Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

CASE DOCKET NO. **70947**

Sir:

Transmitted herewith for filing is the Patent Application of:

Inventors **: Roderick Allen GAMMONS; Andrew FRANCIS; Roderick Aaron GAMMONS.**

FOR **: LIGHTING SYSTEM AND CONTROL THEREOF**

Enclosed are:

☒ **21 pages of specification (including Abstract page)**
☒ **5 sheets of drawings**
☒ **26 total pages**
☒ **Executed Declaration**
☒ **Executed Power of Attorney; Executed Assignment; Form SB/439**
☒ **Request For Prioritized Examination**
☒ **Application Data Sheet. See 37 CFR 1.76.**
☒ **Applicant is entitled to Small Entity Status under 37 CFR 1.9 and 37 CFR 1.27**

THE FILING FEE HAS BEEN CALCULATED AS SHOWN BELOW:

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Utility Search Fee				**$300.00**		**$**
Utility Examination Fee				**$360.00**		**$**
Utility Application Size Fee (**26** x .75 = **19.50** pages; Per 50 Pages Over 100)			**0 x $200.00**	**$0.00**		**$**
Multiple Dependent Claim			**0 x $390.00**	**$0.00**		**$**
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Respectfully,

Date: December 21, 2017

/Martin D. Moynihan/

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Doc Code: TRACK1.REQ
Document Description: TrackOne Request

PTO/AIA/424 (04-14)

CERTIFICATION AND REQUEST FOR PRIORITIZED EXAMINATION UNDER 37 CFR 1.102(e) (Page 1 of 1)

First Named Inventor:	Roderick Allen GAMMONS	Nonprovisional Application Number (if known):	
Title of Invention:	LIGHTING SYSTEM AND CONTROL THEREOF		

APPLICANT HEREBY CERTIFIES THE FOLLOWING AND REQUESTS PRIORITIZED EXAMINATION FOR THE ABOVE-IDENTIFIED APPLICATION.

1. The processing fee set forth in 37 CFR 1.17(i)(1) and the prioritized examination fee set forth in 37 CFR 1.17(c) have been filed with the request. The publication fee requirement is met because that fee, set forth in 37 CFR 1.18(d), is currently $0. The basic filing fee, search fee, and examination fee are filed with the request or have been already been paid. I understand that any required excess claims fees or application size fee must be paid for the application.

2. I understand that the application may not contain, or be amended to contain, more than four independent claims, more than thirty total claims, or any multiple dependent claims, and that any request for an extension of time will cause an outstanding Track I request to be dismissed.

3. The applicable box is checked below:

I. ☑ Original Application (Track One) - Prioritized Examination under § 1.102(e)(1)

i. (a) The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a). This certification and request is being filed with the utility application via EFS-Web.

---OR---

(b) The application is an original nonprovisional plant application filed under 35 U.S.C. 111(a). This certification and request is being filed with the plant application in paper.

ii. An executed inventor's oath or declaration under 37 CFR 1.63 or 37 CFR 1.64 for each inventor, **or** the application data sheet meeting the conditions specified in 37 CFR 1.53(f)(3)(i) is filed with the application.

II. ☐ Request for Continued Examination - Prioritized Examination under § 1.102(e)(2)

i. A request for continued examination has been filed with, or prior to, this form.
ii. If the application is a utility application, this certification and request is being filed via EFS-Web.
iii. The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a), or is a national stage entry under 35 U.S.C. 371.
iv. This certification and request is being filed prior to the mailing of a first Office action responsive to the request for continued examination.
v. No prior request for continued examination has been granted prioritized examination status under 37 CFR 1.102(e)(2).

Signature /Martin D. Moynihan/	Date December 21, 2017
Name (Print/Typed) Martin D. Moynihan	Practitioner Registration Number 40338

Note: *This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. Submit multiple forms if more than one signature is required.**

☑ *Total of 1 forms are submitted.

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The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

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8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
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Doc Code: ECOMM.AUTH/ECOMM.WTDW
Doc Description: Internet Communications Authorized/Internet Communications Authorization Withdrawn

PTO/SB/439 (11-15)

AUTHORIZATION FOR INTERNET COMMUNICATIONS IN A PATENT APPLICATION OR REQUEST TO WITHDRAW AUTHORIZATION FOR INTERNET COMMUNICATIONS		
	Application No.	
	Filing Date	
	First Named Inventor	Roderick Allen GAMMONS
	Art Unit	
	Examiner Name	
	Practitioner Docket No.	70947

To: Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

I. To authorize permission for Internet Communications.

☑ Recognizing that Internet communications are not secure, I hereby authorize the USPTO to communicate with the undersigned and practitioners in accordance with 37 CFR 1.33 and 37 CFR 1.34 concerning any subject matter of this application via video conferencing, instant messaging, or electronic mail. I understand that a copy of these communications will be made of record in the application file. (MPEP 502.03)

II. To withdraw authorization for Internet Communications.

☐ The authorization given on _____, to the USPTO to communicate with the undersigned and any practitioner in accordance with 37 CFR 1.33 and 37 CFR 1.34 concerning any subject matter of this application via Internet communications such as video conferencing, instant messaging, or electronic mail is hereby withdrawn. I understand that the withdrawal is effective when approved rather than when received.

I am the

☐ applicant.

☑ attorney or agent of record. Registration number 40338.

☐ attorney or agent acting under 37 CFR 1.34. Registration number _____.

/Martin D. Moynihan/ — Signature

December 21, 2017 — Date

Martin D. Moynihan — Typed or printed name

(703) 859-9634 — Telephone Number

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. Juristic entities must be represented by a patent practitioner (see 37 CFR 1.31, which is applicable to any paper filed on or after September 16, 2012, that is presented on behalf of a juristic entity, regardless of application filing date). Submit multiple forms if more than one signature is required, see below*.

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6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
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APPLICATION FOR PATENT

Inventors: Roderick Allen GAMMONS, Andrew FRANCIS and Roderick Aaron GAMMONS

Title: LIGHTING SYSTEM AND CONTROL THEREOF

RELATED APPLICATIONS

This application is a Continuation of US Patent Application No. 15/481,460 filed on April 7, 2017, which claims the benefit of priority of U.S. Provisional Patent Application No. 62/319,809 filed on April 8, 2016 and United Kingdom Patent Application No. 1606907.2 filed on April 20, 2016. The contents of the above applications are all incorporated herein by reference in their entirety.

FIELD AND BACKGROUND OF THE INVENTION

This invention relates to a lighting system, and the control of a lighting system, and the simulation of lighting special effects, and in particular to a lighting system for videography, broadcasting and cinematography.

In the film, broadcast and TV industry a lighting controller called a 'flicker box' which is independent of a lighting device, is used to produce flickering light effects to mimic flickering light for example from a fire place, candle, electrical spark or lightning for on set television/broadcast production use.

The flicker effect provided by these devices is typically created using the analogue circuitry modulators contained within the 'flicker box', controlled manually by dials and levers. Use of a flicker box is typically a complex, costly and time consuming process that requires the setup, connection and control of multiple pieces of hardware typically including external Digital Multiplex (DMX) and power distribution devices, as well as typically requiring a physical wired connection to the 'hot' light source desired to be controlled.

Typically such 'flicker boxes' require specialist knowledge and understanding to operate and remain inaccessible or 'out of reach' to lower budget television

productions.

Furthermore, many 'flicker boxes' are incompatible with LED light sources, and such systems require the use of 'hot' incandescent light sources which are energy inefficient and also pose health and safety risks to those working on set, typically therefore requiring qualified lighting gaffers and operators.

An improved solution is desired.

According to one aspect of the invention, there is provided a method for controlling a lighting device to produce user customisable lighting effect, the method comprising: calculating a time varying lighting value based on at least one simulation parameter; and outputting said time varying lighting value thereby to simulate a lighting effect.

Optionally, the method may further comprise receiving said at least one simulation parameter for characterising a lighting effect.

Optionally, said at least one simulation parameter for characterising a lighting effect is random.

Optionally, said at least one simulation parameter for characterising a lighting effect is random within predefined boundaries.

Optionally, the random simulation parameter is determined in dependence on one or more user-selectable simulation parameters.

Optionally, the random simulation parameter is in a range determined in dependence on one or more user-selectable simulation parameters.

Optionally, the simulation parameter is a colour or colour temperature.

Optionally, the colour or colour temperature varies in dependence on a brightness lighting value.

Optionally, the simulation parameter is related to one or more of: a rate of increase of brightness; a rate of decrease of brightness; a rate of change of colour; a brightness; a local maximal brightness; a local minimal brightness; a brightness fluctuation period; and a colour fluctuation period.

Optionally, the method may further comprise receiving a user input of one or more user-selectable simulation parameters and adapting the simulation in dependence on the one or more user-selectable simulation parameters.

Optionally, the simulation parameter comprises at least one of: a maximum brightness; a minimum brightness; a colour; a fluctuation period; and a trigger.

Optionally, the simulation parameter comprises a camera recording frequency.

Optionally, the time varying lighting value is calculated so as to vary at a slower rate than said camera recording frequency.

Optionally, the simulation iterates through repeated cycles of receiving at least one random simulation parameter and simulating the lighting effect.

Optionally, the lighting effect is designed to mimic at least one or more of: fire flickering; police light; television; lightning flashing; electrical sparking; and fireworks.

Optionally, the lighting value comprises brightness and/or colour data.

Optionally, the method may further comprise converting brightness and/or colour data into lighting signals and outputting the lighting signal data.

Optionally, the method may further comprise controlling one or more light in dependence on the output.

Optionally, the controlling comprises changing the brightness and/or colour of the light.

Optionally, the method may further comprise receiving a definition of a trigger event, said trigger event initiating said output of the time varying lighting value thereby to simulate a lighting effect.

Optionally, the method may further comprise detecting an occurrence of the trigger event and outputting said time varying lighting value thereby to simulate a lighting effect.

Optionally, the method may further comprise storing the calculated lighting value.

A method according to any of the preceding claims, wherein the controlling is for a lighting system for videography, broadcast, cinematography, studio filming and/or location filming.

Optionally, the method may further comprise controlling a plurality of lights in dependence on the output.

Optionally, the said plurality of lights output different lighting values so as to simulate a lighting effect.

Optionally, the output of said plurality of lights is offset in time.

Optionally, the output of said plurality of lights overlap with one-another so as to simulate a moving light source.

Optionally, one light is a master light and the others of said plurality of lights

are slaves.

According to another aspect there is provided a controller for controlling a lighting device to produce a lighting effect, the controller comprising: a calculating device adapted to calculate a time varying lighting value based on at least one simulation parameter; and an output adapted to control a lighting device according to the determined variation of lighting over time.

Optionally, the controller may further comprise a random number source adapted to provide a random number for producing a random simulation parameter for characterising a lighting effect.

Optionally, the controller is adapted to control a plurality of lighting devices in dependence on the time varying lighting value.

Optionally, the controller comprises a wireless communication interface adapted for wireless communication with one or more lighting devices.

Optionally, the controller comprises an input interface adapted to receive a user input.

Optionally, the input interface comprises at least one of: a wireless communication interface; a dial; a slider; a display and buttons; and a touch screen.

Optionally, the controller may further comprise a converter adapted to convert brightness and/or colour data from the simulator into lighting signals for output by the output.

Optionally, the controller may be adapted to perform a method as described herein.

According to another aspect there is provided a lighting system comprising a controller as described herein and at least one lighting device.

Optionally, said controller and said lighting device are integrated in a combined unit.

Optionally, the lighting system may further comprise a further lighting device separate from said controller.

Optionally, the lighting device is a lighting device for videography, broadcast, cinematography, studio filming and/or location filming.

According to another aspect there is provided a lighting device comprising a controller as described herein.

Optionally, the lighting device is a lighting device for videography, broadcast,

cinematography, studio filming and/or location filming.

According to another aspect there is provided a computer program product for controlling a lighting device to produce a lighting effect, the computer program product adapted to perform, when executed, the steps of: calculating a time varying lighting value based on at least one simulation parameter; and outputting said time varying lighting value thereby to simulate a lighting effect.

Optionally, the computer program product may be adapted to perform, when executed, the steps of a method as described herein.

According to another aspect of the invention there is provided a controller for controlling a lighting device to produce a lighting effect, the controller comprising: a calculating device adapted to calculate a time varying lighting value based on at least one simulation parameter; and an output adapted to control a lighting device according to the determined variation of lighting over time.

In a further aspect of the present invention there is provided a light with the built-in capability to generate a range of customizable cinematic special lighting effects, by modulating the speed, duration, power/brightness, and/or colour temperature of the light output.

Preferably, the parameters of the effects including but not limited to speed, duration, power/brightness and colour temperature can be controlled locally via a simple user interface on the light itself.

Preferably, the start/stop "triggering" of the effects can be controlled locally via a simple user interface on the light itself, remotely via WiFi, Bluetooth, Zigbee or wireless DMX from a smart phone or tablet, or from a wired 3.5mm minijack remote trigger, or a wired DMX trigger.

Preferably, the parameters of the effects can be controlled remotely via WiFi, Bluetooth, Zigbee or wireless DMX from a smart phone or tablet.

Preferably, the parameters of the effects can be controlled Via a serial communications interface (eg. RS232, USB or DMX) from a PC running custom lighting control software.

Preferably, the light source containing in built special effects is in the form of an LED lighting fixture. Alternatively it is in the form of or 'hot' light incandescent fixture.

Preferably, multiple lights may be connected together via wired DMX, or via

WiFi, Bluetooth, Zigbee or wireless DMX to produce a synchronised large area special effect.

Preferably, when multiple lights are connected together to produce a synchronized large area special effect, the inter-relationship of those connected lights is customizable so as to allow all of the connected devices to fire at the same time if desired, or, to enable a staggered effect to take place over an extended time duration and with customizable power intensity, in order to create the effect that a static object is moving as the lights "chase" around a scene.

Preferably, the system includes rolling shutter compensation enabling the minimum light pulse width to be adjusted to suit the shutter speed or frame rate of the user's camera in order to prevent 'strobing' due to the light effect being out of phase/sync with the frame rate of the camera, ensuring that each frame captured by the camera is fully illuminated.

Preferably, a light source can be designated as a 'master', and have connected 'slave' light sources which fire in synchronization with the 'master', or in a customizable sequence, with regard duration, power and/or colour temperature.

Preferably, the 'slave' light sources are connected to the 'master' light source via wired DMX, wireless DMX, wifi, Bluetooth, or RS232 sync cable.

Preferably, the light contained in built special effects, can be powered both from mains power, and/or via its own internal battery power source, providing greater flexibility and portability for location shooting.

Preferably, the light source is capable of producing customisable effects including, but not limited to : Fire, Lightning, Police light, TV simulation, Neon Flickering sign, Muzzle (gunshot), Welding, Spark/Short Circuit, Scan (e.g. fingerprint scanner), Papparrazi flashes, Propeller, (Nuclear) Explosion and Wormhole.

The invention extends to any novel aspects or features described and/or illustrated herein.

Further features of the invention are characterised by the other independent and dependent claims.

Any feature in one aspect of the invention may be applied to other aspects of the invention, in any appropriate combination. In particular, method aspects may be applied to apparatus aspects, and vice versa.

Furthermore, features implemented in hardware may be implemented in software, and vice versa. Any reference to software and hardware features herein should be construed accordingly.

Any apparatus feature as described herein may also be provided as a method feature, and vice versa. As used herein, means plus function features may be expressed alternatively in terms of their corresponding structure, such as a suitably programmed processor and associated memory.

It should also be appreciated that particular combinations of the various features described and defined in any aspects of the invention can be implemented and/or supplied and/or used independently.

The invention also provides a computer program and a computer program product comprising software code adapted, when executed on a data processing apparatus, to perform any of the methods described herein, including any or all of their component steps.

The invention also provides a computer program and a computer program product comprising software code which, when executed on a data processing apparatus, comprises any of the apparatus features described herein.

The invention also provides a computer program and a computer program product having an operating system which supports a computer program for carrying out any of the methods described herein and/or for embodying any of the apparatus features described herein.

The invention also provides a computer readable medium having stored thereon the computer program as aforesaid.

The invention also provides a signal carrying the computer program as aforesaid, and a method of transmitting such a signal.

The invention extends to methods and/or apparatus substantially as herein described with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

The invention will now be described by way of example, with references to the accompanying drawings in which:

Figure 1 is a schematic diagram of a 'flickerbox' lighting system;

Figure 2 is a schematic diagram of a further lighting system;

Figure 3 is a flow diagram of a method for adjusting a lighting device;

Figure 4 is a schematic diagram of a further lighting system;

Figure 5 shows a time/brightness plot for a system of linked lights;

Figure 6 is a graphic user interface for user input of simulation parameters; and

Figure 7 is a graph of light brightness over time.

DESCRIPTION OF SPECIFIC EMBODIMENTS OF THE INVENTION

In the present description the term 'camera' may be understood to mean a camera (such as a digital camera, or 'film' camera) operable to record moving images. The lighting system may therefore be for a lighting system for videography, broadcasting, cinematography, studio filming and/or location filming.

Figure 1 shows a schematic diagram of a 'flickerbox' lighting control system. The system comprises an analogue effect simulator, 300, a DMX distribution hub 302, an AC power generator 306, an AC power distribution module 302 and a plurality of incandescent lights 102. The analogue effect simulator 300 simulates a lighting effect such as fire, or electrical sparking based on various parameters 104. The analogue effect simulator 300 produces data 106 such as brightness parameters that vary over time for producing the desired lighting effect. The data 106 is used to modulate the light 102 such that the desired lighting effect is produced. The user has very limited ability to alter many of the parameters to adapt the lighting effect as desired.

Figure 2 schematically shows an example where a lighting effect simulator 100 and the light 102 are integrated in a single studio lamp device 120. In one example, the lamp device is an array of LEDs, preferably of differing colours. This arrangement does not require the DMX distribution hub 302, power elements 304, 306 as described above, and is more flexible in producing effects as will be described in more detail below. A microcontroller or other computing unit is integrated in the lamp 120 for performing calculations.

A control panel is provided at a back panel of the light 120. The control panel can include for example buttons, rotary knobs, sliders, and/or a display/input panel for user input of parameters for simulating an effect. In a variant a simple digital interface is provided on the light itself for user input of simulation parameters to control the lighting effect. In another variant the light 120 is adapted for communication with a wireless user device and receives user-selectable simulation parameters to control the

lighting effect from the user device. The user device may for example be a tablet or smart phone with suitable hardware / software (e.g. an app) for receiving user input of simulation parameters and transmitting that data to the light 120.The system of Figure 2 is simpler to set up and less expensive than that of Figure 1 as there are fewer pieces of hardware.

Furthermore the energy inefficiency of 'hot light' systems (i.e. a 1K hot light consumes 1000 watt/hour, vs 38 watt per hour of current generation LED system), Systems such as that described in Figure 1 using a flicker box and typically 'hot lights' also suffer from the significant disadvantage that a hot light is a fixed colour of light, either daylight 5600K or most commonly tungsten 3200K. When recreating an effect such a lightning this effect would appear at the blue end of the colour spectrum i.e. 7000K+ so utilising a 3200K light for this would require an operator to climb up a ladder to apply one or more CTB (Colour temperature blue) filter(s) to the light in order to achieve the desired colour temperature.

Having the ability to control the special FX from the light source, which in itself is a bi-colour LED Fixture also entirely eliminates that aspect of the process, the user can simply adjust the colour temperature from the back of the unit, with a visible numeric display of that number eliminating significant time from the process.

This is also a significant limiting factor in the creation of effects such as fire which typically burn blue on hotter peaks. It would be possible using an LED light source containing in built special effects to reproduce both the warm "orange" light output near the tungsten end of the scale, whilst also adding a "colour swing blue" on the peaks from the same light source, something that would not be possible using a legacy system.

Examples of user defined parameters that the light containing in built special effects can customize in simulating a lighting effect are now described in more detail:

- **Brightness**: The peak luminance of the effect from 1% to 100% of the lamp's available luminance output.
- **Colour**: For multicolour effects this sets the range of colours used over the spectrum of red, green and blue. For single colour effects it sets the colour temperature of the light.
- **Trigger**: To start the effect running. For example, a manual trigger may be selected for manually triggering the start of a lightning burst, TV screen, or other effect.

- **Frequency**: typically from 0.5Hz to 50Hz. This sets an average period between light peaks – e.g. a roaring fire may have a higher frequency than a single candle flame.
- **Depth**: typically from 0% to 90%. This sets a base level of illumination of the effect. For example a fire may have a base level of 50% illumination superimposed on a level varying from 50% to 100% to simulate flickering flames.
- **Rolling Shutter Compensation**: Film and TV cameras typically operate at frequencies between 24Hz and 60Hz. In order to provide consistent illumination during each camera frame, short time-period (e.g. stroboscopic) lighting effects should have a minimum pulse width which lasts at least one camera frame period. This parameter can be adjusted to suit the camera and frame rate.
- **'Colour Swing Blue'** simulates the effect of flame going up the chimney, 'peaks' within the fire effect can be switched to transition between yellow and blue, to match the colour of a flame, creating a more dynamic and 3D fire effect. The brighter the 'spark' the more blue the light output is. The colour of the output is therefore dependent on the brightness of the output (or vice versa).

Further examples of lighting effects are for example to mimic television screen flicker, cinema illumination, illumination in a vehicle passing through a tunnel, or any situation where the lighting varies over time in a characteristic manner. A simulation can be defined that represents the characteristics of the lighting effect, and suitable random parameters can be used to introduce a realistic variance in the lighting effect.

In a variant the simulator operates with pre-defined parameters and random numbers, without further user input of parameters. This can still provide a realistic lighting effect, albeit with less adaptation to the user's preferences.

Figure 3 illustrates a simple example of a method for simulating a lighting effect. In a first step S1 simulation parameters are received, such as random parameters and/or user-selectable parameters. Where a random parameter is algorithmically generated it is only pseudo-random, but for the purposes of the simulation a pseudo-random parameter is sufficiently random for realistic simulation and is hence considered to be equivalent to a truly random parameter. In a second step S2 a simulation is performed based on a simulation model and the received parameters. The nature of the simulation model can vary greatly, depending on the lighting effect that is desired and the sophistication of the desired simulation.

