in the art as white LEDs. However, other types of LEDs can be utilized, for example, red and green LEDs.

[0018] The LEDs **14** utilized in the lamp **10** are those known in the art. The LEDs **14** can be, for example, surface-mounted LEDs, organic LEDs, or high-power surface-mount devices of a type available from Nichia. The LEDs **14** may have power ratings of 0.1 watts or more, or more specifically, power ratings of one watt or more. However, the power ratings are provided as examples and are not meant to be limiting. Other power ratings can be used as desired or required.

[0019] The lamp **10** also has a housing **26** consisting of a cover **28** and a base **30**. It is contemplated that the housing **26** may be of any suitable shape required or desired for use with light fixtures. As a non-limiting example, the housing **26** may be a shroud open along its length. The housing **26** may have as many ends as necessary for a secure fit and the proper electrical connection.

[0020] The cover **28** may be made of any material known in the art to be used in the lighting industry, including but not limited to UV resistant plastic or glass. For example, the cover **28** can be made from polycarbonate, acrylic, glass or another light transmitting material. That is, the cover **28** can be transparent or translucent. A translucent cover **28** can be made from a composite, such as polycarbonate with particles of a light refracting material interspersed in the polycarbonate.

[0021] The LEDs **14** can be arranged on the circuit board **24** or another surface within the housing **26** to emit or shine through only one side of the cover **28**, thus directing the light to a predetermined point of use, or arranged to emit light through more than one side of the cover **28**.

[0022] The photodetector **16** of the LED lamp **10** with failure alerting system is shown in FIG. **1** located within the housing **26** and mounted on the circuit board **24**. The photodetector **16** is located to provide an accurate indication of the actual light output of the at least one LED **14**. The actual light output is typically measured in lux. The photodetector **16** can be, for example, a photo diode, a photo transistor, a photo cell or other device capable of outputting a signal with respect to the light level sensed.

[0023] The photodetector **16** is configured to detect the actual light output from at least one LED **14** and send a signal to the regulator **18** when the actual light output is below a target light output. For example, the photodetector **16** can send a signal when the LED provides lux implying less than **30** lumens, the target light output. The photodetector **16** can be a single detector detecting the actual light output of a single LED, a single detector detecting the actual light output of multiple LEDs, and more than one detector each detecting the actual light output from a different LED. The configurations are provided by way of example and not limitation and other configurations known to those skilled in the art may be used.

[0024] In FIG. **1**, the photodetector **16** is located within the housing **26** on the circuit board **24**. Alternatively, the photodetector **16** can be located external to the LED lamp **10**, as shown in FIG. **2**. In FIG. **2**, the photodetector **16** is embedded on a work surface **32**. This location is provided by way of example and not limitation, and other locations can be used as desired or required by those skilled in the art. For example, the photodetector may be embedded in a floor, a hallway, or a stairwell.

[0025] The photodetector **16** sends a signal to the regulator **18** when the actual light output falls below the target light output. The signal can be sent electronically or wirelessly, depending on the desired or required location of the photodetector **16** in relation to the regulator **18**. For example, with the configuration in FIG. **1**, the photodetector **16** can transmit the signal to the regulator **18** electronically, whereas in FIG. **2**, the transmission can be wirelessly.

[0026] The regulator **18** is configured to increase the current to the at least one LED **14** in response to the signal from the photodetector **16** so that the target light output is maintained. Alternatively, the regulator **18** may send current to a supplemental LED or a plurality of supplemental LEDs to generate the additional lumens. For example, in FIG. **1**, LEDs **14***a* can be supplemental LEDs that are only provided current by the regulator **18** when the photodetector **16** sends a low light output signal. The regulator **18** can be a current regulator, a transistor and Zener diode, a Hall effect type current sensor, or other regulators known by those skilled in the art to regulate current.

[0027] It is contemplated that the regulator **18** may be outside of the lamp **10** and may control the light output and temperature of a plurality of lamps in series. For example, the regulator may monitor a plurality of lamps in an area and can increase current to those lamps when a low output signal is received. The regulator may monitor a plurality of lamps

in an area and send current to another plurality of supplemental lamps in the same area when a low output signal is received.

[0028] The thermal sensor **20** of the LED lamp **10** with failure alerting system is shown in FIG. **1** located within the housing **26** and mounted on the circuit board **24**. The thermal sensor **20** is located to provide an accurate indication of the operating temperature of the at least one LED **14**. The thermal sensor **20** transmits a signal to the regulator **18** indicating the operating temperature to the regulator **18**. The regulator **18** is programmed with a target temperature which the system is not to exceed. When the target temperature has been exceeded, the regulator **18** will reduce the current to the at least one LED **14** until the operating temperature drops below the target temperature. The target temperature overrides the low light output signal. In other words, even if the low light output signal is being transmitted to the regulator **18**, if the signal from the thermal sensor **20** exceeds the target temperature, the regulator **18** addresses the thermal sensor signal rather than the low light output signal.

[0029] The location of the thermal sensor **20** on the circuit board **24** shown in FIG. **1** is provided by way of example and not limitation. It is contemplated that the thermal sensor **20** can be located on other surfaces with in the housing **26** of the lamp **10**. Types of thermal sensors known by those skilled in the art can be used, including contact and non-contact sensors.

[0030] The lamp **100** can also include a heat sink (not shown) within the housing **26** to dissipate the heat generated by the at least one LED **14**. Some of these heat sinks include projections for increasing the surface area of the heat sink. The heat sinks are typically formed by extruding billets of material, generally aluminum, through a die. The thermal sensor **20** protects the LEDs and so detects the temperature not withstanding the heat sink.

[0031] When the photodetector **16** detects low light for a predetermined period of time, the photodetector **16** sends a signal to the low light output indicator **22**. When the signal from the photodetector **16** is received, the low light output indicator **22** produces a low light output signal. In other words, when the actual light output remains below the target light output because the regulator **18** can no longer maintain the target light output without exceeding the target temperature, a low light output signal is generated.

[0032] The low light output indicator **22** can generate a variety of signals indicating that the light output is low, depending on the indication desired or required. The following are provided as non-limiting examples.

[0033] The low light output signal can be an audible broadcast. For example, the audible broadcast can be an alarm, a beep, a series of sounds, or a verbal indication to change the bulb.

[0034] The low light output signal can be a visual signal. For example, the visual signal can be one or more LEDs within the lamp that are of a different color, the low light output indicator **22** turning on those one or more LEDs by providing current. The visual signal can be one or more LEDs that form a shape or word or words indicating the low output. The visual signal may be one or more flashing LEDs or a combination of flashing LEDs. The LEDs used to visually indicate low light output can be supplemental or can be the currently used LEDs. The visual signal can be a complete shutdown of the current such that the lamp provides no illumination to encourage replacement.

[0035] The low light output indicator **22** can be configured to transmit a wireless signal or broadcast to an external receiver. The external receiver can than provide an audible or visual indication of low light output. Other indicators can be used as desired or required and known to those skilled in the art.

[0036] The low light output indicator **22** may indicate the status of individual LEDs or a plurality of LEDs as a whole, such as a plurality of LEDs in one lamp. The low light level indicator **22** can be tied to a plurality of lights in a common area, wherein the low light output signal is only generated if the light output of the area is below a predetermined level.

[0037] FIG. **3** illustrates another embodiment of an LED lamp **100** with a failure alerting system. The lamp **100** is configured for use in an existing fluorescent fixture. The lamp **100** comprises an LED lighting unit **102** comprising at least one LED **104**, a photodetector **106**, a regulator **108**, a thermal sensor **110**, and a low light output indicator **112**.

[0038] The embodiment illustrated in FIG. **3** operates in the same manner as the embodiments described in FIGS. **1** and **2**. However, the lamp **100** of this embodiment is made to fit an existing fluorescent fixture, and so is formed in the same shape as a typical fluorescent tube with typical pin connections for cooperation with existing sockets. The illustrative shape of the housing **114** in FIG. **3** is tubular. While not illustrated to scale, the housing **114** can be approximately 48" long with a 0.625", 1.0", or 1.5" diameter for engagement with the typical fluorescent fixture.

[0039] The cover **116** can be made from polycarbonate, acrylic, glass or another light transmitting material that is transparent or translucent. For example, a translucent cover **116** can be made from a composite, such as polycarbonate with particles of a light refracting material interspersed in the polycarbonate. While the illustrated housing **114** is cylindrical, the housing **114** or cover **116** can alternatively have a square, triangular, polygonal, or other cross sectional shape. Similarly, while the illustrated housing **114** is linear, the housing **114** can have an alternative shape, e.g., a U-shape.

[0040] The at least one LED **104** is enclosed within the tubular housing **114** and mounted for emitting light through the cover **116**. At least one electrical connector **118** at a longitudinal end of the tubular housing **114** is in electrical communication with the at least one LED **104**. The number of LEDs **104** may vary such that the lamp **100** outputs the desired or required lumens, and the spacing between the LEDs **104** can also vary. The arrangement of LEDs **104** can be such as to substantially fill the entire space between ends of the housing **114**.

[0041] The at least one LED **104**, photodetector **106**, regulator **108**, thermal sensor **110**, and low light output indicator **112** of the LED lighting unit **102** of FIG. **3** can operate in the same manner as described above with reference to FIGS. **1** and **2** and will therefore not be repeated.