The simulation calculates how the lighting changes over time in order to produce the desired lighting effect. Following simulation in a third step S3 the lighting information determined by the simulation is output, for example to a lighting device, in order to produce the desired lighting effect.

Figure 4 schematically shows an example showing a master light source 102 built into a lighting control unit 130 and a 'slave' light source 102-1 separate from the lighting control unit. The lighting effect simulator 100 creates data 106 characterising a lighting effect and controls the master light 102 as described above. The data 106 is transmitted to the slave light 102-1 via (for example) a serial communication interface (e.g. RS232, USB or DMX) or by wireless transmission (e.g. Wi-Fi®, Bluetooth® Zigbee®, or via a mobile communication network utilising protocols such as GSM (Groupe Special Mobile) 3GPP (3rd Generation Partnership), or 4G LTE (Long term evolution)).

The additional 'slave' light source 102-1 thereby allows the production of a lighting effect with more than one light device but without duplication of controllers 130. Such additional light sources can for example increase the area of illumination or increase the power of the lighting effect.

The use of multiple lights 102 affords additional options for producing advanced effects. Figure 5 shows a time/brightness plot of a 'chase' effect. In this example, three lights produce outputs 200, 202 and 204 separated in time. In such a way, an effect of a light source (such as a passing car) can be replicated. The relative timing of the light sources can be adjusted depending on the relative location of the sources, and the speed of the effect to be replicated. It should be noted that the 'fade up' and 'fade down' portions of each light output 200, 202, 204 overlap with one-another to more accurately replicate the effect of a moving object, as opposed to a element jumping from one location to another.

Related effects utilising similar timing controls are be 'paparazzi' of multiple flashes coming from different locations, or a 'propeller' simulating a light source being obscured by a rotating propeller. The use of a single controller 130 may be used to control all of the lights 102 so as to ensure an appropriate delay (or absence of delay).

Figure 6 shows an example of a graphic user interface 800 for user input of simulation parameters. In the illustrated example the lighting effect to be simulated is a fire effect. The user can select a fire activity (with a slider positioned from 'low' to

'high') to set a frequency parameter as described above; a fire colour; a peak brightness; a baseline brightness to set a depth parameter as described above; and a camera frequency.

A wide range of further parameters can be provided for user input, for example if the fire activity, brightness and/or colour is to change over time (to mimic a fire dying down and reducing to embers or to mimic addition of fuel to a fire). The user may also be provided with an option of superimposing different types of lighting effects, for example to mimic candlelight during a lightning storm.

In one example, the rolling shutter compensation controls a minimum light pulse to match the shutter speed or frame rate of the user's camera (camera frequency) to ensure even illumination across the frame and eliminate possible strobing. Therefore, the duration of the light pulse is longer than one period of the camera's recording frequency, or in other words, the lighting value varies at a lower frequency than the frequency of the camera.

The lighting effect simulator 100 typically provides data 106 in the form of brightness and/or colour values that vary over time. In order to cause the light 102 to produce the desired effect a lighting data converter may convert the data 106 from the lighting effect simulator 100 into a suitable signal for a particular light 102. For example for a light emitting diode (LED) array lighting the data conversion occurs at an LED lamp control logic that produces and supplies a separate pulse-width-modulation output for each LED colour to an LED drive circuit. A lighting data converter may be provided separately from the lighting effect simulator 100 and the light 102 or it may be integrated with one or the other or both.

The light 102 in one example comprises an array of different types of LEDs, preferably red, green, blue and white LEDs, or a bi colour fixture comprising warm typically 2800K LEDs and 'cool' 7000K LEDs which blend together to create a range of colour from 3200-6300K. The array may be a panel, flood light, spot light, a cluster or any other arrangement of LEDs. This provides the ability for the lighting to produce light of any visible colour by varying the relative intensities of the different LEDs. The lighting may alternatively be a filament (incandescent), halogen or other type of lighting.

The simulation may be performed on the fly, with lighting data values output from the simulator 100 to the light 102 in near-real time, or the simulation may be

performed in advance and the lighting data values output for storage and later use to enable quick reproduction on set or location.

The lighting control system can reduce the number of devices required to provide lighting effects, especially where the lighting effect simulator is integrated in a light. This can significantly reduce equipment costs and time required to set up equipment. The system is also more portable allowing power from its on internal power source or battery instead of requiring an external power generator or mains powered solution. The lighting control system can be used for studio and location filming lighting systems, and more generally for videography, broadcast and/or cinematography.

A non-exhaustive list of example effects that may be produced by the system are as follows:

- Strobe - The strobe range in one example is from 1hz up to 4hz. The last used strobe parameters are stored in non-volatile memory (which applies to any effect described herein). A user may rotate a knob on the device to adjust the 'duty cycle' (flash duration) to eliminate issues with rolling shutter cameras.
- Lightning – this effect simulates lightning in a random manner, but a user may control the speed at which the lighting bursts re-occur. This effect is most realistic if the brightness is set to 100% and colour temperature is set at 6000K. A user may rotate a knob on the device to adjust the 'duty cycle' (flash duration) to eliminate issues with rolling shutter cameras. The duration of the lightning flashes in one example is 20ms. The lightning strikes in one example come in bursts of between 2 and 8 random length pulses.
- Throb - Throb is a regular smoothly pulsing light
- Weld - this effect replicates a welding arc.
- Colour cycle – This is a regular smoothly pulsing light which fades between the tungsten and blue LEDs
- Fire – this effect replicates a fire with 'dancing flames' as is described in more detail below.
- Police – This effect is an emulation of an emergency services light, and may be most realistic in blue light.
- Television – This effect is an emulation of someone watching TV.

It should be appreciated that due to the nature of the light 102, the effects may be customised by a user, for example, the frequency/speed, peak/minimum brightness or colour / colour temperature may be dynamically changed, and/or made to vary over time in a customised manner. Such user-customised effects may be stored and recalled at a later time. The effects may be triggered on cue (for example from a director) by sending a signal over a wired remote trigger or wireless device.

It should also be appreciated that multiple effects may be emulated simultaneously, for example, fire and lightning may be present simultaneously using a single lighting unit.

An example of a simulation for producing a fire effect is now described in more detail.

Fire is simulated as a series of 'sparks'. Each spark has the following random parameters:

- ***Interval***: New sparks are generated at an interval which varies randomly between a defined maximum and minimum interval.
- ***Peak***: The peak luminance of each spark varies randomly between a defined minimum and maximum.
- ***Ramp-up time***: The luminance of each spark ramps up to the peak at a randomly generated rate.
- ***Fade-down time***: The fade from the peak is linked to the ramp-up time but is much slower – simulating the gradual decline in luminance of a burning ember.

  If the interval is short with respect to the ramp-up and fade-down time, then sparks can overlap in time – in which case the brightest spark determines the lamp luminance.

The lighting effect simulator typically cycles round a loop calculating new lamp brightness and colour values. Alternatively the calculation can be triggered by an interrupt generated by a timer. The calculation is typically performed every 250μs.

The duration of each spark can be controlled by choosing whether or not to perform a new brightness calculation based on the value of a counter which is decremented every time an interrupt occurs. When the counter reaches zero it is either reset to its previous start value or, for a new spark, a new count start value is randomly generated. In this way each spark has a different speed, duration and peak – simulating the look of a real flame.

Generating the light output with the simulation provides a greater level of user adjustment and control than that produced by simply sampling the intensity of a real flame and replaying it at different speeds.

An example sequence of instructions for the simulation is as follows:

At the end of a spark up and down period:

- Reset duration for next spark to between 2.5s to 5s
- Generate new brightness targets for the next spark between 12.5% and 100% of current maximum brightness setting.
- Offset the random brightness targets by the requested brightness floor value
- Set the new peak brightness target for the new spark
- Ensure the new targets are greater than the existing faded brightness value to prevent downward jumps
- Set the fade direction to UP

Start new animation frame:

- Calculate brightness fade step sizes:
    - Fade up fast, progressively larger fade step sizes
    - Change fade direction at peak
    - Fade down slow, progressively smaller fade step sizes
- Set the frame rate for the new spark to a random value
    - prevent the curtailment of a long fade by a new short pulse: if the faded brightness is still > 25% of max then don't allow new FramePeriod to be less than old.

Figure 7 shows an example of the brightness varying over time produced according to a simulation as described above. Two peaks can be seen, one reaching 100% intensity and the other reaching 91% intensity. The first peak fades up from 10% to 100% in 0.85 seconds, and back down to 56% in 0.75 seconds.

The second peak fades up from 56% to 91% in 0.33 seconds, and back down to 60% in 1.07 seconds. The fade up starts shallower and becomes steeper as it progresses.

The fade down starts steep and becomes shallower as it progresses. A toggle switch is also shown which toggles between 'Colour Swing Blue' and 'Monochrome'. Colour Swing Blue represents modifying the colour of peaks in brightness so as to replicate the increased temperature of sparks in a fire, Monochrome may be used when (for example) filming in black and white, or when altering colour of the effect may have

deleterious effects on other elements of the scene (for example, rendering text difficult to read).

An example of a simulation for producing a lightning effect is now described in more detail. Lightning is simulated as a sequence of 'bursts' or groups of flashes. The number of flashes in each burst, the delay between bursts, the delay between each flash within the burst, and the amplitude of each flash are all set randomly within certain boundaries. The minimum 'on' time period of each flash can be set by the user to ensure full illumination of the camera frame. The lamp can also be set into a mode where a burst of flashes is triggered by the push of a button. In this way the effect can be triggered on demand by the user.

An example sequence of instructions for the simulation of lightning, with a series of bursts of flashes, is as follows:

At the end of a burst of flashes recalculate the parameters for the next burst:

- Reset the number of flashes in a burst to a random number between 2 and 10
- Reset the period to next burst to a random number between 2.5 and 5s.

Calculate parameters for each flash in a burst of flashes:

- Randomly modulate brightness of each flash slightly
- Reset the time to next flash to a random number between 8ms and 220ms
- Reset the 'on' flash duration to a random number between 8ms and 120ms
    - ensure a minimum off-period is maintained between flashes
- For the final flash set the duration to a random number between 10ms and 113ms.

The lighting system, lighting effect simulator, lighting controller, lighting device, computing device, and/or computer program product may have one or more of the following features:

- built-in capability to generate a range of cinematic special effects by modulating the colour and brightness of the light output.
- the parameters of the effects can be controlled via a simple user interface on the lamp itself.
- the parameters of the effects can be controlled remotely via WiFi or DMX from a smart phone or tablet.
- networked with other lights to produce a synchronised large area special effect.

- minimum light pulse width can be adjusted to suit the shutter speed or frame rate of the user's camera to ensure even illumination across the frame.

Various other modifications will be apparent to those skilled in the art. It will be understood that the present invention has been described above purely by way of example, and modifications of detail can be made within the scope of the invention. For example, it should be appreciated that the effect simulator 100 or the computing device 130 may be separate from any light 102, and connectable to lights 102, by either a wired or wireless connection.

The lighting effect simulator 100 may be provided by way of a suitably adapted computing device 120 or 130 such as a PC, tablet or smart phone, with suitable software for user input of simulation parameters. The computing device 120 or 130 may be a suitably adapted light controller device with suitable controls for user input of simulation parameters

Reference numerals appearing in the claims are by way of illustration only and shall have no limiting effect on the scope of the claims.

WHAT IS CLAIMED IS:

1. A lighting system comprising:

a lighting device; and

a controller for controlling the lighting device to produce a range of user customisable realistic lighting effects, the controller comprising:

means for receiving user input to enable a user to select an effect from said range of user customisable realistic lighting effects;

a calculating device adapted to calculate a time varying lighting value based on at least one simulation parameter, said simulation parameter depending on the lighting effect being simulated; and

adapted to output said time varying lighting value to said lighting device so as to simulate said user customizable realistic lighting effect;

wherein said lighting device and said controller are integrated in a combined unit.

2. A lighting system according to Claim 1, wherein the controller comprises means for receiving user input to enable a user to customise a realistic lighting effect.

3. A lighting system according to Claim 1, wherein the lighting device comprises at least one LED.

4. A lighting system according to Claim 3, wherein the lighting device comprises multiple different coloured LEDs.

5. A lighting system according to Claim 4, wherein the multiple different coloured LEDs comprise at least one RGB, or RGB+W, LEDs.

6. A lighting system according to Claim 3, wherein the controller comprises means for controlling the colour or colour temperature of said LEDs.

7. A lighting system according to Claim 3, wherein the lighting device comprises at least one ‘warm’ white and at least one ‘cool’ white LEDs.

8. A lighting system according to Claim 6, wherein the lighting device is operable to produce light at a colour temperature typically in the range of 2800-7000 Kelvin.

9. A lighting system according to Claim 3, wherein the controller comprises means for controlling the brightness of said LEDs.

10. A lighting system according to Claim 1, wherein the simulation parameter comprises a colour or colour temperature.

11. A lighting system according to Claim 1, wherein the lighting effect is designed to mimic at least of fire; lightning; police car light; television; a neon flickering sign; a candle; muzzle (gunshot); welding; spark/short circuit; a scan (e.g. fingerprint scanner); paparazzi flashes; fireworks; flashes (strobe); a propeller; a (nuclear) explosion; and a wormhole.

12. A lighting system according to Claim 1, wherein the controller further comprises means for storing the calculated lighting value as a recallable preset.

13. A lighting system according to Claim 1, wherein the controller is adapted to control a plurality of lighting devices in dependence on the time varying lighting value.

14. A lighting system according to Claim 1, further comprising a further lighting device separate from said controller.

15. A lighting system according to Claim 14, wherein the controller comprises a wireless communication interface adapted for wireless communication with said further lighting device.

16. A lighting system according to Claim 14, wherein the controller is adapted to offset and/or overlap the output of said plurality of lights with one-another so as to simulate a moving light source.

17. A lighting system according to Claim 1, wherein the controller comprises an input interface adapted to receive a user input.

18. A lighting system according to Claim 1, wherein the controller is separable from the lighting device.

19. A lighting system according to Claim 17, wherein the input interface comprises at least one of: a wireless communication interface; a dial; a slider; a display and buttons; and a touch screen.

20. A lighting system according to Claim 1, further comprising a converter adapted to convert brightness and/or colour data from the simulator into lighting signals for output by the output.

21. A lighting system according to Claim 1, wherein the lighting system is a lighting system for videography, broadcast, cinematography, studio filming and/or location filming.

ABSTRACT OF THE DISCLOSURE

The invention relates to a lighting system, the system comprising: a lighting device; and a controller for controlling the lighting device to produce user customisable realistic lighting effects, the controller comprising: a calculating device adapted to calculate a time varying lighting value based on at least one simulation parameter; and adapted to output said time varying lighting value to said lighting device so as to simulate a user customizable realistic lighting effect; wherein said lighting device and said controller are integrated in a combined unit.

Doc Code: Oath
Document Description: Oath or declaration filed

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DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☒ Declaration Submitted With Initial Filing

☐ Declaration Submitted After Initial Filing (surcharge (37 CFR 1.16(f)) required

Attorney Docket Number	70947
First Named Inventor	Roderick Allen GAMMONS
COMPLETE IF KNOWN	
Application Number	
Filing Date	
Art Unit	
Examiners Name	

LIGHTING SYSTEM AND CONTROL THEREOF

(Title of the invention)

As below named inventor, I hereby declare that:

This declaration is directed to:

☒ The attached application,
OR
☐ United States Application or PCT Number _____
Filed On _____

The above-identified application was made or authorized to be made by me.

I believe I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

Authorization To Permit Access To Application by Participating Office

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In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the above-identified patent application with respect to: 1) the above-identified patent application-as-filed; 2) any foreign application to which the above-identified patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the above-identified patent application; and 3) any U.S. application-as-filed from which benefit is sought in the above-identified patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date of filing the Authorization to Permit Access to Application by Participating Offices.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 21 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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DECLARATION — Utility or Design Patent Application

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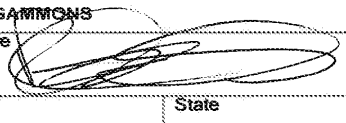
I have reviewed and understand the contents of the above identified application.

I acknowledge the duty to disclose information material to the patentability of the claims, as defined by 37 CFR 1.56.

LEGAL NAME OF SOLE OR FIRST INVENTOR:

(E.g., Given Name (first and middle (if any)) and Family Name or Surname)

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☒ Additional inventors are being named on the 1 supplemental sheet(s) PTO/AIA/10 attached hereto

Attorney Docket Number: 70947

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SUPPLEMENTAL SHEET FOR DECLARATION

ADDITIONAL INVENTOR(S)
Supplemental Sheet (for PTO/AIA/08,09)

Page 1 of 1

Legal Name of Additional Joint Inventor, if any:			
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Legal Name of Additional Joint Inventor, if any:			
(*E.g.*, Given Name (first and middle (if any)) and Family Name or Surname)			
Inventor's Signature			Date (Optional)
Residence: City	State	Country	
Mailing Address			
City	State	Zip	Country

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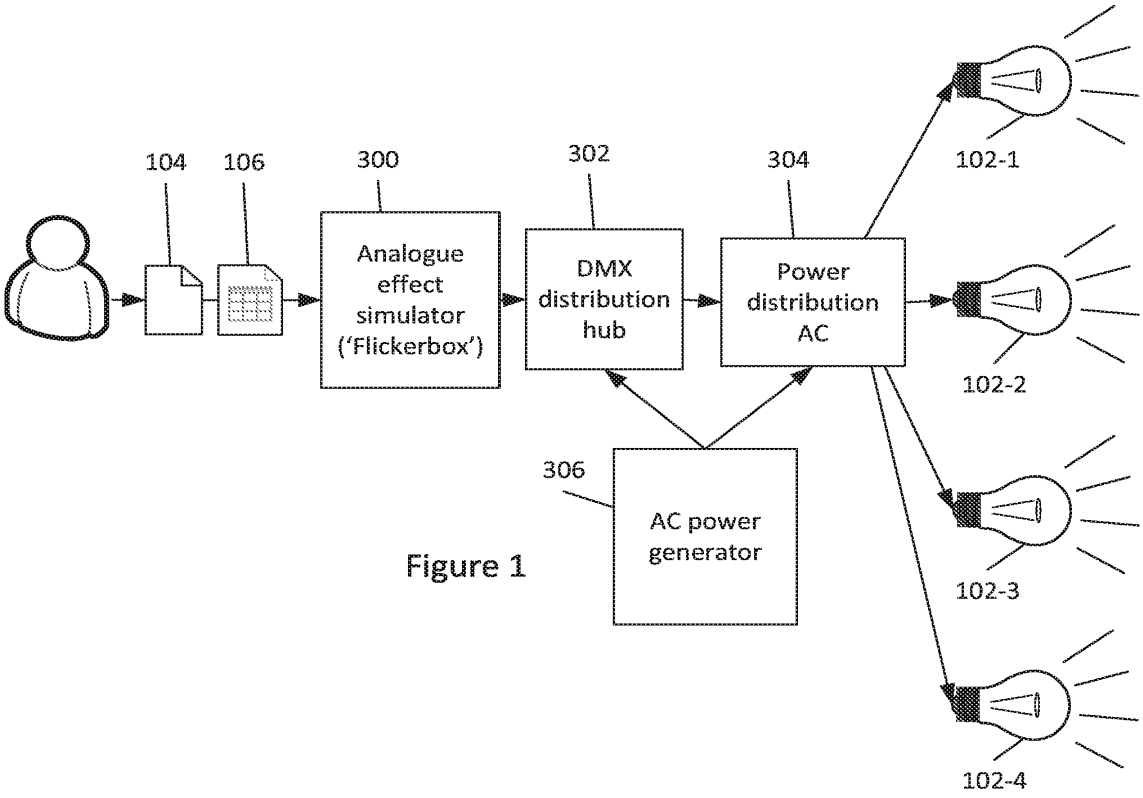