[0042] Another embodiment disclosed herein is of a failure alerting system for use with LED lighting fixtures having at least one LED. The illustrative failure alerting system **200** shown in FIG. **4** comprises a photodetector **202** configured to detect an actual light output from the at least one LED, a regulator **204** configured to receive a signal from the photodetector **202** when the actual light output is below a target light output and to increase a current to the at least one LED to maintain the target light output, a thermal sensor **206** configured to sense an operating temperature of the at least

one LED and to control the regulator **204** to increase the current and the target light output to ensure the operating temperature does not exceed a target temperature, and a low light output indicator **208** configured to receive a signal from the photodetector **202** when the actual light output remains below the target light output and to produce a low light output signal.

[0043] The photodetector **202**, regulator **204**, thermal sensor **206** and low light output indicator **208** of the failure alerting system **200** shown in FIG. **4** are adaptable for use with existing LED lamps of any configuration. The failure alerting system **200** can be installed during manufacture or can be installed subsequent to manufacturing by a purchaser or installer. Once installed, the photodetector **202**, regulator **204**, thermal sensor **206** and low light output indicator **208** of the failure alerting system of FIG. **4** can operate in the same manner as described above with reference to FIGS. **1** and **2** and will therefore not be repeated.

[0044] Yet another embodiment of a failure alerting system for use with LED lighting fixtures having at least one LED is disclosed herein. The illustrative failure alerting system **300** shown in FIG. **5** comprises a photodetector **302** configured to detect an actual light output from the at least one LED, a regulator **304** configured to receive a signal from the photodetector **302** when the actual light output is below a target light output and to increase a current to the at least one LED to maintain the target light output, and a low light output indicator **306** configured to receive a signal from the photodetector **302** when the actual light output remains below the target light output and to produce a low light output signal.

[0045] The photodetector **302**, regulator **304** and low light output indicator **306** of the failure alerting system **300** shown in FIG. **5** are adaptable for use with existing LED lamps of any configuration. The failure alerting system **300** can be installed during manufacture or can be installed subsequent to manufacturing by a purchaser or installer. Once installed, the photodetector **302**, regulator **304** and low light output indicator **306** of the failure alerting system of FIG. **5** can operate in the same manner as described above with reference to FIGS. **1** and **2**.

[0046] When the photodetector **302** detects low light for a predetermined period of time, the photodetector **302** sends a signal to the low light output indicator **306**. When the signal from the photodetector **302** is received, the low light output indicator **306** produces a low light output signal. In other words, when the actual light output remains below the target light output because the regulator **18** can no longer maintain the target light output, a low light output signal is generated.

[0047] The low light output indicator **22** can generate a variety of signals indicating that the light output is low, depending on the indication desired or required. The examples provided above are equally applicable for this embodiment.

[0048] While the invention has been described in connection with certain embodiments, it is to be understood that the invention is not to be limited to the disclosed embodiments but, on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims, which scope is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures as is permitted under the law.

What is claimed is:

1. A system comprising:

a first fluorescent tube replacement device configured for use in a first conventional fluorescent tube fixture, comprising:

one or more first LEDs; and

a first connector configured to physically engage the first device with one or more sockets of the first fluorescent tube fixture;

a second fluorescent tube replacement device configured for use in a second conventional fluorescent tube fixture comprising:

one or more second LEDs; and

a second connector configured to physically engage the second device with one or more sockets of the second fluorescent tube fixture;

at least one photodetector configured to generate one or more first signals indicating that a light output of the first device is below a target minimum light output; and

a regulator configured to regulate currents in the first device and the second device in response to the one or more first signals.

2. The system of claim **1**, wherein the regulator is in communication with the at least one photodetector for receiving the one or more first signals.

3. The system of claim **1**, further comprising:

at least one thermal sensor configured to generate one or more second signals indicating an operating temperature of the one or more first LEDs, the regulator in communication with the at least one thermal sensor for receiving the one or more second signals, wherein the regulator is further configured to regulate the current in the first device in response to the one or more second signals.

4. The system of claim **3**, wherein the regulator is further configured to:

determine that the operating temperature of the one or more first LEDs exceeds a target temperature; and

in response to determining that the operating temperature of the one or more first LEDs exceeds the target temperature, reduce current to the first device until the operating temperature of the one or more first LEDs drops below the target temperature.

5. The system of claim **1**, further comprising:

a low light output indicator in communication with the at least one photodetector, wherein the low light output indicator is configured to generate at least one of a visual signal or an audio broadcast indicating that the light output has been below the target minimum light output for a predetermined period of time.

6. The system of claim **5**, wherein the visual signal is generated using one or more first LEDs.

7. The system of claim **5**, wherein generating the visual signal comprises generating light of a different color than light emitted from the sone or more first LEDs.

8. The system of claim **1**, wherein the one or more first LEDs includes one or more supplemental LEDs on standby, and wherein regulating current in the first device comprises supplying current to the one or more supplemental LEDs, such that the one or more supplemental LEDs contribute to maintaining the light output at the target minimum light output.