Figure 1

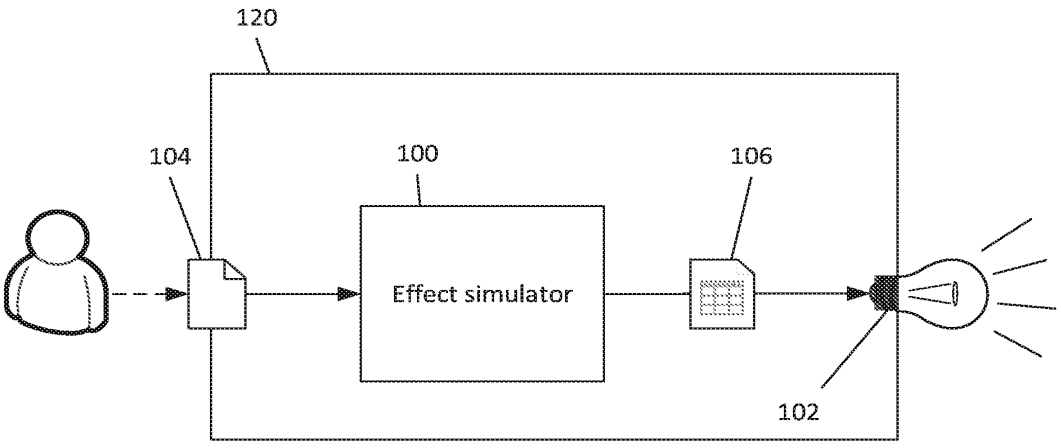


Figure 2

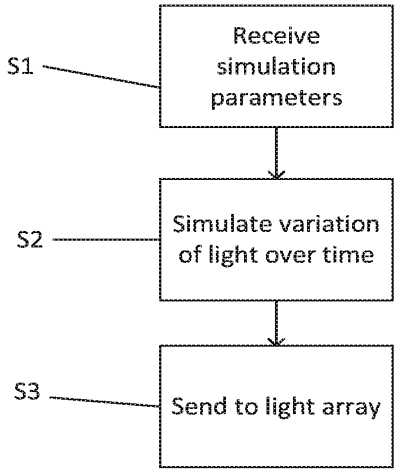


Figure 3

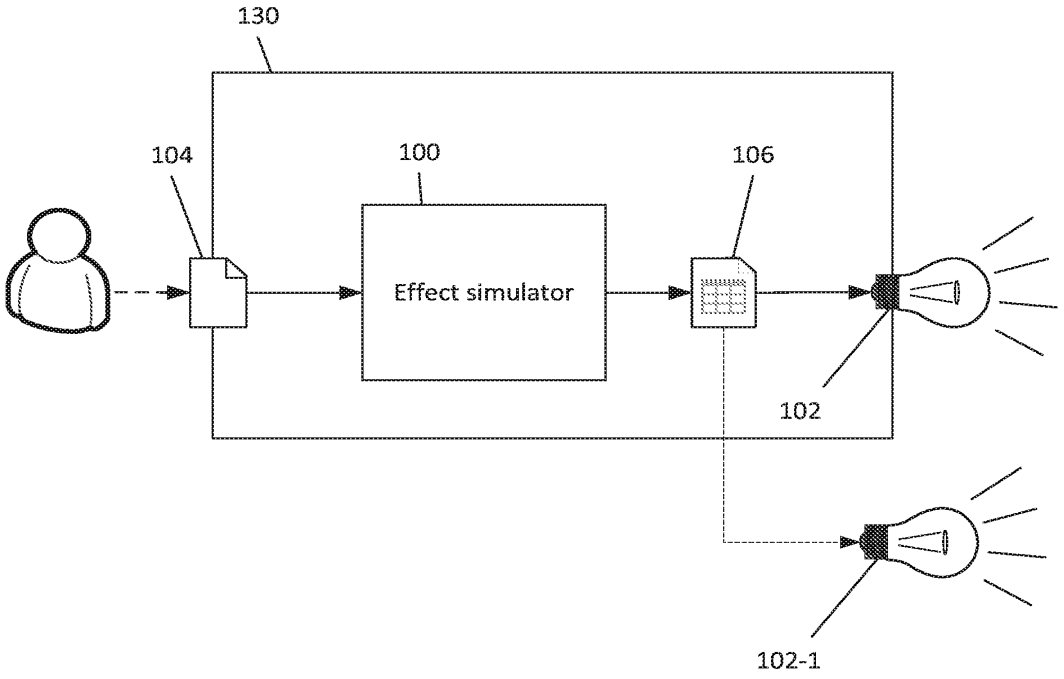


Figure 4

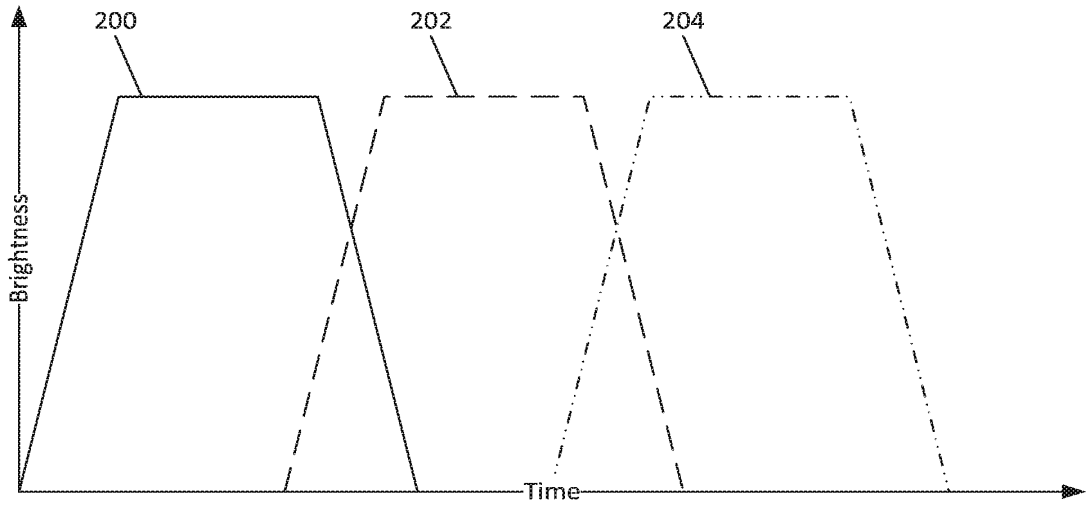


Figure 5

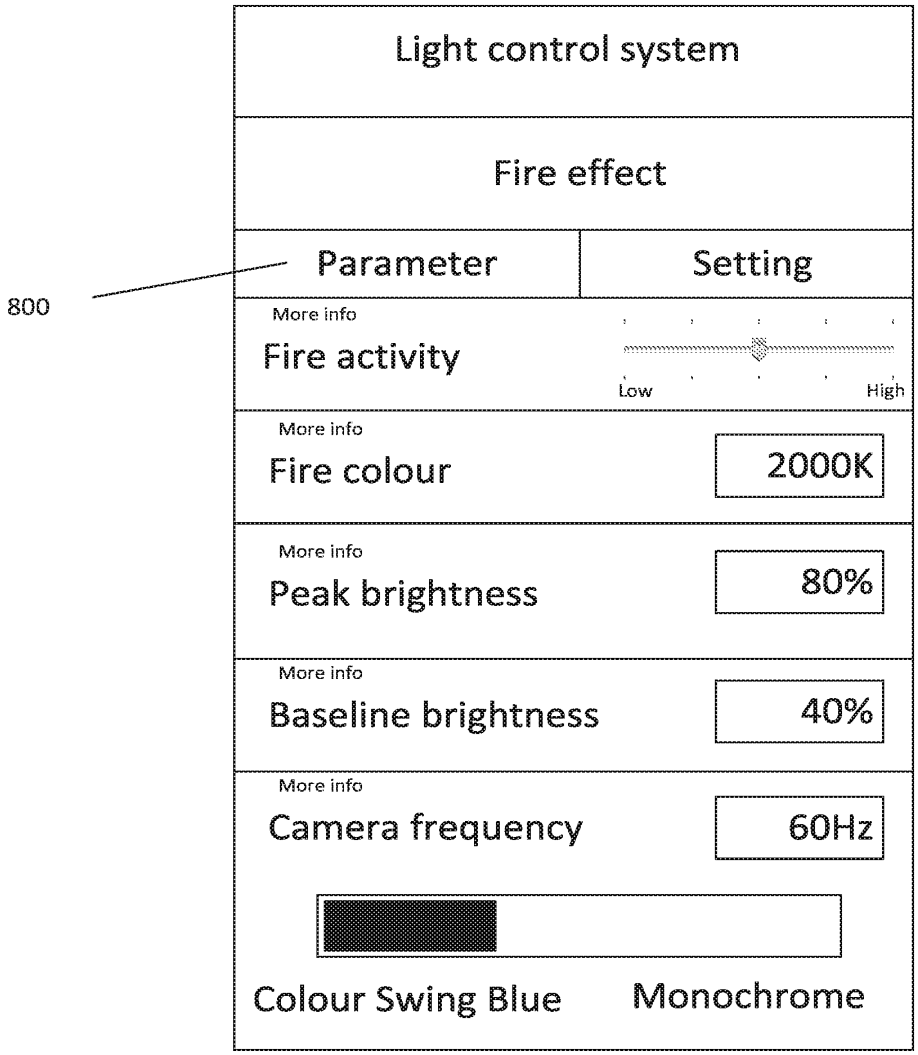

800
Light control system
Fire effect
Parameter
Setting
More info
Fire activity
Low
High
More info
Fire colour
2000K
More info
Peak brightness
80%
More info
Baseline brightness
40%
More info
Camera frequency
60Hz
Colour Swing Blue
Monochrome

Figure 6

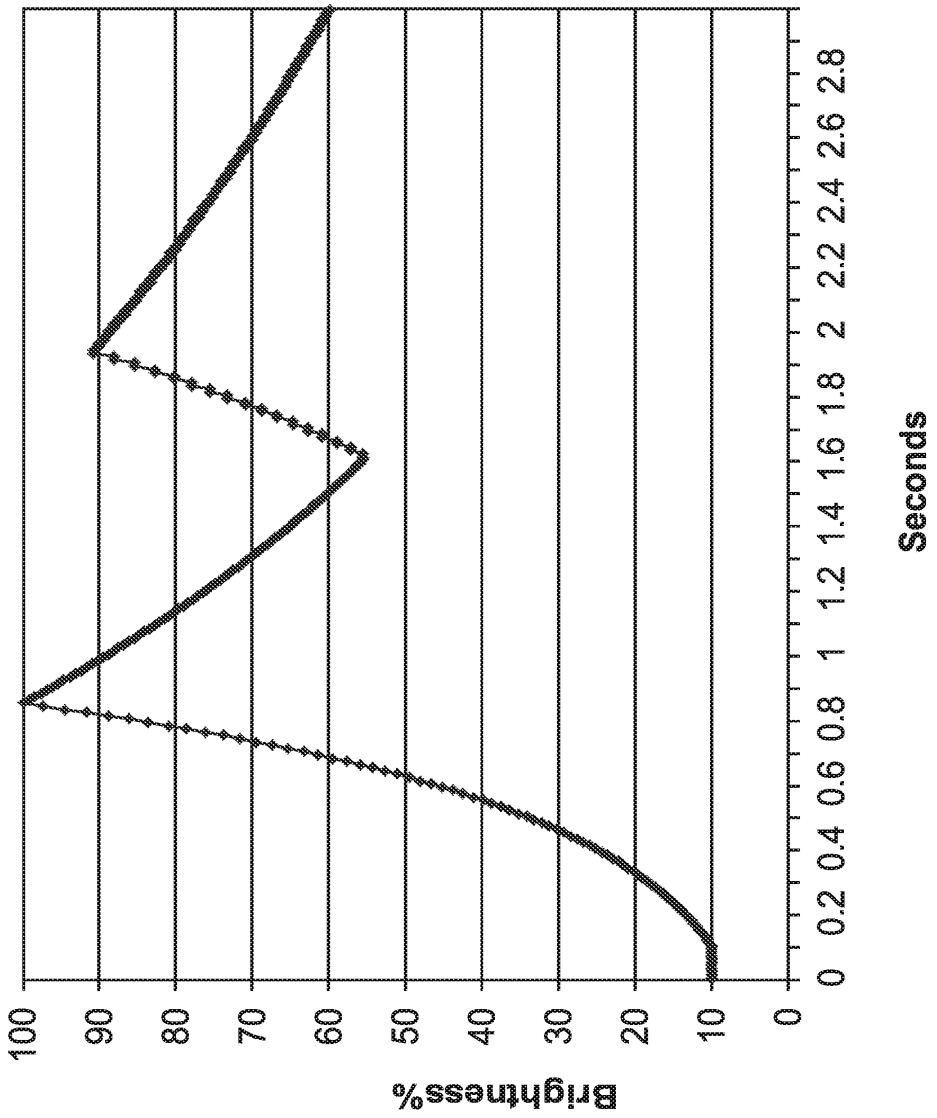

Brightness%
100
90
80
70
60
50
40
30
20
10
0
Seconds
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8

Figure 7

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	70947
	Application Number	
Title of Invention	LIGHTING SYSTEM AND CONTROL THEREOF	

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This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Roderick Allen		GAMMONS	

Residence Information (Select One) ○ **US Residency** ◉ **Non US Residency** ○ **Active US Military Service**

City	Staines Upon Thames	State/Province	Surrey	Country	GB

Mailing Address of Inventor:

Address 1	135 Chertsey Lane		
Address 2			
City	Staines Upon Thames	**State/Province**	Surrey
Postal Code	TW18 3LR	**Country**	GB

Inventor 2

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Andrew		FRANCIS	

Residence Information (Select One) ○ **US Residency** ◉ **Non US Residency** ○ **Active US Military Service**

City	Witham	State/Province	Essex	Country	GB

Mailing Address of Inventor:

Address 1	4 Wickham Bishops		
Address 2			
City	Witham	**State/Province**	Essex
Postal Code	CM8 3NU	**Country**	GB

PTO/AIA/14 (08-12)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	70947
	Application Number	
Title of Invention	LIGHTING SYSTEM AND CONTROL THEREOF	

Inventor 3					
Legal Name					
Prefix	**Given Name**	**Middle Name**	**Family Name**		**Suffix**
	Roderick Aaron		GAMMONS		
Residence Information (Select One) ○ **US Residency** ◉ **Non US Residency** ○ **Active US Military Service**					
City	Winkfield	**State/Province**	Windsor	**Country**	GB

Mailing Address of Inventor:			
Address 1	Vetch Cottage, Lovel Road		
Address 2			
City	Winkfield	**State/Province**	Windsor
Postal Code	SL4 2EU	**Country**	GB

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ An Address is being provided for the correspondence Information of this application.

Customer Number	**67801**
Email Address	martin@ipatent.co.il

Application Information:

Title of the Invention	LIGHTING SYSTEM AND CONTROL THEREOF		
Attorney Docket Number	70947	**Small Entity Status Claimed** ☒	
Application Type	Non Provisional		
Subject Matter	Utility		
Suggested Class (If any)		**Sub Class (If any)**	
Suggested Technology Center (if any)			
Total Number of Drawing Sheets (if any)	**5**	**Suggested Figure for Publication (if any)**	

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application.
Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	70947
	Application Number	
Title of Invention	LIGHTING SYSTEM AND CONTROL THEREOF	

CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.			
Please Select One:	⊙Customer Number	○US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	67801		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

Prior Application Status	**Pending**		
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Continuation Of	15/481,460	2017-04-07
Prior Application Status	**Expired**		
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
15/481,460	Claims Benefit Of Provisional	62/319,809	2016-04-08

Foreign Priority Information:

This section allows for the applicant to claim benefit of foreign priority and to identify any prior foreign application for which priority is not claimed. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(a).

Application Number	Country	Filing Date (YYYY-MM-DD)	Priority Claimed
1606907.2	**GB**	**2016-04-20**	⊙ Yes ○ No

Authorization to Permit Access:

☒ Authorization to Permit Access to the Instant Application by the Participating Offices

If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the instant patent application is filed access to the instant patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the instant patent application is filed to have access to the instant patent application.

In accordance with 37 CFR 1.14(h) (3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date of filing this Authorization.

PTO/AIA/14 (OB-12)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	70947
	Application Number	
Title of Invention	LIGHTING SYSTEM AND CONTROL THEREOF	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

⊙ Assignee	O Legal representative under 35 U.S.C 117
O Person to whom the inventor is obligated to assign.	O Person who shows sufficient propriety interest

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor :	

If the Assignee is an Organization check here. ☒

Organization Name	Rotolight Limited		
Mailing Address Information:			
Address 1	c/o London Law, The White House, 57-63 Church Road, Wimbledon Village		
Address 2			
City	London	**State/Province**	
Country GB		Postal Code	SW19 5SB
Phone Number		Fax Number	
Email Address			

Signature:

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications

Signature	**/Martin D. Moynihan/**			Date (YYYY-MM-DD)	2017-12-21
First Name	Martin	Last Name	Moynihan	Registration Number	40338

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82A (07-13)
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TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

Attorney Docket Number: 70947

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	
Filing Date	
First Named Inventor	Roderick Allen GAMMONS
Title	LIGHTING SYSTEM AND CONTROL THEREOF
Art Unit	
Examiner Name	
Attorney Docket Number	70947

SIGNATURE of Applicant or Patent Practitioner

Signature	/Martin D. Moynihan/	Date (Optional)	December 21, 2017
Name	Martin D. Moynihan	Registration Number	40338
Title (if Applicant is a juristic entity)			
Applicant Name (If Applicant is a juristic entity)			

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ *Total of 4 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32 and 1.33.The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Doc Code: PA..
Document Description: Power Of Attorney

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POWER OF ATTORNEY BY APPLICANT

Attorney Docket Number: 70947
Title: LIGHTING SYSTEM AND CONTROL THEREOF
By: Roderick Allen GAMMONS et al.

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 67801

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☑ The address associated with the above-mentioned Customer Number

OR

☐ The address associated with Customer Number:

OR

Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

Rotolight Limited

☐ Inventor or Joint Inventor (title not required below)
☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)
☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)
☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature		Date (Optional)	
Name	ROD GAMMONS		
Title	CHAIRMAN		

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ Total of _____ forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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STATEMENT UNDER 37 CFR 3.73(c)

Applicant/Patent Owner: Roderick Allen GAMMONS et al.

Application No./Patent No.:_____ Filed/Issue Date: _____

Titled: LIGHTING SYSTEM AND CONTROL THEREOF

Rotolight Limited, (Name of Assignee) a Corporation (Type of Assignee, e.g., corporation, partnership, university, government agency, etc.)

states that, for the patent application/patent identified above, it is (choose **one** of options 1, 2, 3 or 4 below):

1. ☑ The assignee of the entire right, title, and interest.
2. ☐ An assignee of less than the entire right, title, and interest (check applicable box):
   - ☐ The extent (by percentage) of its ownership interest is ____%. Additional Statement(s) by the owners holding the balance of the interest must be submitted to account for 100% of the ownership interest.
   - ☐ There are unspecified percentages of ownership. The other parties, including inventors, who together own the entire right, title and interest are:

     Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.
3. ☐ The assignee of an undivided interest in the entirety (a complete assignment from one of the joint inventors was made). The other parties, including inventors, who together own the entire right, title, and interest are:

   Additional Statement(s) by the owner(s) holding the balance of the interest must be submitted to account for the entire right, title, and interest.
4. ☐ The recipient, via a court proceeding or the like (e.g., bankruptcy, probate), of an undivided interest in the entirety (a complete transfer of ownership interest was made). The certified document(s) showing the transfer is attached.

The interest identified in option 1, 2 or 3 above (not option 4) is evidenced by either (choose **one** of options A or B below):

A. ☑ An assignment from the inventor(s) of the patent application/patent identified above. The assignment was recorded in the United States Patent and Trademark Office at Reel _____, Frame _____, or for which a copy thereof is attached.

B. ☐ A chain of title from the inventor(s), of the patent application/patent identified above, to the current assignee as follows:
   1. From: _____ To: _____
      The document was recorded in the United States Patent and Trademark Office at
      Reel _____, Frame _____, or for which a copy thereof is attached.
   2. From: _____ To: _____
      The document was recorded in the United States Patent and Trademark Office at
      Reel ____, Frame _____, or for which a copy thereof is attached.

This collection of information is required by 37 CFR 3.73(b). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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STATEMENT UNDER 37 CFR 3.73(c)

3. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

4. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at
Reel ___, Frame _____, or for which a copy thereof is attached.

5. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at
Reel _____, Frame _____, or for which a copy thereof is attached.

6. From: _____ To: _____
The document was recorded in the United States Patent and Trademark Office at
Reel ___, Frame _____, or for which a copy thereof is attached.

☐ Additional documents in the chain of title are listed on a supplemental sheet(s).

☐ As required by 37 CFR 3.73(c)(1)(i), the documentary evidence of the chain of title from the original owner to the assignee was, or concurrently is being, submitted for recordation pursuant to 37 CFR 3.11.

[NOTE: A separate copy (i.e., a true copy of the original assignment document(s)) must be submitted to Assignment Division in accordance with 37 CFR Part 3, to record the assignment in the records of the USPTO. See MPEP 302.08]

The undersigned (whose title is supplied below) is authorized to act on behalf of the assignee.

/Martin D. Moynihan/	December 21, 2017
Signature	Date
Martin D. Moynihan	40338
Printed or typed Name	Title or Registration Number

ASSIGNMENT

For good and valuable consideration, the receipt and sufficiency of which is hereby acknowledged, the undersigned (hereinafter called the "Assignors"):

Roderick Allen GAMMONS	**135 Chertsey Lane, Staines Upon Thames, TW18 3LR Surrey, Great Britain**
Andrew FRANCIS	**4 Wickham Bishops, Witham, CM8 3NU Essex, Great Britain**
Roderick Aaron GAMMONS	**Vetch Cottage, Lovel Road, Winkfield SL4 2EU Windsor, Great Britain**

hereby sell(s), assign(s) and transfer(s) to:

Rotolight Limited
c/o London Law, The White House
57-63 Church Road, Wimbledon Village
SW19 5SB London
Great Britain

(hereinafter called the "Assignee"), its successors, assigns, nominees or other legal representatives, the undersigned's entire rights, title and interest in and to the invention titled:

LIGHTING SYSTEM AND CONTROL THEREOF

described and claimed in the following Patent Application:

Patent Application to be filed in the USA, executed the same date as this assignment, and identified as Attorney Docket No. 70947

and in and to said Patent Application, and all original and reissued Patents granted therefore, and all divisions and continuations thereof, any corresponding PCT Patent Application and the National Phases thereof, including the right to apply and obtain Patents in all other countries, the right to claim priority under International Conventions, and the Letters Patent which may be granted thereon:

covenant that the undersigned have (has) the full right to convey the entire interest therein assigned;

authorize(s) and request(s) the Registrar of Patents, and any Official of any country whose duty it is to issue Patents on applications as aforesaid, to issue the said Letters Patent to the said Assignee;

and agree(s) to sign all lawful papers, make all rightful oaths, do all lawful acts requisite for such Patent Applications, and do everything possible to aid said Assignee to apply for, obtain and enforce Patent protection for said invention.

ASSIGNORS

Roderick Allen GAMMONS	**Andrew FRANCIS**	**Roderick Aaron GAMMONS**
Date: 7th April 2017	**Date:** 7th April 2017	**Date:** 7th April 2017

ASSIGNEE

Rotolight Limited

Signature :
Name : Peter Commons
Capacity : Director
Date : 24 April 2017.

Patent Application to be filed in the USA, executed the same date as this assignment, and identified as Attorney Docket No. 70947

Electronic Patent Application Fee Transmittal					
Application Number:					
Filing Date:					
Title of Invention:	LIGHTING SYSTEM AND CONTROL THEREOF				
First Named Inventor/Applicant Name:	Roderick Allen GAMMONS				
Filer:	Martin Moynihan				
Attorney Docket Number:	70947				
Filed as Small Entity					
Filing Fees for	**Track I Prioritized Examination - Nonprovisional Application under 35 USC 111(a)**				
Description		**Fee Code**	**Quantity**	**Amount**	**Sub-Total in USD($)**
Basic Filing:					
UTILITY FILING FEE (ELECTRONIC FILING)		4011	1	70	70
UTILITY SEARCH FEE		2111	1	300	300
UTILITY EXAMINATION FEE		2311	1	360	360
REQUEST FOR PRIORITIZED EXAMINATION		2817	1	2000	2000
Pages:					
Claims:					
CLAIMS IN EXCESS OF 20		2202	1	40	40
Miscellaneous-Filing:					

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
PUBL. FEE- EARLY, VOLUNTARY, OR NORMAL	1504	1	0	0
PROCESSING FEE, EXCEPT PROV. APPLS.	2830	1	70	70
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**2840**

Electronic Acknowledgement Receipt	
EFS ID:	31299723
Application Number:	15849819
International Application Number:	
Confirmation Number:	1042
Title of Invention:	LIGHTING SYSTEM AND CONTROL THEREOF
First Named Inventor/Applicant Name:	Roderick Allen GAMMONS
Customer Number:	67801
Filer:	Martin Moynihan
Filer Authorized By:	
Attorney Docket Number:	70947
Receipt Date:	21-DEC-2017
Filing Date:	
Time Stamp:	10:31:26
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$2840
RAM confirmation Number	122117INTEFSW00013096501407
Deposit Account	501407
Authorized User	Martin Moynihan
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal of New Application	1-70947TransmittalSheetFiledUSCON.pdf	34767 f09d603378df470fdb17faafbeffbd6f89b65119	no	1
Warnings:					
Information:					
2	TrackOne Request	2-70947PrioritizedExaminationUSPTORequestForm.pdf	134538 c18d6f2d7935b3d86a6fe08a5473d281fa975f41	no	2
Warnings:					
Information:					
3	Internet Communications Authorized	3-70947FormPTOSB439.pdf	77913 7b10a31db159c2f03aa5abb6aea2c2c64aba48f7	no	2
Warnings:					
Information:					
4	Specification	4-70947.pdf	118168 e9155cc9e79f5afa628ba7988166e8f61a124735	no	21
Warnings:					
Information:					
5	Oath or Declaration filed	5-70947ExecutedDeclaration.pdf	1039567 448b6a1c43c3398f17e7b787e160bcc450fd1706	no	3
Warnings:					
Information:					
6	Drawings-only black and white line drawings	6-70947Figures.pdf	264766 82ba704c38b4dfcdbf59f008e862fcd404f5150e	no	5
Warnings:					
Information:					

7	Application Data Sheet	7-70947ApplicationDataSheet.pdf	71706 215306e0c5add5e66d1d56edb880023a04f7cd61	no	4
Warnings:					
Information:					
This is not an USPTO supplied ADS fillable form					
8	Power of Attorney	8-70947ExecutedPowerOfAttorney.pdf	495251 014bb53d752153c82ce349b1da1b7411db0136ab	no	4
Warnings:					
Information:					
9	Miscellaneous Incoming Letter	9-70947ExecutedAssignment.pdf	402146 83ad79ae97940f4749d097612d461eb9e8340fa1	no	2
Warnings:					
Information:					
10	Fee Worksheet (SB06)	fee-info.pdf	41738 d8804aa90eec443f0350f89387081dae15c51cfb	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	2680560		

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New Applications Under 35 U.S.C. 111

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If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(*use as many sheets as necessary*)

Complete if Known	
Application Number	15/849,819
Filing Date	December 21, 2017
First Named Inventor	GAMMONS Roderick Allen et al
Art Unit	
Examiner Name	
Attorney Docket Number	70947

Sheet 1 of 2

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No. [1]	Document Number Number-Kind Code [2] (if known)	Publication Date DD-MMM-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	2007/0159347	12-Jul-2007	Weitzel	
	2	2008/0129226	05-Jun-2008	DeWitt et al.	
	3	5,307,295	26-Apr-1994	Taylor et al.	
	4	5,921,659	13-Jul-1999	Hunt et al.	
	5	5,924,784	20-Jul-1999	Chliwnyj et al.	
	6	7,038,399	02-May-2006	Lys et al.	
	7	7,353,071	01-Apr-2008	Blackwell et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No. [1]	Foreign Patent Documents Country Code [3]-Number [4]-Kind Code [5] (*if known*)	Publication Date DD-MMM-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T [6]
	8	GB 2209229	04-May-1989	Pearce-Harvey et al.		
	9	EP 2383608	02-Nov-2011	Wu		
	10	GB 2424525	27-Sep-2006	Rafter et al.		
	11	GB 2482562	08-Feb-2012	Hjerde		
	12	JP H0448588	18-Feb-1992	Iwata		
	13	WO 01/05195	18-Jan-2001	Lys et al.		
	14	WO 2005/052751	09-Jun-2005	Chemel et al.		

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[1] Applicant's unique citation designation number (optional).

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[3] Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3).

[4] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document.

[5] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible.

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This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. this collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450

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Application Number	15/849,819
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Group Art Unit	
Examiner Name	
Attorney Docket Number	70947

Sheet 2 Of 2

OTHER PRIOR ART – NON PATENT LITERATURE DOCUMENTS

Examiner Initials	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial symposium, catalog, etc.) date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	15	European Search Report and the European Search Opinion Dated 01 August 2017 From the European Patent Office Re. Application No. 17165609.3. (7 Pages)	
	16	Patents Act 1977: Combined Search and Examination Report Under Sections 17 and 18(3) Dated 13 June 2016 From the Intellectual Property Office of the United Kingdom Re. Application No. GB1606907.2. (7 Pages)	
	17	Patents Act 1977: Examination Report under Section 18(3) Dated 30 August 2017 From the Intellectual Property Office of the United Kingdom Re. Application No. GB1606907.2 (3 Pages)	

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:		§	
		§	
	GAMMONS Roderick Allen et al	§	
		§	Confirmation No.: 1042
Serial No.:	15/849,819	§	
		§	
Filed:	December 21, 2017	§	Group Art Unit:
		§	
For:	LIGHTING SYSTEM AND CONTROL THEREOF [CineSFX]	§	
		§	Attorney Docket: 70947
Examiner:		§	

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Sir:

Enclosed is a PTO Form 1449 which lists citations which may be material to the patentability and examination of the above identified application. Also enclosed are copies of the references cited, other than U.S. Patents and U.S. patent applications. These are submitted in compliance with the duty of disclosure defined in 37 CFR 1.56, 37 CFR 1.97 and 37 CFR 1.98. The Examiner is requested to make these citations of official record in this application.

The undersigned states:

A. NO CERTIFICATION OR FEE DUE

☒ This Information disclosure Statement is being filed within three months of filing a national application or entry of a national phase of an international application; or before the mailing date of a first Office action on the merits of the above-identified application. Accordingly, no fee or Certification is believed due. However, if a fee is due, authorization to deduct such fee from the Deposit Account 501407 of the undersigned is hereby provided.

B. CERTIFICATION

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement; or

That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement.

C. FEE

☐

☒ No Fee is Due.

This Information Disclosure Statement under 37 CFR 1.56 is not to be construed as a representation that a search has been made, that additional matter which is material to the examination of this application does not exist, or that any one or more of the citations listed constitutes prior art as defined by 35 U.S.C. 102.

It is respectfully requested that the Examiner consider the cited information, along with any other information, in reaching a determination concerning the patentability of the present claims, and sign the enclosed form PTO-1449 to evidence that the cited information has been fully considered by the Patent and Trademark Office during the examination of this application. Notwithstanding any statements by the Applicant, the Examiner is urged to form his/her own conclusion regarding the relevance of the cited information.

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Unless indicated otherwise, to the best of our knowledge and procedures, each item of information contained in the information disclosure statement was first known no more than thirty days prior to the filing of the information disclosure statement, either by the inventor named in the application, Attorney or agent who prepares or prosecutes the application, and every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, the applicant, an assignee, or anyone to whom there is an obligation to assign the application.

Respectfully submitted,

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G3N NGA N272A N272B N383A N387
F4R RFE RFN R330
U1S S1933

(56) Documents cited
GB 2168138 A **GB 2132329 A** **GB 1434052 A**
GB 1332412 A **EP 0253082 A2** **EP 0060068 A1**
US 3845351 A

(58) Field of search
UK CL (Edition J) **F4R RFE RFJ RFM RFN RL RS, G3N NGA NGBA NGBA1 NGCA NGCA1 NGCA4 NGE2**
INT CL⁴ **F21P**

(54) Remote control system

(57) A control system for the remote control of equipment such as stage lighting or sound equipment 300 comprises a micro computer (101-104) which is used to input commands to the equipment. The setting of one item of equipment (eg, a spotlight) can be set by the user and then the setting(s) of other equipment can be calculated to achieve a user-set co-ordination between the operation of the items of equipment. Control signals are sent to the remote equipment in pulse width modulated form to achieve rapid updating with high noise immunity.

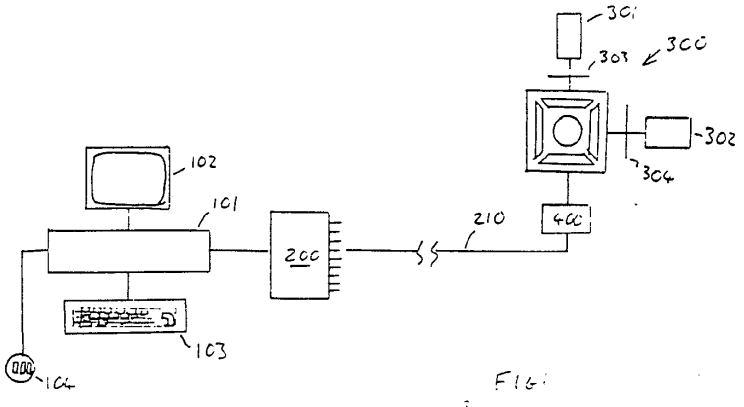


Fig 1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1982.

This print takes account of replacement documents submitted after the date of filing to enable the appliction to comply with the formal requirements of the Patents Rules 1982.

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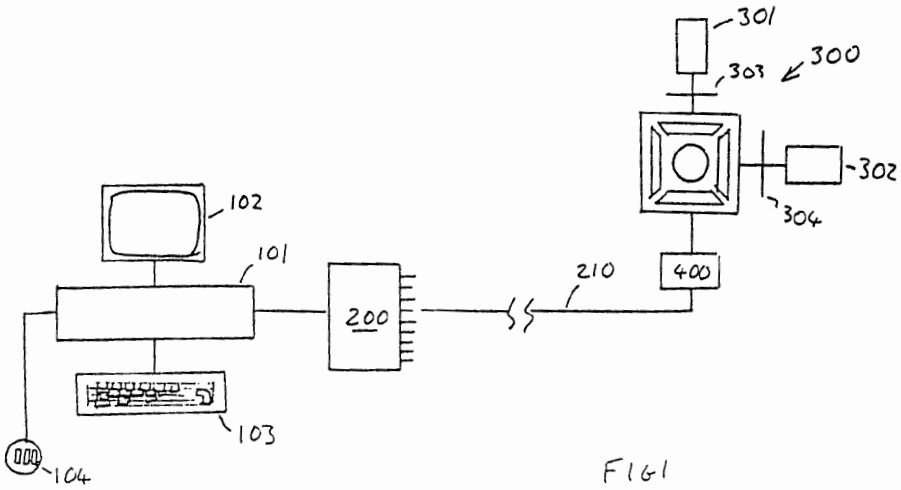


FIG1

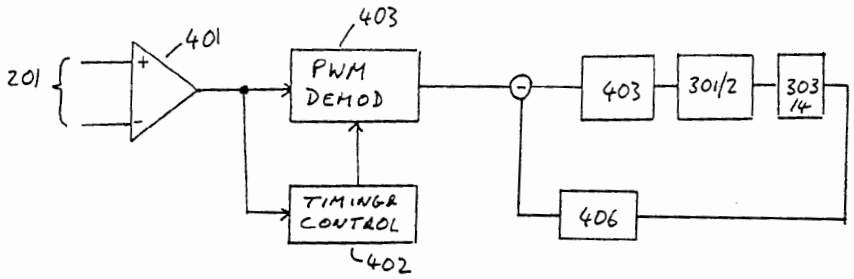
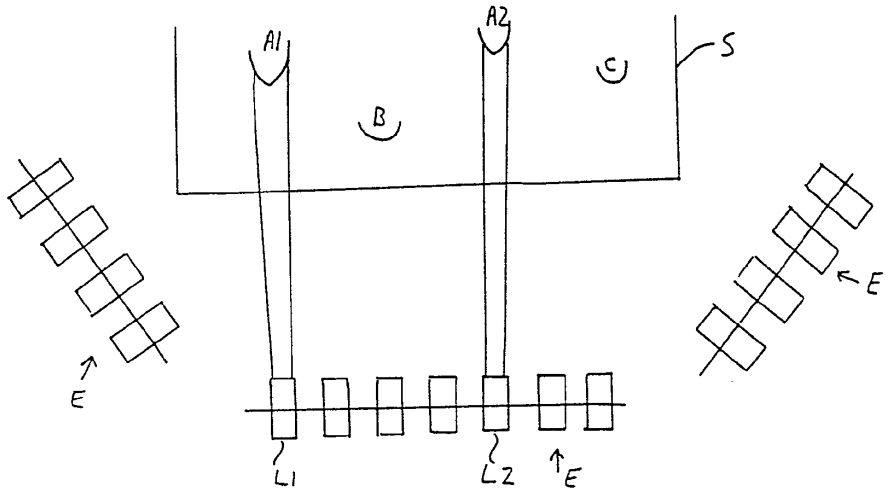


FIG2

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FIG 3

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REMOTE CONTROL SYSTEM

The present invention relates to a remote control system, particularly, but not exclusively, for use in controlling lighting, sound and/or other stage equipment for stage performances and similar uses.

It is conventional to control stage lighting equipment from a control desk which is provided with a number of individual controls for to what may be a large number of stage lights. Conventionally, such a desk is provided with facilities for fading in and fading out individual lights or groups of lights.

Over the past few years, stage lighting equipment has become available which has the facility for controlling remotely mechanical aspects of the operation of the individual lights. For example, each light may be provided with motor-driven mechanisms for controlling the pan and/or tilt of the light and other operating parameters such as the iris aperture and focus of the light. Systems have been proposed in which the control desk
incorporates a desk-top computer into which commands for the individual lights can be typed by the operator. Perhaps because of the basically digital nature of the controller and the trend towards the use of digital techniques generally,

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such systems have transmitted the commands to the individual lights as digital data over a wire link, and individual lights have been provided with digital decoders which receive the commands from the control desk, decode and control the electro-mechanical actuators associated with the light in accordance with the decoded commands.

Various problems have been encountered with such systems. The use of digital transmission requires a substantial degree of local "intelligence" at the decoders associated with the individual lights, making the equipment expensive. Secondly, difficulties are encountered in operating such equipment because the operating environment is relatively hostile, both electrically and physically, i.e; the power supplies to the lighting and sound equipment involves large electrical currents which are a source of noise and interference which can cause mis-operation of the digital equipment and, from a physical point of view, amongst other things, the equipment may generate a substantial amount of heat - present stage lighting equipment may operate at power levels of several tens or even hundreds of kilowatts. Thirdly, neither the use of a conventional control desk layout of faders nor input of commands from computer keyboards provides a simple and rapid method of setting up and issuing commands for operating the lights in a coordinated fashion.

The present invention is concerned, inter alia, with reducing the above problems. It is not limited, however, to applications where those specific problems arise.

A first aspect of the present invention provides a control system for controlling operation of a number of remote electrical devices, comprising a user-operable system controller for enabling a user to set operating variables of the remote devices, and generating corresponding control signals for each of the controlled devices, means for transmitting the control signals to the remote devices, and means associated with each of the remote devices for decoding the control signals received from the system controller and setting the operating variable (s) of the associated device as commanded by the control signals, the system controller being operative to accept user-input setting the required value of the operating variable of one of the remote devices and a user-command which instructs the corresponding operating variable of at least one other remote device to be set to a value coordinated with that value, to calculate the required coordinated value of the operating variable of that other remote device or devices and to generate the corresponding command for that other remote device or devices.

In the application of this aspect of the invention to the control of the pan and/or tilt of two or more stage lights,

suppose that the operator requires two spotlights to converge on the same point on the stage or to follow the same path at the same time on the stage. In those circumstances, the system controller is arranged to accept commands from the user setting the position (or sequence of positions) required of one of the spotlights, to calculate and generate the corresponding command signals for that spotlight and transmit them to the spotlight which has control circuitry associated with it which de-codes the commands and operates the spotlight accordingly. The system controller further accepts a command from the user as to the manner in which the operation of the second spotlight is to be coordinated with that of the first (as by being directed at the same spot or following the same path), calculates the required value or sequence of values of the operating variable (eg; pan and/or tilt) of the second spotlight required to achieve the instructed coordination and then generates and transmits those commands to the second spotlight, simultaneously with the first spotlight, or not depending on the coordination required. Facilities in the controller may be provided for enabling the user to see the effect of a "test run" of the command or commands to the first spotlight before the system controller generates the coordinated commands for the second one.

A second aspect of the present invention provides a control system for controlling the operation of one or more remotely

located lighting, sound or other stage equipment comprising a user/operable system controller for user/setting operating variables of the remote equipment and for generating corresponding command signals to the control equipment, means for transmitting the control signals to the remote equipment, and means associated with the remote equipment for decoding the command signals received from the system controller and setting the operating variable (s) of the associated device accordingly, the required value of the operating variable being encoded for transmission as the pulse-width modulation of pulses in a train of pulses transmitted to the remote device.

For the or each remote item of equipment, a number of operating variables (eg; in the stage lighting application, the pan and/or tilt of a stage light), they be controlled by the system controller. In those circumstances, the command signals for each variable may be time-interleaved in a cyclical fashion, so that the pulse train transmitted comprises a cyclical succession of pulse-width modulated pulses representing commands for respective operating variables of the particular remote device. It has been found that such an arrangement provides a good degree of immunity from noise and other interference in the hostile stage environment, enables the individual remote devices to be controlled by circuitry which does not have to possess a

substantial degree of local intelligence and enables the commands for each device to be updated very frequently without requiring a very high data transmission rate.

A control system incorporating both of the above aspects of the present invention will now described by way of non-limitative examples reference to the accompanying drawings in which:-

Figure 1 is a schematic block diagram of a control system in accordance with both aspects of the present invention;

Figure 2 is a schematic block diagram of the de-coder associated with one of the remotely controlled devices in the system of figure 1;

Figure 3 is a schematic plan view of a stage showing how the system may be used to coordinate the operation of two or more stage lights to achieve a required effect.

Before describing in detail the illustrated embodiment of the invention, reference will be made to Figure 3 which illustrates one typical way in which it may be used.

In Figure 3, S denotes a stage on which a performance is to take place, lit by stage lighting equipment E which includes,

amongst others, spotlights L1, L2 which are currently directed at areas A1 and A2 of the stage. The lighting equipment operates under the control of a lighting (and optionally, sound) control desk D. The spotlights L1, L2, are of a type having electromechanical actuators to set their pan and tilt angles.

Suppose that the operator wishes the spotlights L1, L2 to pan and tilt in synchronism so that they end up converging at point B. The illustrated embodiment is provided with control facilities whereby a computer (100 in Figure 1) at the desk D has data as to the current and required positions of the spotlights L1, L2 and can calculate and transmit to each of the two spotlights a sequence of position commands which will result in their beams converging at the required position B at the same time. Even where the positions of the two spotlights relative to the stage are not symmetrical, given data as to their actual positions, the computer can calculate the required sequences of movements of the two spotlights to coordinate their actions as required.

As a second example, the operator might want both of the spotlights to move in synchronism from position B to a position C and again it can calculate the required sequences of position commands for the two lights so that they move in the required way, even allowing for assymetries in their

positions.

Where coordination of the operation (e.g. the movements) of two or more such lights is required, the present invention proposes a method of operation which does not require the operator to programme each of the lights individually. Specifically, it is proposed that the software of the computer of the desk D is arranged so that it first accepts a command (or series of commands) from the user indicating the action(s) required of one of the devices to be controlled - in this case the lights (say, L1 in Figure 3) and then a command in respect of one or more of the other devices indicating the coordinated action required (e.g. in the case of light L2, arrive at C at the same time or move in a manner to keep its beam parallel, say, to that of L1). Any number of other required coordinated actions of the controlled devices may be handled in a similar way.

Referring now to Figure 1, this shows the overall arrangement of the illustrated embodiment. The control desk D of Figure 3 is provided with a desk-top computer 100 (e.g. an IBM PS2 System 50 PC) which comprises a system unit 101, VDU 102, keyboard 103 and two-axis input device 104 such as a "mouse", trackball or lightpen. The computer 100 operates under the control of a suitably written application program running under a convenient operating system such as MS Windows. The

VDU 102 can display a map in plan or perspective of the stage and the lighting and other equipment which is to be controlled and the input device 104 can be used to select lights and other items of equipment whose operation is to be controlled and to call up "icons" or menu-bars to pre-programme or operate in real time the items in question. The device 104 and/or the keyboard 103 can further be used to control the operating mode of the software, establish the required settings or operation of the items of equipment to be controlled and so forth.

The computer 100 calculates the required commands for each of the lights, etc., which are to be controlled and outputs them via a standard high-speed parallel communications port to a transmitter 200 which distributes the commands across a number of output channels for transmission via cables such as 210 to the individual items (or groups of items, where appropriate). One such item, a pan and tilt spotlight is shown at 300. For functions which do not register a change between successive cycles (i.e. the instructed value does not change), the previous value is retransmitted.

The transmitter 200 acts in effect as a time-division demultiplexer, distributing the serially generated command signals across its N output channels. N may be, say, 40, with, say, 9 functions (per light or other controlled device) on

each channel. The pulse rate on each channel may be such that, say, 40 or 50 cycles of the various function signals on each channel occur per second. The transmitter 200 also serves to produce the appropriate pulse width modulated signals for transmission and incorporates suitable line drivers for driving the cables 210. These may be screened twisted wire pairs to which a balanced drive signal is applied so as to reduce the sensitivity to electrical noise.

The spotlight 300 has electronically controlled pan and tilt DC electric motors 301, 302 which are actuated by circuitry 400 as required in accordance with the PWM signals received via the associated cable 210. The control signal comprises a cyclically repeating series of PWM pulses; each of the pulses in the series may represent the required setting of a different operating parameter of the device (in this case, the spotlight) under control. In the case of a spotlight, the parameters can include: pan & tilt angles, iris setting, which one of a number of colour filters is to be in effect, lamp power and so forth (alternatively the lamp power may be controlled by conventional triac or SCR phase control of the mains supply to the lamp). The width modulation (and subsequent demodulation and position servo) is preferably such as to allow an overall resolution of 11 bits or more in positional commands, although in certain applications lower resolutions may be acceptable.