9. A system comprising:

a first fluorescent tube replacement device configured for use in a first conventional fluorescent tube fixture, comprising:

at least one first LED; and

a first connector configured to physically engage the first device with one or more sockets of the first fluorescent tube fixture;

a second fluorescent tube replacement device configured for use in a second conventional fluorescent tube fixture, comprising:

at least one second LED; and

a second connector configured to physically engage the second device with one or more sockets of the second fluorescent tube fixture; and

a control system configured to manage the first device and the second device, the control system configured to:

detect a light output of the first device, and

regulate currents in the first device and the second device in response to the detected light output of the first device.

10. The system of claim **9**, wherein the control system is further configured to:

sense an operating temperature of the at least one first LED;

determine that the operating temperature of the at least one first LED exceeds a target temperature;

in response to determining that the operating temperature of the at least one first LED exceeds the target temperature, reduce current in the first device until the operating temperature of the at least one first LED drops below the target temperature.

11. The system of claim **9**, wherein the control system is further configured to generate at least one of a visual signal or an audio broadcast indicating that the light output has been below the target minimum light output for a predetermined period of time, and

wherein generating the visual signal comprises turning on one or more LEDs.

12. The system of claim **11**, wherein the visual signal is generated using the at least one first LED.

13. The system of claim **11**, wherein generating the visual signal comprises generating light of a different color than light emitted from the at least one first LED.

14. The system of claim **9**, wherein the at least one first LED includes one or more supplemental LEDs on standby, and wherein regulating current in the first device comprises powering the one or more supplemental LEDs, such that the one or more supplemental LEDs contribute to maintaining the light output at the target minimum light output.

15. A system comprising:

a first fluorescent tube replacement device configured for use in a first conventional fluorescent tube fixture, comprising:

at least one first LED;

a first light transmitting cover at least partially enclosing the at least one first LED, the first light transmitting cover at least partially forming a first housing for the first device; and

a first connector attached to the first housing and configured to physically engage the first device with one or more sockets of the first fluorescent tube fixture;

a second fluorescent tube replacement device configured for use in a second conventional fluorescent tube fixture, comprising:

at least one second LED;

a second light transmitting cover at least partially enclosing the at least one second LED, the second light transmitting cover at least partially forming a second housing for the second device; and

a second connector attached to the second housing and configured to physically engage the second device with one or more sockets of the second fluorescent tube fixture; and

a control system configured to manage the first device and the second device, the control system configured to:

detect a light output of the first device, and

regulate currents in the first device and the second device in response to the detected light output of the first device.

16. The system of claim **15**, wherein the control system is further configured to generate at least one of a visual signal or an audio broadcast indicating that the light output has been below the target minimum light output for a predetermined period of time.

17. The system of claim **15**, wherein the at least one first LED includes one or more supplemental LEDs on standby, and wherein regulating current in the first device comprises powering the one or more supplemental LEDs only upon the generation of the visual signal or the audio broadcast, such that the one or more supplemental LEDs contribute to maintaining the light output at the target minimum light output.

18. The system of claim **1**, wherein the first device comprises at least two LEDs, and wherein at least one photodetector is disposed between two of the LEDs.

19. A system comprising:

a first fluorescent tube replacement device for use in a first conventional fluorescent tube fixture, comprising:

a first housing;

a first plurality of LEDs disposed within the first housing; and

one or more first connectors coupled to the first housing, wherein the first connectors are configured to physically engage the first device with one or more sockets of the first fluorescent tube fixture;

a second fluorescent tube replacement device for use in a second conventional fluorescent tube fixture, comprising:

a second housing;

a second plurality of LEDs disposed within the second housing; and

one or more second connectors coupled to the second housing, wherein the second connectors are configured to physically engage the second device with one or more sockets of the second fluorescent tube fixture;

a photodetector configured to measure the light output from the first device; and

a regulator in electrical communication with the first device and the second device, wherein the regulator is configured to regulate currents in the first device and the second device in response to the measured light output.

20. The system of claim **19**, wherein the photodetector is disposed between at least two LEDs of the first plurality of LEDs.

21. The system of claim **19**, further comprising an indicator disposed on the first housing and visible from an exterior of the first housing, wherein the indicator is configured to provide a visual signal when the regulator is unable to maintain the light output above the threshold amount, and wherein the indicator is disposed between at least two LEDs of the first plurality of LEDs.

22. The system of claim **21**, wherein the first plurality of LEDs and the indicator are directed towards a front of the first housing.

23. The system of claim **1**, wherein the regulator is further configured to:

supply a substantially constant current to the first device while allowing the light output from the first device to degrade over time towards the target minimum light output without varying the substantially constant current in response to the degradation, and

once the light output of the first device is below the target minimum light output, increase current to the first device to maintain the light output at the target minimum light output.

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