Figure 2 illustrates part of the control circuitry 400 associated with the light 300. A differential amplifier 401 whose inputs are connected to the two wires of the twisted pair signal cable 210 produces an output voltage whose waveform is the PWM pulse signal containing the commands for the light 300. This signal is applied to a timing signal generating circuit 402 which generates a clock signal used to identify each of the PWM pulses in the repeating series and to route them to corresponding decoding circuits. One such circuit is shown at 403 and is operative to convert one of the pulses in the series (say, the commanded tilt angle) to a DC voltage corresponding to the commanded value which is sampled and held to produce a DC level Vc which indicates the commanded value. This decoding may take place in any suitable fashion. For example, an analogue or quasi-analogue ramp may be started as the PWM signal crosses zero (or reaches some other preset value) going in one direction and by sampling and holding the value of the ramp when the PWM pulse crosses zero going in the other direction, a DC voltage corresponding to the demanded value can be derived. Alternatively, a digital code can be derived directly from the width-modulated pulse and converted to analogue by a D/A converter.

The voltage Vc is applied as a set point signal to the set point input of a servo circuit 404 which in the cases of the

pan and tilt angles operates as a position servo. A drive amplifier 405 applies to the pan or tilt motor 301/302 a DC drive voltage proportional to the difference between the set-point signal Vc and an error voltage signal Ve derived by analogue-to-digitally converting in D-to-A circuit 406 the output of a sensor reading an optical position encoder disk 303/304 (or other position detector such as a potentiometer) on the output shaft of the motor 301/302. The motor is thus operated to servo the pan or tilt angle, as appropriate, to the position commanded by the incoming PWM pulse from the computer 100.

The demultiplexing of the pulses in the incoming train may take place before or after each of the PWM pulses is converted to a DC voltage. Demultiplexing after conversion has the advantage of only requiring one PWM decoder; the succession of sampled and held levels can then be distributed across the various output channels by demultiplexing them via analogue switches operated by the timing circuit 402 to individual sample and hold circuits associated with each of the output channels.

Circuits such as 404 may be provided for each of the controllable analogue functions of the light 300 which it desired to control. Further, the light 300 may have one or more "digital" functions which only assume one of a finite

number of states (e.g. the opening or closing of shutters) or the position of a colour filter wheel, and PWM command pulses to control these states may be incorporated in the PWM pulse train. Other functions may be controlled in the same way; for example it may be desirable to have "calibration" commands which cause the light's various functions to be reset to a predetermined initial state (e.g. the pan and tilt angles are set to values at one or other end of the operating range.

The use of the PWM pulse train provides good noise immunity, avoids the need for local "intelligence" in the circuitry at each of the devices being controlled and complex two-way digital signalling protocols, and, perhaps most importantly, enables the commanded values of each of the controlled parameters of an individual light to be updated at a high rate.

The system above described, as well as overcoming the problem described above of existing systems has a number of advantages, including:-

1) The use of PWM enables a speed of response which can provide "instant" effects.

2) By avoiding have local intelligence at the controlled devices it avoids the need for error checking which slows the speed of transmission.

3) The speed of initialising the system is greatly reduced

-existing systems may take several minutes.

4) Interfacing with other apparatus is easy and they can be controlled in the same way by the software, using icons to represent them.

5) The reliability and flexibility of the system is increased, while the cost is decreased.

6) The intelligence of the system is provided by an industry-standard, widely available and supported computer.

7) Language problems on the part of the operator are largely avoided by the use of a graphical representation of the controlled environment and by the other facilities available in a computer windowing environment.

8) Interfacing with existing "off the shelf" controllers such as MIDI interfaces is easily carried out.

Although, in the above, the invention has been described with reference to the control of stage lighting it may, of course, be applied to a wide range of stage and other equipment, including cameras and stage effects equipment and sound equipment.

CLAIMS

1. A control system for controlling operation of a number of remote electrical devices, comprising a user-operable system controller for enabling a user to set operating variables of the remote devices, and generating corresponding control signals for each of the controlled devices, means for transmitting the control signals to the remote devices, and means associated with each of the remote devices for decoding the control signals received from the system controller and setting at least one operating variable of the associated device as commanded by the control signals, the system controller being operative to accept user-input setting the required value of the operating variable of one of the remote devices and a user-command which instructs the corresponding operating variable of at least one other remote device to be set to a value co-ordinated with that value, to calculate the required co-ordinated value of the operating variable of that other remote device or devices and to generate the corresponding command for that other remote device or devices.

2. A control system according to claim 1, wherein the system controller is operative to accept a user command designating the manner in which the operation of the at least one other device is to be co-ordinated with that of the one remote device.

3. A system according to claim 1 or 2 in which the remote devices comprise stage lighting or stage effects equipment, sound equipment and/or cameras.

4. A system according to claim 3 wherein the remote devices include devices for the control of the pan and/or tilt of two or more stage lights.

5. A system according to claim 4 wherein the stage lights include spot lights the system controller is arranged to accept commands from the user setting the position, or sequence of positions, required of one of the spotlights, to calculate and generate the corresponding command signals for that spotlight and transmit them to the spotlight, the

spotlight having control circuitry associated with it which decodes the commands and operates the spotlight accordingly.

6. A system according to claim 5 wherein the system controller is arranged to accept a command from the user as to the manner in which the operation of the second spotlight is to be co-ordinated with that of the first to direct the second spotlight at the same spot as the first spotlight or following the same path, to calculate the required value or sequence of pan and/or tilt of the second spotlight required to achieve the instructed co-ordination and to then generate and to transmit those commands to the second spotlight.

7. A control system for controlling the operation of one or more remotely located lighting, sound or other stage equipment comprising a user/operable system controller for user/setting operating variables of the remote equipment and for generating corresponding command signals to the control equipment, means for transmitting the control signals to the remote equipment, and means associated with the remote

equipment for decoding the command signals received from the system controller and setting at least one operating variable of the associated device accordingly, the required value of the operating variable being encoded for transmission as the pulse-width modulation of pulses in a train of pulses transmitted to the remote equipment.

8. A system according to claim 7 wherein there are a number of operating variables associated with a remote equipment and the system controller is operative to time-interleave the command signals for each variable for that remote equipment may be time-interleaved in a cyclical fashion, so that the pulse train transmitted comprises a cyclical succession of pulse-width modulated pulses representing commands for respective operating variables of that particular remote equipment.

9. A control system according to claim 7 or 8 wherein the system controller is arranged to enable a user to set operating variables of the remote equipment, and generating corresponding control signals for each of the controlled

equipment, means for transmitting the control signals to the remote equipment, and means associated with each of the remote equipment for decoding the control signals received from the system controller and setting at least one operating variable of the associated equipment as commanded by the control signals, the system controller being operative to accept user-input setting the required value of the operating variable of one of the remote equipment and a user-command which instructs the corresponding operating variable of at least one other remote equipment to be set to a value co-ordinated with that value, to calculate the required co-ordinated value of the operating variable of that other remote equipment and to generate the corresponding command for that other remote equipment.

10. A control system according to claim 1, wherein the system controller is operative to accept a user command designating the manner in which the operation of the at least one other equipment is to be co-ordinated with that of the one remote equipment.

11. A system according to claim 1 or 2 in which the remote equipment comprise stage lighting or stage effects equipment, sound equipment and/or cameras.

12. A system according to claim 3 wherein the remote equipment includes equipment for the control of the pan and/or tilt of two or more stage lights.

13. A system according to claim 4 wherein the stage lights include spot lights the system controller is arranged to accept commands from the user setting the position, or sequence of positions, required of one of the spotlights, to calculate and generate the corresponding command signals for that spotlight and transmit them to the spotlight, the spotlight having control circuitry associated with it which decodes the commands and operates the spotlight accordingly.

14. A system according to claim 5 wherein the system controller is arranged to accept a command from the user as to the manner in which the operation of the second spotlight

is to be co-ordinated with that of the first to direct the second spotlight at the same spot as the first spotlight or following the same path, to calculate the required value or sequence of pan and/or tilt of the second spotlight required to achieve the instructed co-ordination and to then generate and to transmit those commands to the second spotlight.

15. A control system according to any one of claim 2 to 6 or any one of claims 10 to 15 wherein the system controller has associated with it a display for displaying a visual representation of a stage area and equipment or devices to be controlled.

16. A control system constructed and arranged to operate substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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(54) Digital imaging apparatus

(57) A digital imaging apparatus (110) is disclosed including: a light source module (240); and a light source controller (230) for receiving an image control signal and setting a radiation pattern of the light source module (240) to be corresponding to the image control signal.

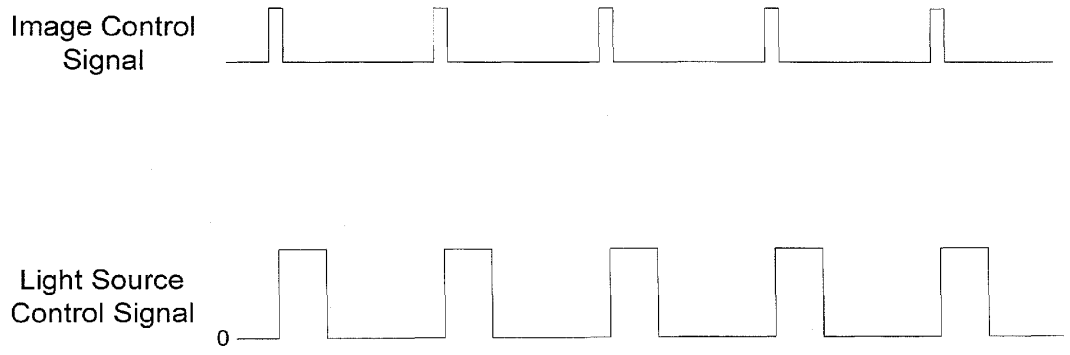


FIG. 3

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Description

[0001] The present disclosure generally relates to a digital imaging apparatus according to the pre-characterizing clause of claim 1.

[0002] Digital imaging technologies are widely applied in various applications, such as digital still cameras, digital video recorders, digital microscopic measurements, image object recognization operations, or the like.

[0003] Image quality is greatly influenced by the digital imaging performance, especially for the image of object details. Poor lighting conditions usually result in image defects such as images with insufficient brightness or contrast. In addition, relative movement between the digital imaging device and a target object could also easily cause motion blur or related problems. These situations often lead to adverse effect to the image quality of object details.

[0004] Clear image of object details, however, is crucial to many applications, such as digital microscopic photography, microscopic measurements, image recognization operations, auto-inspection systems, or the like. It may easily cause erroneous results in subsequent processes or judgments if the clearness of image details is insufficient or the image details are blurred, thereby reducing the system performance and reliability.

[0005] This in mind, the present invention aims at providing a digital imaging apparatus that improves the image quality of the details of the sensed image, thereby increasing the accuracy and imaging reliability.

[0006] This is achieved by a digital imaging apparatus according to claim 1. The dependent claims pertain to corresponding further developments and improvements.

[0007] As will be seen more clearly from the detailed description following below, the claimed digital imaging apparatus includes a light source controller that is coupled with a light source module for receiving an image control signal and setting a radiation pattern of the light source module to be corresponding to the image control signal.

[0008] In the following, the invention is further illustrated by way of example, taking reference to the accompanying drawings. Thereof

[0009] Fig. 1 is a simplified functional block diagram of an object inspection system in accordance with an exemplary embodiment,

[0010] Fig. 2 is a simplified functional block diagram of a digital imaging apparatus in accordance with an exemplary embodiment, and

[0011] Fig. 3 through Fig. 5 are simplified schematic diagrams of light source control signals generated by a light source controller of Fig. 2.

[0012] Reference will now be made in detail to exemplary embodiments of the invention, which are illustrated in the accompanying drawings. The same reference numbers may be used throughout the drawings to refer to the same or like parts or operations.

[0013] Certain terms are used throughout the description and following claims to refer to particular components. As one skilled in the art will appreciate, vendors may refer to a component by different names. This document does not intend to distinguish between components that differ in name but not in function. In the following description and in the claims, the terms "include" and "comprise" are used in an open-ended fashion, and thus should be interpreted to mean "include, but not limited to ...." Also, the phrase "coupled with" is intended to compass any indirect or direct connection. Accordingly, if this document mentioned that a first device is coupled with a second device, it means that the first device may be directly connected to the second device (including through an electrical connection or other signal connections, such as wireless communications or optical communications), or indirectly connected to the second device through an indirect electrical connection or signal connection via other intermediate device or connection means.

[0014] Fig. 1 shows a simplified functional block diagram of an object inspection system 100 in accordance with an exemplary embodiment. As shown in Fig. 1, the object inspection system 100 comprises a digital imaging apparatus 110, a host device 120, a display 130, and a supporting device 140. The digital imaging apparatus 110 and the display 130 are coupled with the host device 120. In this embodiment, the host device 120 comprises a processor 122 and a storage module 124, wherein the storage module 124 may be used for storing computer programs and image data required for the operations of the object inspection system 100.

[0015] The digital imaging apparatus 110 may be implemented with a digital camera, digital video recorder, digital microscope, and any other apparatus with image sensing capability. The operations of the digital imaging apparatus 110 will be described further in the following.

[0016] Fig. 2 is a simplified functional block diagram of the digital imaging apparatus 110 in accordance with an exemplary embodiment. In this embodiment, the digital imaging apparatus 110 comprises a control circuit 210, an image sensing circuit 220, a light source controller 230, and a built-in light source module 240. As shown, the image sensing circuit 220 and the light source controller 230 are coupled with the control circuit 210, and the built-in light source module 240 is coupled with the light source controller 230.

[0017] In operations, the control circuit 210 is coupled with the host device 120 through a predetermined transmission interface, such as USB or IEEE 1394, and receives electricity required for the operations of the digital imaging apparatus 110 from the host device 120. In one embodiment, the built-in light source module 240 of the digital imaging apparatus 110 may be implemented with LED devices to reduce required power consumption.

[0018] The image sensing circuit 220 may comprise one or more CMOS (Complementary Metal Oxide Semiconductor) sensors, CCD (Charge Coupled Device) sensors, CMOS/CCD hybrid sensors, CID (Charge Injection Device) sensors, or other optical sensing components,

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for sensing images of a target object 102 positioned on the supporting device 140 to generate corresponding image signals. In operations, the image sensing circuit 220 also generates image synchronization signals, such as frame synchronization signals, V-sync signals, and/or H-sync signals. The image sensing circuit 220 transmits the generated image synchronization signals together with the object image signals to the control circuit 210.

[0019] As described previously, poor lighting conditions during the operations of the digital imaging apparatus 110 or relative movement between the digital imaging apparatus 110 and the target object 102 could adversely affect the quality of resulting image of the target object 102, especially for the object details. For example, the object inspection system 100 may encounter slight vibrations due to some environmental factors, such as vibration generated by the operation of mechanical components during the transportation of target objects conducted by the supporting device 140. Such vibration would cause relative movement between the digital imaging apparatus 110 and the target object 102 when the digital imaging apparatus 110 is sensing images of the target object 102.

[0020] In order to improve the imaging quality of the digital imaging apparatus 110, the image sensing circuit 220 of one embodiment generates and transmits an image control signal to the light source controller 230 during the image sensing operations. The image control signal is utilized for indicating the time points or period of an image acquisition operation conducted by the image sensing circuit 220, and is not the ordinary clock signal employed for the operations of the light source controller 230. In implementations, the image control signal may be implemented with the aforementioned image synchronization signal, such as the frame synchronization signal, V-sync signal, or H-sync signal. Alternatively, the image control signal may be implemented with a signal synchronized with the image synchronization signal and having a frequency that is multiple times of the frequency of the image synchronization signal.

[0021] When receives the image control signal generated by the image sensing circuit 220, the light source controller 230 generates a light source control signal having a frequency corresponding to that of the image control signal to control the radiation pattern of the light source module 240. In one embodiment, as shown in Fig. 3, the light source controller 230 generates a light source control signal synchronized with the image control signal and having the same frequency as the image control signal.

[0022] In the embodiment shown in Fig. 3, the light source module 240 illuminates when triggered by the edges of the light source control signal. If the image control signal is implemented with the frame synchronization signal or V-sync signal, then the light source module 240 would thus have a lighting frequency the same as the image acquisition frequency of the image sensing circuit 220, and only radiate during the image acquisition operation conducted by the image sensing circuit 220.

[0023] In another embodiment, as shown in Fig. 4, the light source controller 230 generates a light source control signal synchronized with the image control signal and having the same frequency as the image control signal. A difference between this embodiment and the previous embodiment of Fig. 3 is that in the embodiment of Fig. 4 the light source controller 230 maintains the light source control signal at a predetermined active level (such as a first predetermined voltage) or above. However, when the light source controller 230 is triggered by the edges of the image control signal, the light source controller 230 pulls up the pulse level of the light source control signal (e.g., pulls it up to a second predetermined voltage), or increases the pulse width of the light source control signal. As a result, the light source module 240 illuminates continuously, but enhances the intensity of light output when triggered by the edges of the image control signal. For example, the light source controller 230 may apply an overshot voltage to the light source control signal to pull up the pulse level (or to increase the pulse width) of the light source control signal at each time the light source controller 230 is triggered by the edge of the image control signal.

[0024] Thus, if the image control signal is implemented with the frame synchronization signal or V-sync signal, then the light source module 240 outputs more beams to illuminate the target object 102 during the image acquisition operation conducted by the image sensing circuit 220.

[0025] In another embodiment, as shown in Fig. 5, the light source controller 230 generates a light source control signal synchronized with the image control signal and having a frequency that is an integer times of the frequency of the image control signal. If the image control signal is implemented with the frame synchronization signal or V-sync signal, the then lighting frequency of the light source module 240 would be the integer times of the image acquisition frequency of the image sensing circuit 220. Accordingly, each time the image sensing circuit 220 conducts the image acquisition operation, the light source module 240 would correspondingly output beams to illuminate the target object 102.

[0026] In another embodiment, the image control signal is implemented with the H-sync signal, and the light source controller 230 generates a light source control signal synchronized with the H-sync signal and having a frequency less than that of the H-sync signal. For example, the light source controller 230 may generate a light source control signal synchronized with the H-sync signal and having a frequency the same as the V-sync signal or the frame synchronization signal. By this way, the lighting frequency of the light source module 240 would become the same as the image acquisition frequency of the image sensing circuit 220. Therefore, the light source module 240 radiates to illuminate the target object 102 during the image acquisition operation conducted by the image sensing circuit 220.

[0027] In some of the foregoing embodiments, the light

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source control signal generated by the light source controller 230 has a duty cycle less than 100%, so the light source module 240 would illuminate only when triggered by the edges of the light source control signal but would not keep illuminating all the time. Power required for the operations of the digital imaging apparatus 110 can be thus reduced.

[0028] In implementations, the image control signal generated by the imaging sensing circuit 220 may have a frequency lower than that of the image synchronization signal. In one embodiment, for example, the image control signal generated by the imaging sensing circuit 220 is half of that of the image synchronization signal. Under this situation, the light source controller 230 may generate a light source control signal having a frequency that is twice of that of the image control signal so that the generated light source control signal is synchronized with the image acquisition operation conducted by the image sensing circuit 220.

[0029] In previous embodiments, the image control signal is generated by the image sensing circuit 220. This is merely an example and not intend to restrict the practical implementations of the digital imaging apparatus 110. For example, the image control signal may be instead generated by the control circuit 210 and then transmitted to the light source controller 230. In one embodiment, the control circuit 210 may utilize the frame synchronization signal or V-sync signal transmitted from the image sensing circuit 220 to be an image control signal and then transmit it to the light source controller 230. In another embodiment, the control circuit 210 may first upconvert or downconvert the frequency of the frame synchronization signal or V-sync signal transmitted from the image sensing circuit 220, and utilize the frequency upconverted or down-converted signal to be an image control signal and then transmit it to the light source controller 230. In yet another embodiment, the control circuit 210 first down-converts the frequency of the H-sync signal transmitted from the image sensing circuit 220, utilizes the frequency down-converted signal to be an image control signal, and then transmits it to the light source controller 230.

[0030] The way the light source controller 230 generates a light source control signal according to the image control signal generated by the control circuit 210 to control the radiation pattern of the light source module 240 is similar to the previously described embodiments. For the sake of brevity, similar descriptions will not be repeated here.

[0031] From one aspect of the circuitry functions, the aforementioned image sensing circuit 220 or control circuit 210 can be regarded as an image synchronization signal generator for generating an image synchronization signal.

[0032] As illustrated in the foregoing embodiments, the light source controller 230 controls the radiation pattern of the light source module 240 according to the image control signal or image synchronization signal generated from the image sensing circuit 220 or control circuit 210, so that the light source module 240 either illuminates only during the image acquisition operation conducted by the image sensing circuit 220 or enhances the intensity of light output during the image acquisition operation conducted by the image sensing circuit 220. This approach offers a sufficient lighting condition for the image sensing circuit 220 during the image acquisition operation so as to mitigate or avoid the imaging problems such as dark images or insufficient contrast.

[0033] As a result, the time of exposure required for the image acquisition operation of the image sensing circuit 220 can be shortened, thereby significantly mitigating the adverse effect to the image quality caused by the relative movement between the digital imaging apparatus 110 and the target object 102. Thus, the digital imaging quality for both still images and real-time dynamic images can be greatly improved by using the approaches disclosed above.

[0034] In implementations, the flicker of the light source module 240 will not be sensed by human eyes if the light source controller 230 controls the light source module 240 to have a lighting frequency of 60 Hz or above.

[0035] The control circuit 210 then transmits the image signals corresponding to the target object 102 generated by the image sensing circuit 220 to the host device 120. The processor 122 of the host device 120 conducts image recognization operations, image measurements, image analyzing operations, or other subsequent processes on part of or the entire sensed image to determine whether the target object 102 complies with predetermined quality control requirements. Since the digital imaging apparatus 110 described above is capable of greatly improving the image quality of the details of the sensed image, mistakes that may be made by the processor 122 in processing or determining the images can be effectively reduced, thereby increasing the accuracy and reliability of the object inspection system 100.

[0036] The processor 122 may also display the images sensed by the digital imaging apparatus 110 or image inspection results generated by the processor 122 on the display 130, so that a quality control operator can monitor the quality inspection procedure or related image analysis parameters for the target object 102. When the inspection for the target object 102 is complete, the processor 122 instructs the supporting device 140 to move to or switch to a next target object to be inspected so as to repeat the aforementioned operations. In some embodiments where the object inspection system 100 is designed to operate automatically, the display 130 may be omitted.

[0037] In the foregoing descriptions, the implementations of the digital imaging apparatus 110 are described as employed in the object inspection system 100. However, such descriptions are exemplary only and shall in no way be interpreted to limit the applications of the present invention. The disclosed digital imaging appara-

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tus 110 has practical applications in many fields including, but not limited to, automotive applications, medicine-related applications, industrial applications, educational applications, and personal hobby applications.

[0038] In addition, when the digital imaging apparatus 110 is used in hand-held fashion, the way the light source controller 230 controls the radiation pattern of the light source module 240 described previously effectively mitigates or reduces the adverse effect to the imaging quality of the digital imaging apparatus 110 caused by hand vibration or movement, thereby achieving better hand vibration proof effect.

[0039] For completeness, various aspects of the invention are set out in the following numbered clauses:

[0040] 1. A digital imaging apparatus comprising:

a light source module;
an image synchronization signal generator for generating an image synchronization signal; and
a light source controller, coupled with the light source module and the image synchronization signal generator, for generating a light source control signal having a frequency corresponding to the image synchronization signal and synchronized with the image synchronization signal to control the light output of the light source module.

[0041] 2. The digital imaging apparatus of clause 1, wherein the image synchronization signal comprises a frame synchronization signal, a vertical synchronization signal, or a horizontal synchronization signal.

[0042] 3. The digital imaging apparatus of clause 2, wherein the light source control signal and the image synchronization signal have the same frequency.

[0043] 4. The digital imaging apparatus of clause 2, wherein a frequency of the light source control signal is multiple times of that of the image synchronization signal.

[0044] 5. The digital imaging apparatus of clause 2, wherein a frequency of the image synchronization signal is multiple times of that of the light source control signal.

[0045] 6. The digital imaging apparatus of clause 1, wherein the image synchronization signal generator comprises an image sensing circuit for sensing images of a target object.

[0046] 7. The digital imaging apparatus of clause 1, wherein the image synchronization signal generator comprises a control circuit and the control circuit receives electricity required for the operations of the digital imaging apparatus from an external device.

[0047] 8. The digital imaging apparatus of clause 1, wherein the light source controller pull up the pulse level of the light source control signal or increases the pulse width of the light source control signal when triggered by an edge of the image synchronization signal.

[0048] 9. A digital imaging apparatus comprising:

a light source module; and
a light source controller for receiving an image control signal and setting a radiation pattern of the light source module to be corresponding to the image control signal.

[0049] 10. The digital imaging apparatus of clause 9, wherein the light source controller sets a lighting frequency of the light source module to be substantially the same as the frequency of the image control signal.

[0050] 11. The digital imaging apparatus of clause 9, wherein the light source controller sets a lighting frequency of the light source module to be a multiple times of the frequency of the image control signal.

[0051] 12. The digital imaging apparatus of clause 9, wherein the light source controller sets a lighting frequency of the light source module so that the frequency of the image control signal is a multiple times of the lighting frequency of the light source module.

[0052] 13. The digital imaging apparatus of clause 9, further comprising:

an image sensing circuit for generating the image control signal, wherein the image control signal corresponds to the time points or period of an image acquisition operation conducted by the image sensing circuit.

[0053] 14. The digital imaging apparatus of clause 9, further comprising:

a control circuit for generating the image control signal and receiving electricity required for the operations of the digital imaging apparatus from an external device.

[0054] 15. The digital imaging apparatus of clause 9, wherein the image control signal corresponds to the time points or period of an image acquisition operation conducted by an image sensing circuit, and the light source controller controls the light source to illuminate or to enhance the intensity of light output during the image acquisition operation conducted by the image sensing circuit.

[0055] 16. An object inspection system comprising:

a supporting device for supporting a target object;
an image sensing circuit for sensing images of the target object and generating an image synchronization signal;
a host device coupled with the image sensing circuit for conducting image processing operations on part of or the entire image sensed by the image sensing circuit;
a light source module;
a light source controller, coupled with the image sensing circuit and the light source module, for generating a light source control signal having a duty circle less than 100% according to the image synchronization signal to control the light output of the

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light source module; and
a control circuit for receiving electricity required for the operations of the image sensing circuit, the light source module, and the light source controller from the host device.

[0056] 17. The object inspection system of clause 16, wherein the light source controller controls the light source module to illuminate during the image acquisition operation conducted by the image sensing circuit.
[0057] 18. The object inspection system of clause 16, wherein the light source controller controls the light source module to enhance the intensity of light output during the image acquisition operation conducted by the image sensing circuit.
[0058] 19. The object inspection system of clause 16, wherein the light source control signal is synchronized with the image acquisition operation conducted by the image sensing circuit.
[0059] 20. The object inspection system of clause 19, wherein the light source control signal has a frequency corresponding to an image acquisition frequency of the image sensing circuit.
[0060] All combinations and sub-combinations of the above-described features also belong to the invention.

Claims

1. A digital imaging apparatus (110) comprising:

   a light source module (240); and

   characterised by:

   a light source controller (230) for receiving an image control signal and setting a radiation pattern of the light source module (240) to be corresponding to the image control signal.

2. The digital imaging apparatus (110) of claim 1, **characterised in that** the light source controller (230) sets a lighting frequency of the light source module (240) to be substantially the same as the frequency of the image control signal.

3. The digital imaging apparatus (110) of claim 1, **characterised in that** the light source controller (230) sets a lighting frequency of the light source module (240) to be a multiple times of the frequency of the image control signal.

4. The digital imaging apparatus (110) of claim 1, **characterised in that** the light source controller (230) sets a lighting frequency of the light source module (240) so that the frequency of the image control signal is a multiple times of the lighting frequency of the light source module.

5. The digital imaging apparatus (110) of claim 1, **characterised by**:

   an image sensing circuit (220) for generating the image control signal, wherein the image control signal corresponds to the time points or period of an image acquisition operation conducted by the image sensing circuit (220).

6. The digital imaging apparatus (110) of claim 1, **characterised by**:

   a control circuit (210) for generating the image control signal and receiving electricity required for the operations of the digital imaging apparatus (110) from an external device (120).

7. The digital imaging apparatus (110) of claim 1, **characterised in that** the image control signal corresponds to the time points or period of an image acquisition operation conducted by an image sensing circuit (220), and the light source controller (230) controls the light source to illuminate or to enhance the intensity of light output during the image acquisition operation conducted by the image sensing circuit (220).

8. The digital imaging apparatus (110) of claim 1, **characterised in that** the image control signal comprises a frame synchronization signal, a vertical synchronization signal, or a horizontal synchronization signal.

9. The digital imaging apparatus (110) of claim 1, 2, 3, 4, 5, 6, 7, or 8, **characterised in that** the light source controller (230) generates a light source control signal having a frequency corresponding to the image control signal and synchronized with the image control signal to control the light output of the light source module (240).

10. The digital imaging apparatus (110) of claim 9, **characterised in that** the light source control signal and the image control signal have the same frequency.

11. The digital imaging apparatus (110) of claim 9, **characterised in that** a frequency of the light source control signal is multiple times of that of the image control signal.

12. The digital imaging apparatus (110) of claim 9, **characterised in that** a frequency of the image control signal is multiple times of that of the light source control signal.

13. The digital imaging apparatus (110) of claim 9, **characterised in that** the light source controller (230) pulls up the pulse level of the light source control

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signal or increases the pulse width of the light source control signal when triggered by an edge of the image control signal.

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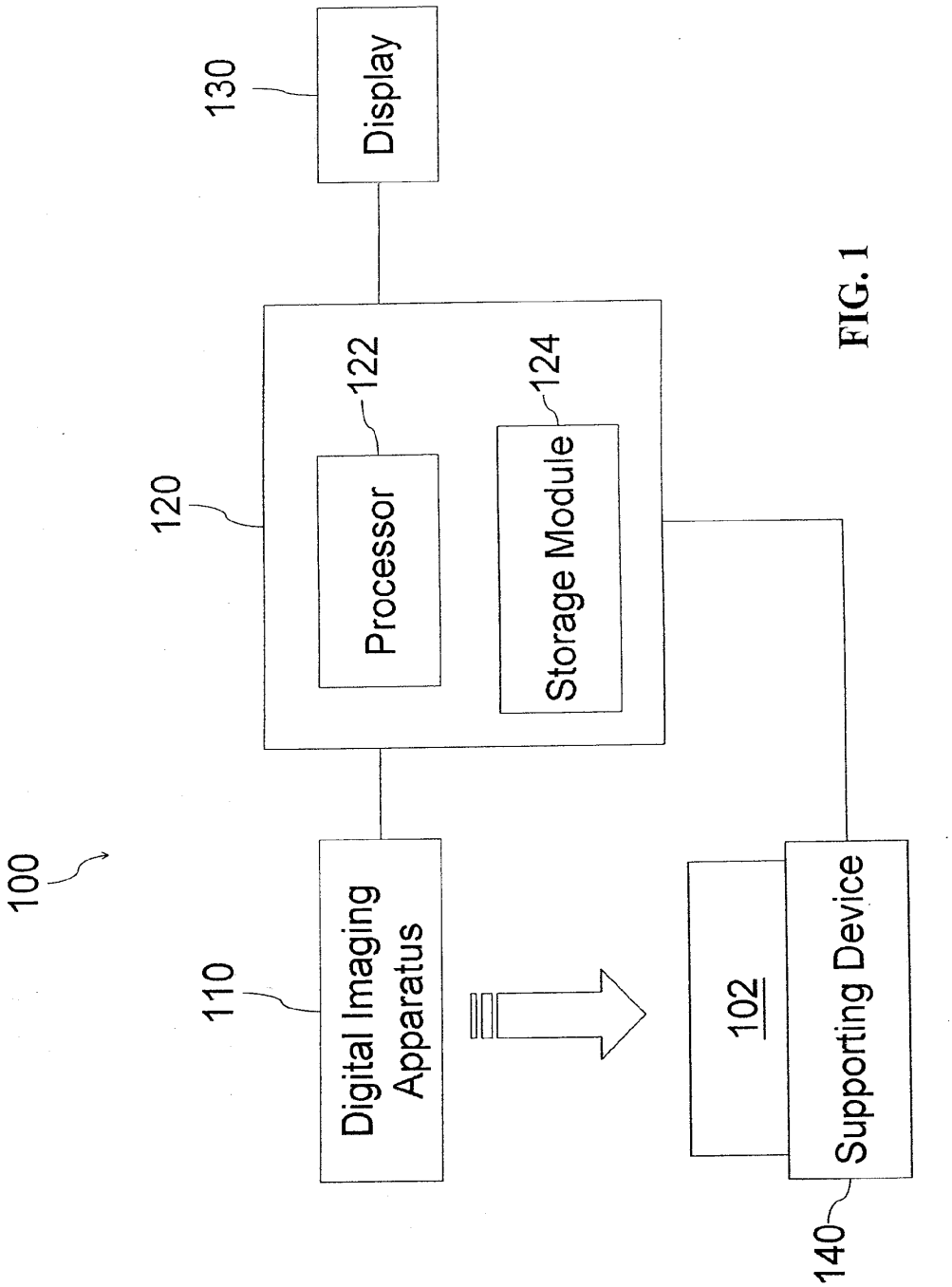


FIG. 1

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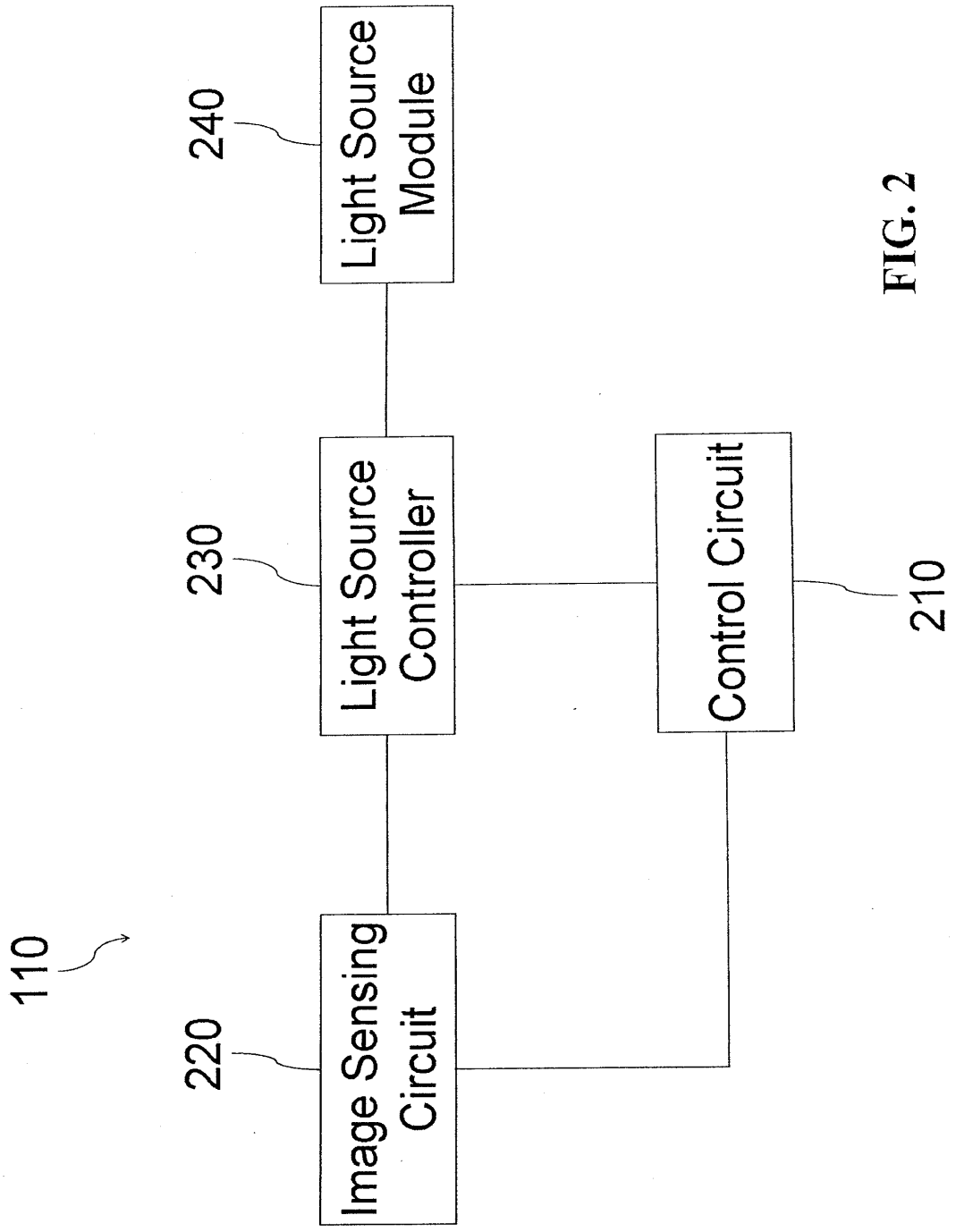


FIG. 2

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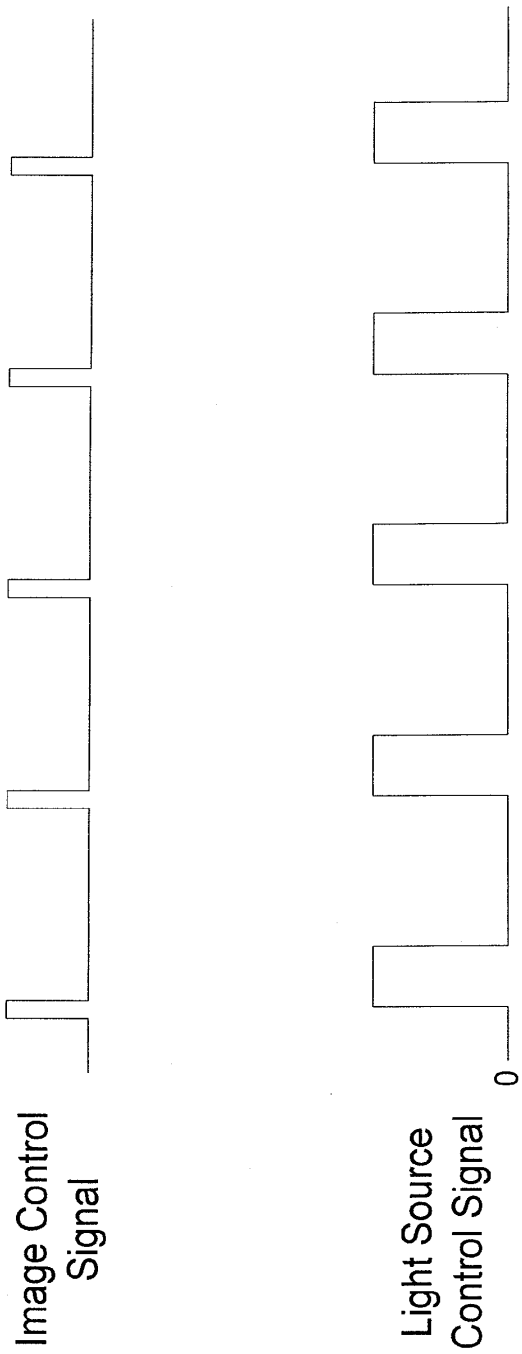


FIG. 3

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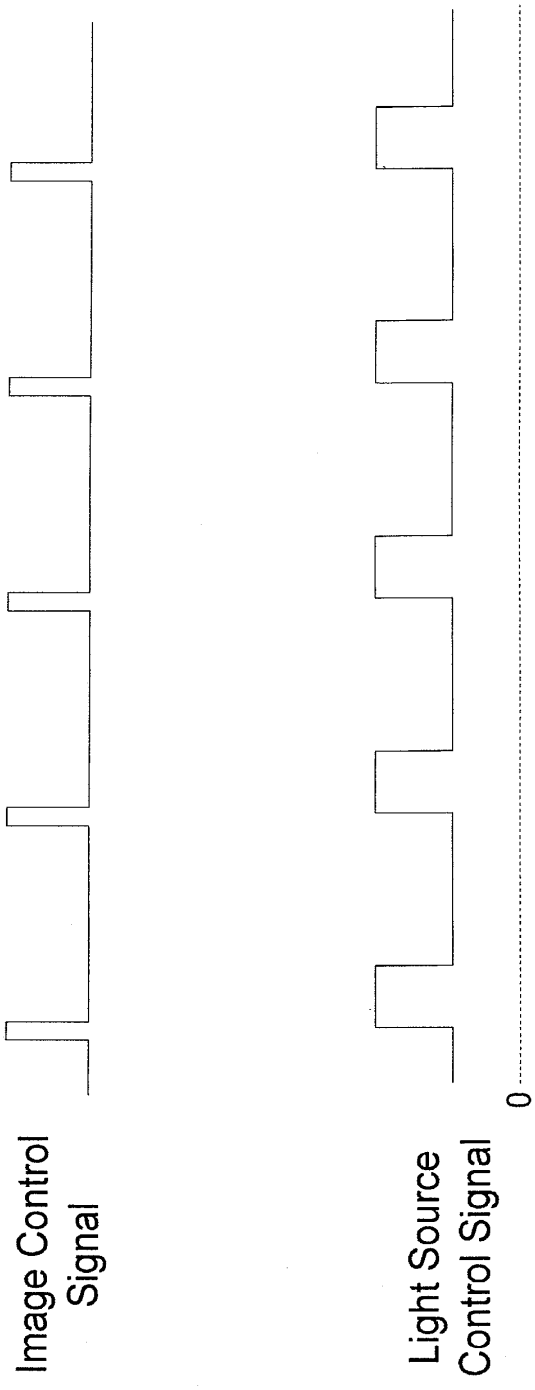


FIG. 4

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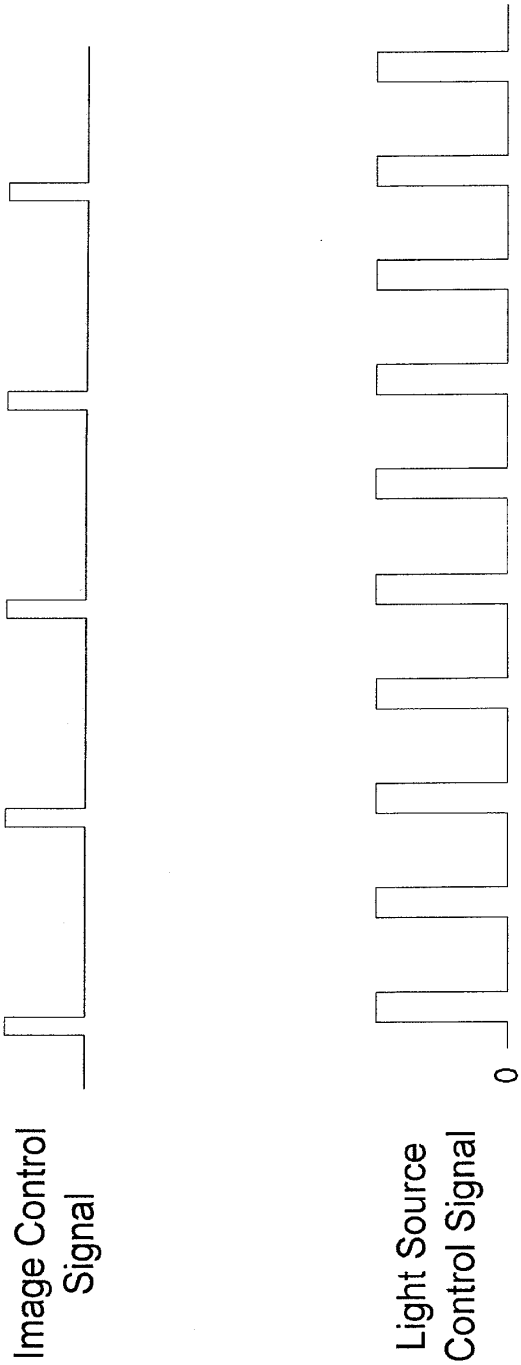


FIG. 5

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Europäisches Patentamt
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EUROPEAN SEARCH REPORT

Application Number
EP 10 17 8318

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP 2003 348463 A (SONY CORP) 5 December 2003 (2003-12-05) * abstract * * figures 1-7 * * paragraph [0063] - paragraph [0113] *	1-3,5,6, 8-11	INV. G03B15/05 H04N5/225
X	US 7 126 640 B1 (TAKEI HIROFUMI [JP]) 24 October 2006 (2006-10-24) * column 7, line 1 - column 9, line 2 * * figure 7 *	1-3, 8-10,13	
X	US 2005/231633 A1 (YUYAMA MASAMI [JP] ET AL) 20 October 2005 (2005-10-20) * paragraph [0016] * * paragraph [0044] - paragraph [0061] * * figures 1,3,8 *	1-12	
			TECHNICAL FIELDS SEARCHED (IPC) G03B H04N H05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	24 March 2011	Breccia, Luca

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 10 17 8318

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

24-03-2011

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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H05B 33/08 (2006.01) G08B 15/00 (2006.01)

(52) UK CL (Edition X):
H2H HLL3

(56) Documents Cited:
GB 2398862 A GB 2398860 A
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(58) Field of Search:
UK CL (Edition X) H2H
INT CL G08B, H05B
Other: WPI, EPODOC

(54) Abstract Title: **Television simulating system**

(57) A television simulating device 1 comprises an array of eight blue light emitting diodes (LEDs) 5 on an LED mounting 2. The LEDs 5 are controlled by an LED control circuit (11, see figure 7) to flash or pulsate in a random fashion to simulate the lighting effect of television. A timer 3 is coupled with a transformer 4. A method of deterring intruders by providing such a television simulating device 1 in a room in a building is also disclosed.

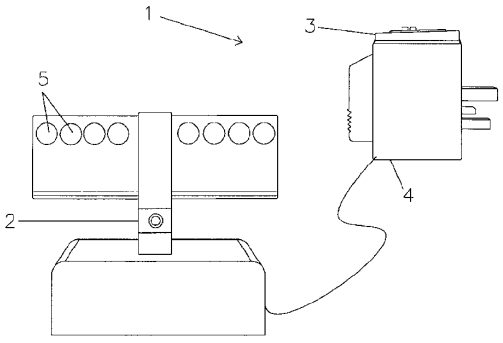


FIGURE 1

GB 2 424 525 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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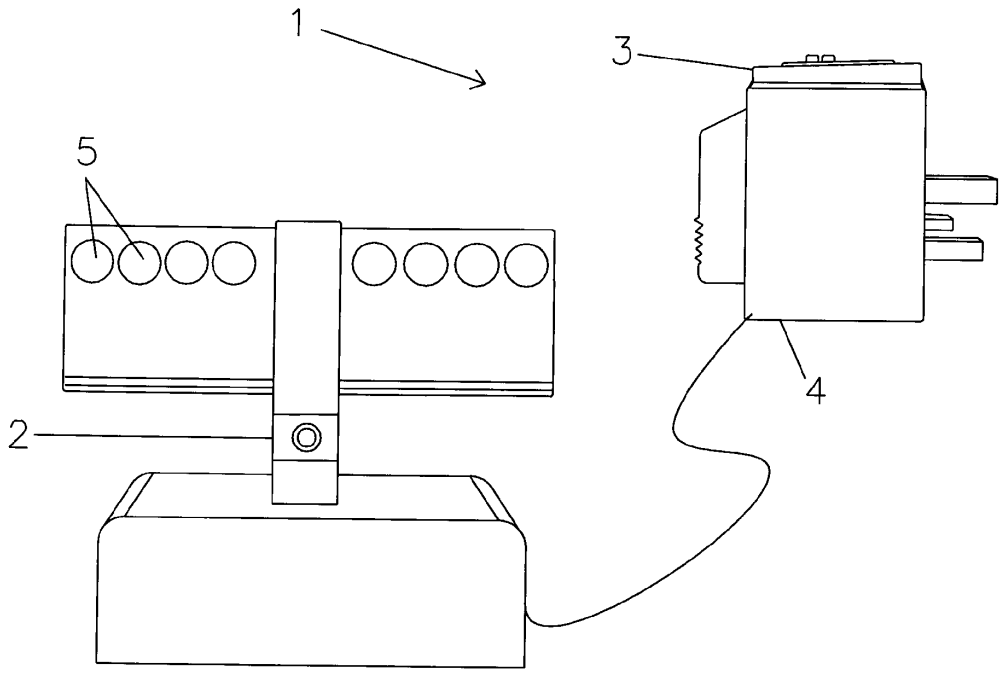


FIGURE 1

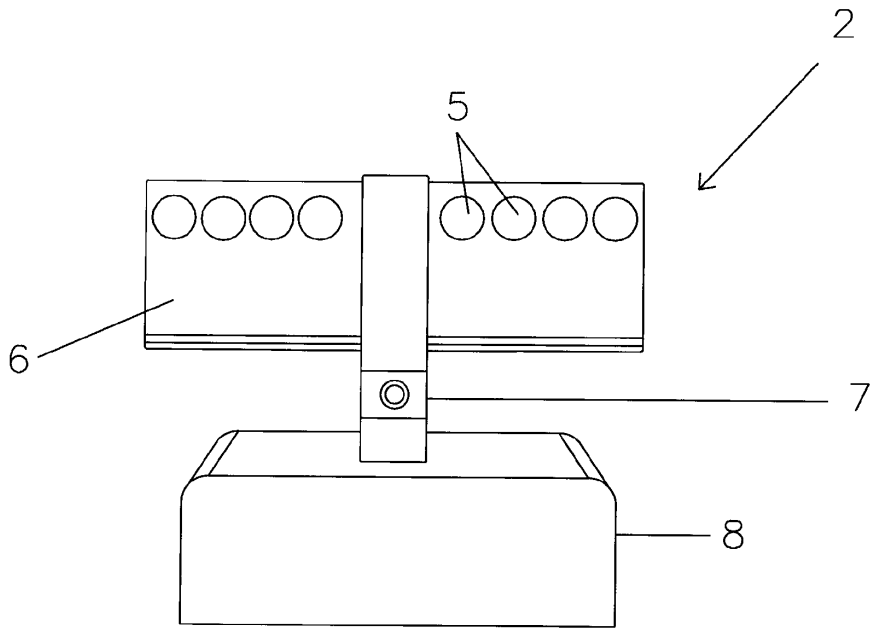


FIGURE 2

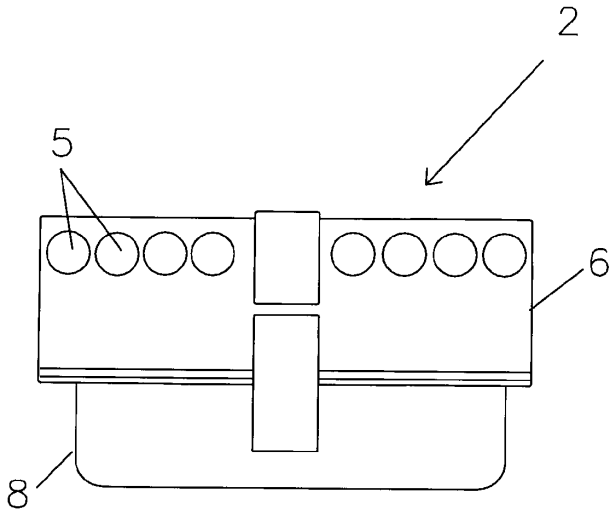


FIGURE 3

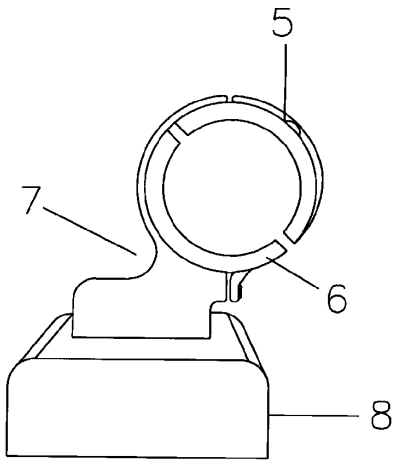


FIGURE 4

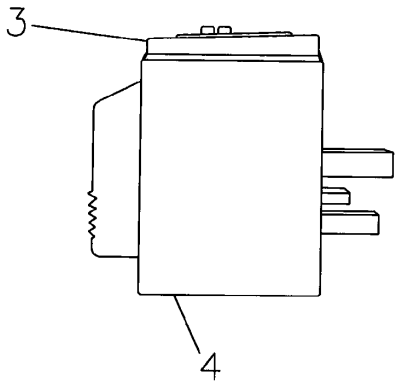


FIGURE 5

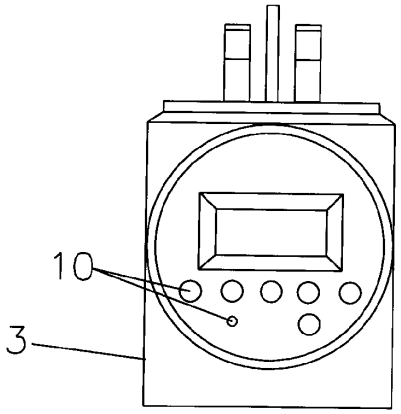


FIGURE 6

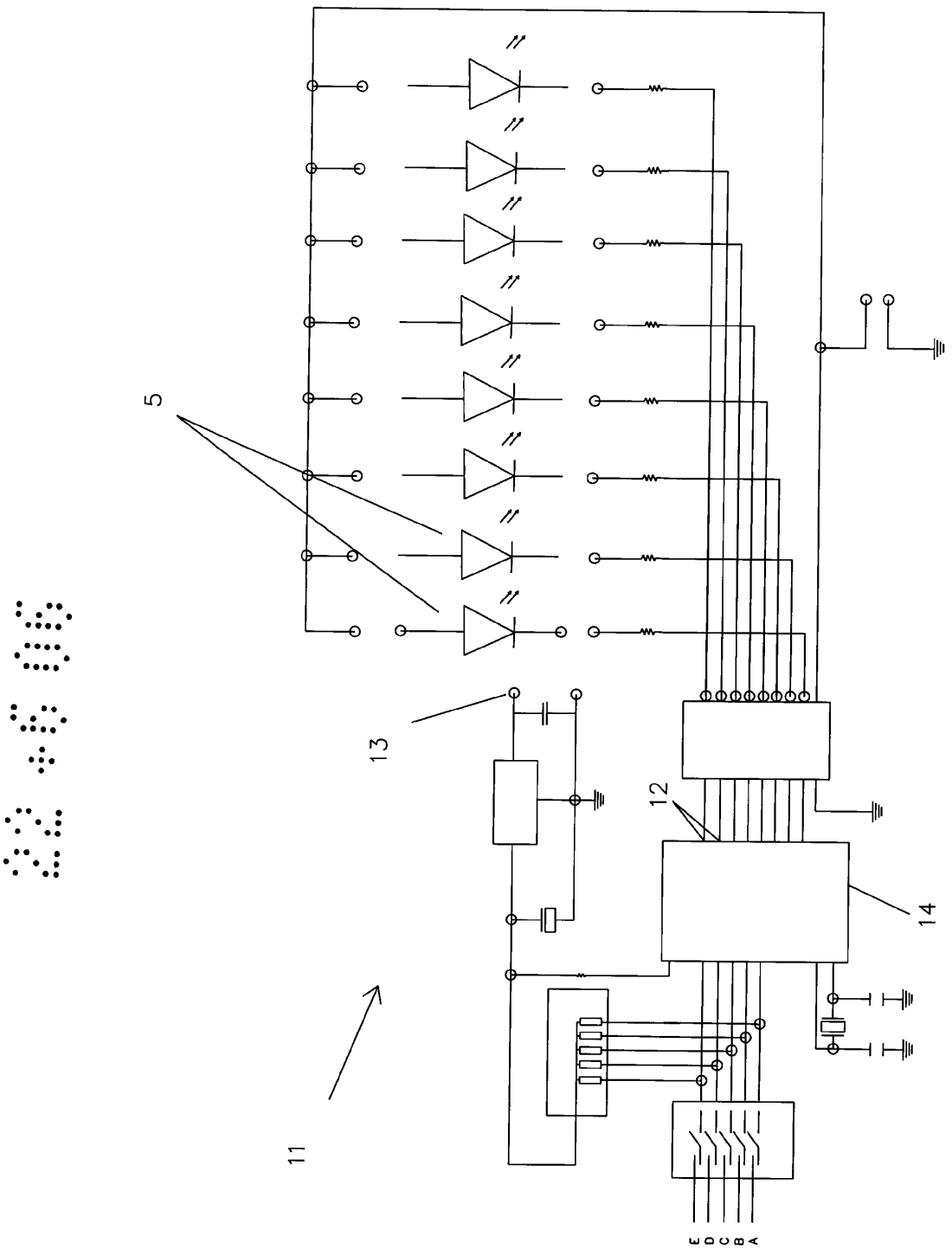


FIGURE 7

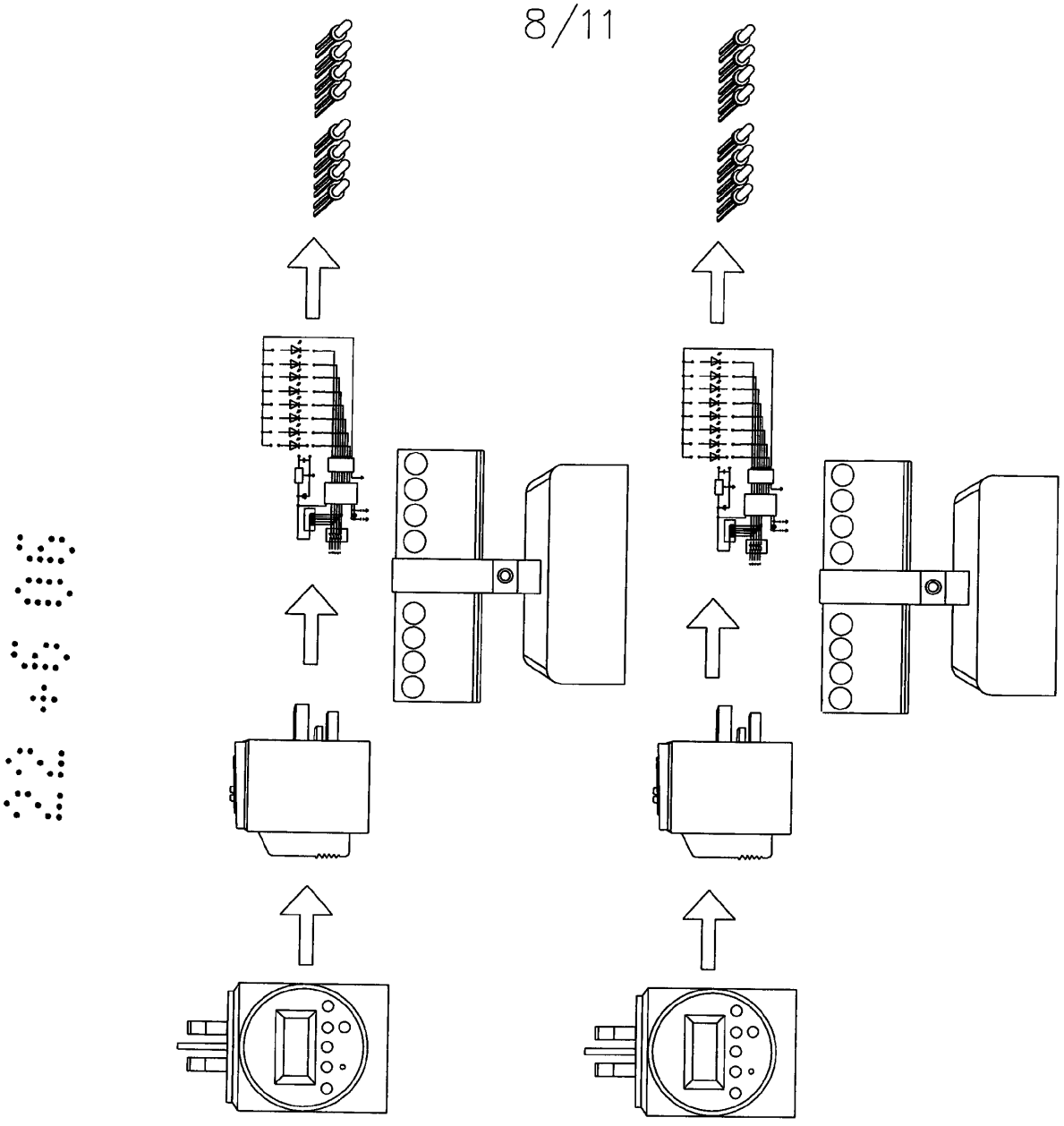


FIGURE 8

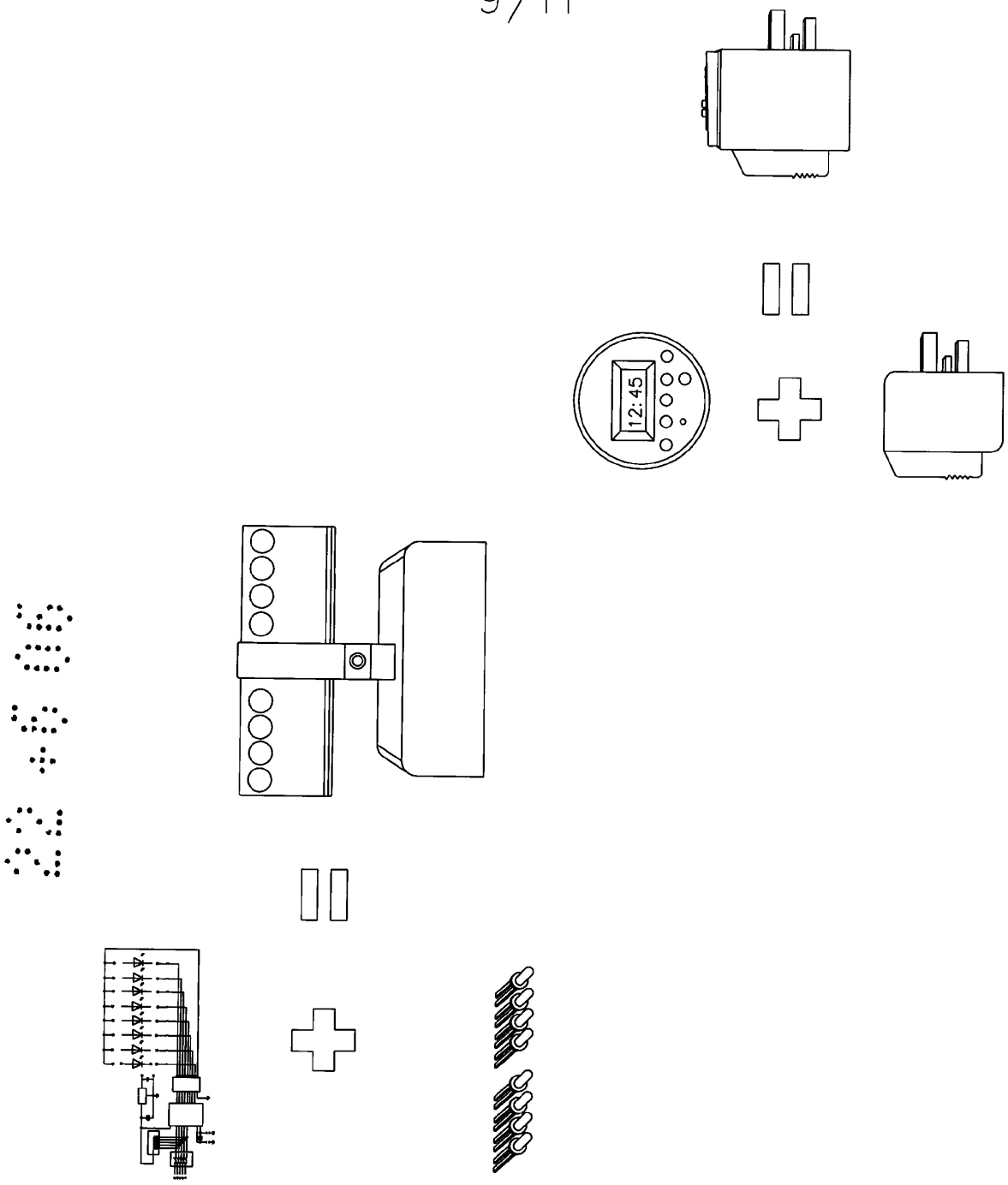


FIGURE 9

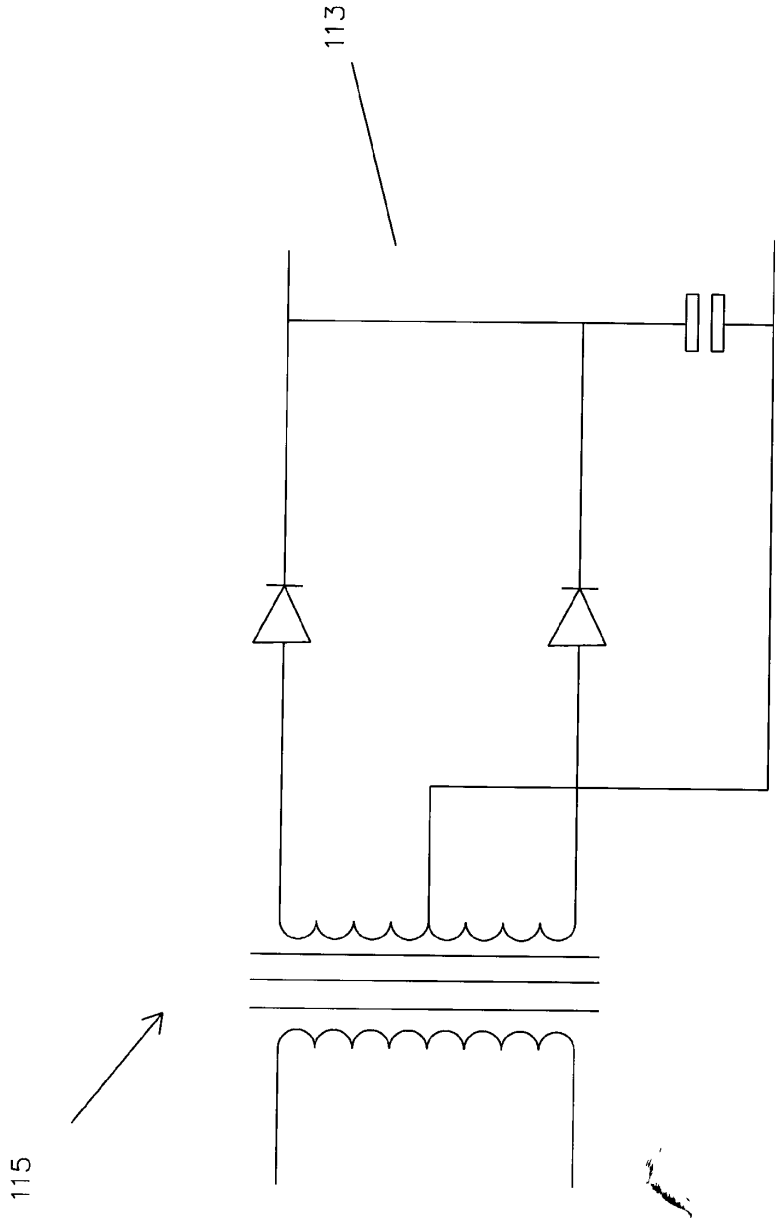


FIGURE 10

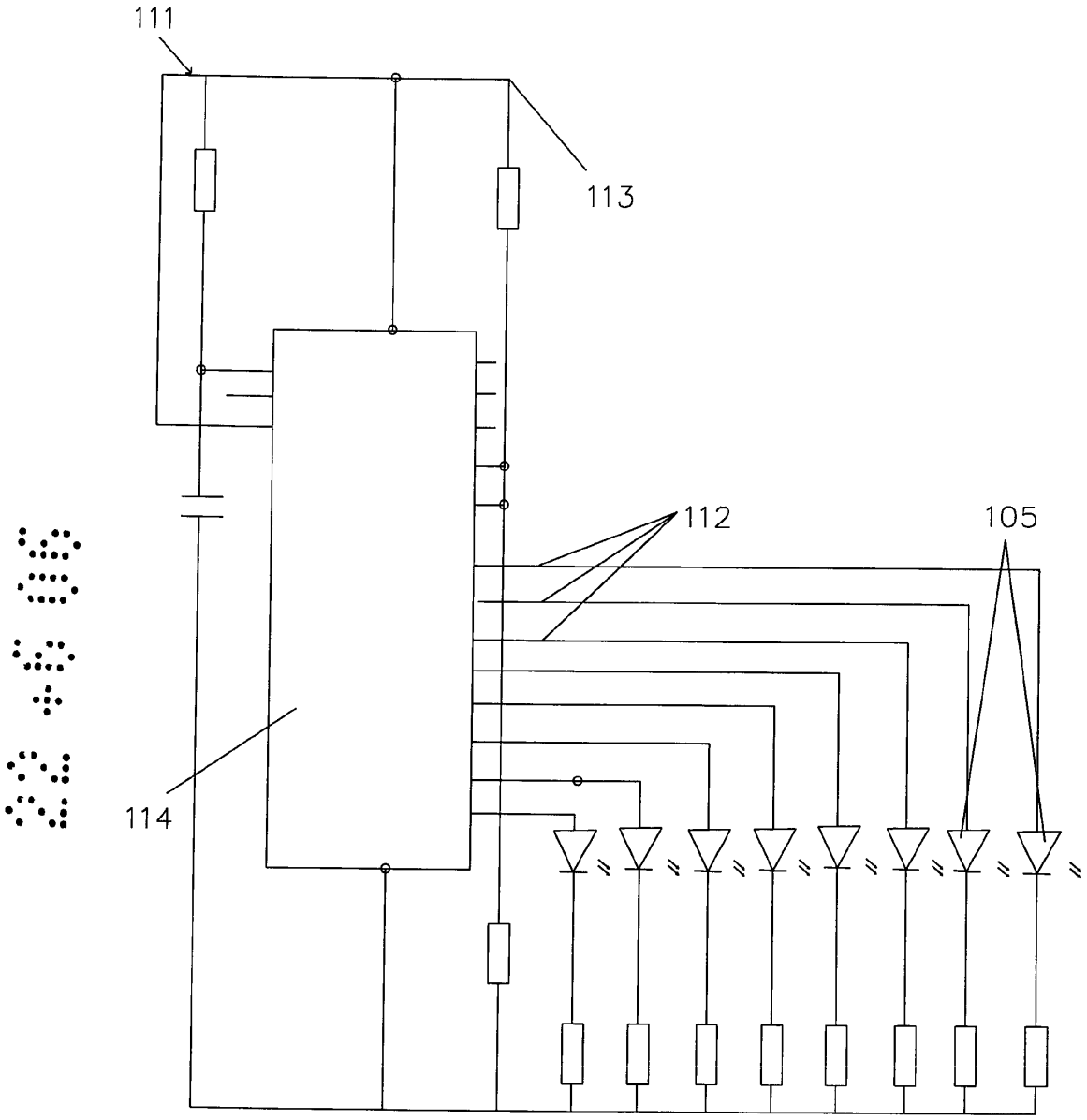


FIGURE 11

TELEVISION SIMULATING SYSTEM

There are many instances when the creation of the lighting effect of a television or other visual display screen can be useful. For example it can be used as a deterrent to potential intruders. It may also be useful during recording or performing of various visual shows, presentations or programmes where the lighting effect of a television or other visual display screen must be visible in a particular scene or part of the display. Usually this lighting effect is created using the actual television or visual display screen.

Nowadays, home security and the security of workplaces etc. is a high priority for many people.

It is particularly pertinent to protect the security of the home or workplace when it is unoccupied.

In particular, security in elderly people's homes is of concern since there are generally a small number of people living in such homes and often the elderly person lives alone. This can lead to a low level of activity entering and exiting such homes which can increase the likelihood of intrusion. Elderly persons are also vulnerable to attack if they disturbed burglars.

One method of protecting a home or workplace from the risk of intrusion by burglars etc. is by deterring potential intruders. One way of achieving this is by artificially creating an illusion that the building is occupied. There are a number of possible ways to accomplish this.

Many people leave lights or lamps switched on in their home while it is unoccupied. Alternatively, these lights or lamps may be switched on using a timer so that they are automatically switched on and off at specific time intervals. However, many burglars are now familiar with this system and are not as deterred by this means of security. Furthermore, the use of such lighting illuminates rooms in the home and can enable a potential intruder to determine whether the home is actually occupied or to examine the contents of the home. This lighting can also facilitate navigation of the home if the burglars get inside. Moreover, the

intruders are not required to make use of their own lighting means or switch on lights in the home. These actions can attract attention and arouse suspicion which intruders usually wish to avoid.

Another means of deterring potential intruders is to leave the television switched on, which can give the impression that there is activity in the home and people are present. However, the television itself may heat up to an extent and can constitute a safety hazard if it is left on over a considerable length of time. There are also timer switches which may be used to control the power supply to the television, to turn it on and off at specific intervals of time in a similar way to the lighting systems described above. However, this can also constitute a safety hazard due to the amount of power required to switch the television on. The television can also heat up when left on for a significant period of time. The safety of the system is also dependent on both the safety of the timer device and the safety of the television itself which increases the overall safety risk. Furthermore, the television tends to dissipate a considerable amount of power when left on and can be costly.

Often the lighting effect of a television or other visual display screen is required in a background stage setting or display. For example a particular scene may require that a room be lit by a television or other visual display screen. It is usually necessary to create this lighting effect by actually

positioning a television on the set. However, televisions can be heavy and cumbersome to move in between different scenes or before the scene commences. Televisions are also valuable pieces of equipment and it may not be desirable to store such equipment.

The object of the present invention is to provide a television simulating device which can mimic the lighting effect of a television or other visual display screen in a room. From observations, a blue coloured light or blue glow is produced by the television in a room irrespective of the colour composition of the image on the television screen. The television simulating device of the present invention uses high intensity blue light emitting diodes (LEDs) or other suitable lighting means to artificially mimic this blue glow.

The television simulating device may be used to act as a deterrent for potential intruders by placing it at a position in the home where a television usually resides or where a television might reside. The device may also be useful in a theatre stage or on a television studio set to mimic the lighting effect of a television, in particular, where a view or camera shot of the television screen itself is not required. The device is particularly effective when there is a low level of peripheral lighting, since the blue glow is more visible with minimal background lighting.

The television simulating device demands minimal power supply to operate and is highly efficient. The device can safely be left active over long periods of time and does not heat up to a considerable degree even if left on for a substantial period of time. The television simulating device is also compact, easily portable and simple to install. The device can also operate independently of other electrical appliances in the home and has low power consumption.

In accordance with a first aspect of the present invention, there is provided a television simulating device comprising lighting means being controlled by controlling means to simulate the lighting effect of television.

Preferably, the lighting means is capable of emitting a blue coloured light or a light which simulates the lighting effect of television.

Preferably, the lighting means has a brightness level being adjustable between an on position and an off position by the controlling means.

Preferably, the lighting means comprises at least one light source.

Preferably, the brightness level of the at least one light source is adjustable between the on position and the off position in a perceived random pattern

with respect to at least one other at least one light source.

Preferably, the at least one light source is a light emitting diode.

More preferably, the at least one light source is a high intensity blue light emitting diode.

Desirably, the at least one light source is a blue ultra bright light emitting diode.

Preferably, the television simulating device is connected to a power supply.

Preferably, the power supply is a direct current power supply.

Advantageously, the power supply to the television simulating device is controlled by a timer.

Preferably, the at least one light source is mountable on a light mounting.

Desirably, the television simulating device operates independently.

In accordance with a second aspect of the present invention, there is provided a method of deterring potential intruders comprising the steps of:

providing at least one television simulating device in accordance with the first aspect of the present invention in a room in a building; and

activating the television simulating device so that it simulates the lighting effect of television in the room.

Embodiments of the invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a schematic representation of a television simulating device of the present invention;

Figure 2 is a schematic representation of a front perspective view of a LED mounting;

Figure 3 is a schematic representation of a plan view of the LED mounting of Figure 2;

Figure 4 is a schematic representation of a side perspective view of the LED mounting of Figures 2 and 3;

Figure 5 is a schematic representation of a side perspective view of a timer and a transformer;

Figure 6 is a schematic representation of a plan view of the timer and the transformer of Figure 5;

Figure 7 is a circuit diagram of the LED control circuit;

Figure 8 is a flow diagram comprising photographs illustrating the state of components of the television simulating device in an off mode and the state of components of the television simulating device in an on mode;

Figure 9 is a flow diagram comprising photographs illustrating the assembly and operation of the television simulating device;

Figure 10 is a circuit diagram of a full wave rectifier; and

Figure 11 is a circuit diagram of an LED control circuit.

Figure 1 shows a television simulating device (1) having a LED mounting (2) connected to a transformer (4). The transformer (4) is coupled with a timer (3). Eight LEDs (5) are mounted on the LED mounting (2). When the timer (3) is set to off in the time cycle, the television simulating device is off and the LEDs (5) are unilluminated. When the timer (3) is set to on in the time cycle, the television simulating device is on and the LEDs (5) are illuminated in a brightness sequence. A LED control circuit (not shown) controls the brightness sequence of the LEDs (5) causing them to flash and/or pulsate randomly, with respect to one another, when the

power is on. It was found that high intensity blue LEDs work particularly well to emulate the lighting effect of a television. For example eight 5mm blue LEDs (5) with intensity 5900 mcd can be used. In fact any kind of LED including low intensity, standard, super bright, ultra bright or hyper bright light emitting diodes may also be used.

It is imperative that the LED control circuit (not shown) causes the LEDs (5) to flash and/or pulsate in a random fashion with respect to one another in order to accurately simulate or mimic the lighting effect of the television on the walls of the room and as perceived from part of the room or outside the room. The use of LEDs (5) to simulate or mimic this lighting effect is particularly advantageous since LEDs (5) tend to have relatively low power consumption and do not tend to heat up to a large extent when flashing and/or pulsating over significant periods of time.

Figures 2, 3 and 4 show the LED mounting (2), eight LEDs (5) being linearly mounted on top of a cylindrical LED mounting head (6) being supported by an aluminium stand (7) and an aluminium base (8). The aluminium stand (7) clamps the cylindrical mounting head (6) in place. The aluminium stand (7) may be loosened to enable the cylindrical LED mounting head (6) to be horizontally rotated to adjust the direction that the LEDs (5) face. The cylindrical LED mounting head (6) may be clamped in position to face upwards, sidewards, downwards or

any direction through 360 degrees. This enables the user to manually control the direction the light from the LEDs (5) is directed. The cylindrical LED mounting head (6) may be adjusted, as appropriate, so that the light from the LEDs (5) bounces off a particular wall, a ceiling or a floor. This is particularly useful if the television simulating device (1) is placed in an upstairs room and the lighting effect is more visible to people outside if the light from the LEDs (5) is reflected off the ceiling. The light from the LEDs (5) may also be easily directed toward a particular wall in the same manner. The LED control circuit (not shown) is mounted in the aluminium base (8). It will be appreciated that the LED mounting (2) can be made of plastic or any other suitable material which affords the requisite properties. The eight LEDs (5) are held in place by the LED mounting (2) and can also be affixed in the LED mounting (2) using glue.

Figure 5 shows the timer (3) coupled with the transformer (4). The timer (3) controls the power supply from the transformer (4) as described above.

Figure 6 shows a front face of the timer (3), the timer (3) being coupled with the transformer (4). The timer (3) comprises an electronic display (9) and various control buttons (10) which enable the timer (3) to be manually set. The time that the power is activated and the time that the power is deactivated may be stored in the timer (3) by setting the times using the control buttons (10).

The timer (3) may also be reset using these control buttons (10).

Figure 7 shows a circuit diagram of the LED control circuit (11). The LED control circuit (11) is a micro controller which can be powered by a 12 volt power supply (13) from the transformer (not shown). The LED control circuit (11) powers the LEDs (5) so that the LEDs slowly increase and decrease in brightness in a perceptually random fashion with respect to one another.

There are five dual in line switches (A, B, C, D and E) which define a total of thirty two possible display options. Switch A and switch B control the speed of the flashing of the LEDs (5) from fully on to fully off to fully on again. The switch settings for speed are shown in Table 1 below. Switch C and switch D control the depth of modulation, as shown in Table 2. The modulation depth dictates how far from fully on the LED goes towards off. For example, selecting a central portion of the brightness array gives a pulsating effect rather than an on/off flash. Switch E selects between two brightness profiles, as shown in Table 3. One of the brightness profiles is smooth and the other brightness profile has a built-in high speed flash. The speed of these profiles is related to the mode set by the other switches (A, B, C and D).

Table 1:

Switch A	Switch B	Speed
0	0	Fast
1	0	Medium Fast
0	1	Medium Slow
1	1	Slow

Table 2:

Switch C	Switch D	Modulation (%)
0	0	100
1	0	50
0	1	25
1	1	12.5

Table 3:

Switch E	Profile
0	Smooth
1	Flash

All of the switches (A, B, C, D and E) can be in a fixed state setting for the duration of the activation of the device (1). The settings are modified to ensure that the device (1) closely mimics the lighting effect of a television. The switch (A, B, C, D and E) settings ensure that the LEDs (5) pulsate at the same speed, modulation and pattern. However, at least two of the LEDs (5) pulsate at different times in a random pattern. It was found that the following switch (A, B, C, D and

E) settings worked particularly well to mimic the lighting effect of a television:

Switch A	1
Switch B	1
Switch C	0
Switch D	0
Switch E	0

The above settings correspond to a slow speed, 100% modulation and a smooth brightness profile.

There are eight outputs (12) which respectively control each of the eight LEDs (5). It is possible to connect more LEDs to the basic eight LEDs (5) in order to increase the overall number of LEDs. This means that groups of LEDs will operate in the same manner. The circuit is capable of powering a large number of LEDs. However, it was found that the use of eight LEDs (5) minimised the size of the device (1) and the voltage required to power the LED control circuit (11).

The LED outputs (12) from a programmable integrated circuit (14) control the brightness of the LEDs (5) using pulse width modulation. The mark/space ratio is used to vary the brightness of the LEDs (5) from fully on to fully off. Higher mark/space ratios generate higher values of brightness of the light emitted from the LEDs (5). Each mark is obtained from an array stored in the programmable integrated circuit (PIC) memory. This array defines the LED

brightness profile which controls the brightness sequence of the LEDs (5). One complete cycle of the LED (5) from off to maximum on and back to off again is generated as the program reads values from the whole array. Each LED output (12) has a slightly different array length, giving a continual shift in phase between the respective LED outputs (12) and an apparently random pattern of brightness of the LEDs (5). Each value of mark/space is repeated a number of times to regulate the speed of flashing or pulsating.

Figure 8 shows photographs of components of the television simulating device (1) and details the state of the components when the television simulating device (1) is on and off. When the television simulating device (1) is in an off state, the timer (3) is set to a predetermined off position and the transformer (4) is not powered on. Therefore, the circuit (11) is not activated and the LEDs (5) are un-illuminated. When the television simulating device (1) is on, the timer (3) is set to a predetermined on position and the transformer (4) receives 240 Volts AC and transforms it to 12 Volts DC. This 12 Volt power supply (13) activates the circuit (11) and each of the outputs (12) from the programmable integrated circuit (14) control the brightness of the respective LEDs (5). The LEDs (5) flash and/or pulsate in a random pattern, with respect to one another, and emit blue light to create the blue glow in a room similar to that created by a television.

Figure 9 shows photographs of components of the television simulating device (1). The high intensity blue LEDs (5) are connected to each of the eight outputs (12) of the LED control circuit (11). The LED control circuit enables each of the LEDs (5) to flash in a random fashion with respect to the other LEDs (5). The LEDs (5) are mounted in the metal LED mounting (2). The LED mounting (2) contains the LED control circuit (11) and the LEDs (5) are mounted on top of the LED mounting (5). The timer (3) is a twenty-four hour, seven day digital timer (3) which means that the power supply to the LED control circuit (11) may be set on at a specific time of the day and set off at a specific time of the day. The timer (3) may be connected the transformer (4) which converts the mains alternating current (AC) supply to 12 Volts direct current (DC). The housing containing the timer (3) and the transformer (4) is made from plastic.

Figure 10 shows a conventional full wave rectifier (115) used to provide a DC power supply (113).

Figure 11 shows a circuit diagram of an LED control circuit (111) similar to the LED control circuit (11) shown in Figure 7. The LED control circuit (111) is a micro controller which can be powered by the DC power supply (113). The LED control circuit (111) powers the LEDs (105) so that the LEDs slowly increase and decrease in brightness in a perceptually random fashion with respect to one

another. LED outputs (112) from a programmable integrated circuit (114) control the brightness of the LEDs (105).

It will be appreciated that the timer functionality, which is provided by a separate timer device (3) in the television simulating device (1) shown in Figure 1, may be incorporated into the LED control circuit (111) in place of using a separate timer. Typically, a timing delay is programmed into the integrated circuit (114) of the LED control circuit (111) to deactivate all the LEDs (105) so that they remain in the off position for an extended period of time. Generally, this extended period of time is during daylight hours when the lighting effect of the television is likely to be less visible.

It will also be appreciated that the speed, modulation and pattern of the flashing LEDs can be programmed into the integrated circuit (114).

It will be appreciated that a light dependent resistor may be used to determine the surrounding lighting conditions and activate the LEDs (5, 105) to simulate the lighting effect of television when the surroundings are sufficiently dark.

It will also be appreciated that the LEDs (5, 105) can comprise two white LEDs, two blue LEDs, 2 green LEDs and two blue LEDs.

While various embodiments of the invention have been described, it will be apparent to those skilled in the art once given this disclosure that various modifications, changes, improvements and variations may be made without departing from the scope of the invention.

Claims

1. A television simulating device comprising lighting means being controlled by controlling means to simulate the lighting effect of television.

2. A television simulating device as claimed in claim 1, wherein the lighting means is capable of emitting a blue coloured light or a light which simulates the lighting effect of television.

3. A television simulating device as claimed in claim 1 or claim 2, wherein the lighting means has a brightness level being adjustable between an on position and an off position by the controlling means.

4. A television simulating device as claimed in any of claims 1 to 3, wherein the lighting means comprises at least one light source.

5. A television simulating device as claimed in claim 4, wherein the brightness level of the at least one light source is adjustable between the on position and the off position in a perceived random pattern with respect to at least one other at least one light source.

6. A television simulating device as claimed in claim 4 or claim 5, wherein the at least one light source is a light emitting diode.

7. A television simulating device as claimed in any of claims 4 to 6, wherein the at least one light source is a high intensity blue light emitting diode.

8. A television simulating device as claimed in any of claims 4 to 7, wherein the at least one light source is a blue ultra bright light emitting diode.

9. A television simulating device as claimed in any of claims 1 to 8, wherein the television simulating device is connected to a power supply.

10. A television simulating device as claimed in claim 9, wherein the power supply is a direct current power supply.

11. A television simulating device as claimed in claim 9 or claim 10, wherein the power supply to the television simulating device is controlled by a timer.

12. A television simulating device as claimed in any of claims 4 to 11, wherein the at least one light source is mountable on a light mounting.

13. A television simulating device as claimed in any of claims 1 to 12, wherein the television simulating device operates independently.

14. A method of deterring potential intruders comprising the steps of:

providing at least one television simulating device as claimed in any of claims 1 to 13 in a room in a building; and

activating the television simulating device so that it simulates the lighting effect of television in the room.

The Patent Office

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21

Application No:	GB0605732.7	**Examiner:**	Peter Keefe
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Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-14	US 5252947 A MARCIANO figures 1-3; column 2 line 13-column 3 line 2
X	1-14	GB 2318461 A CUMBERLAND p2 line 24-p3 line 8
X,&	1-10, 12-14	GB 2398860 A CRUET COMPANY p2 lines 4-25; p5 lines 29-30
X,&	1-10, 12-14	GB 2398862 A CRUET COMPANY p2 line 13-p3 line 13; p7 lines 17-18
A		US 5032766 A GUNDLACH, LUNDGREN, IRWIN

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

H2H

Worldwide search of patent documents classified in the following areas of the IPC

G08B; H05B

The following online and other databases have been used in the preparation of this search report

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(54) Title of the Invention: **Light control device**
Abstract Title: **Light control device**

(57) In accordance with embodiments there are provided methods and devices for use in photography. In one embodiment the device comprises a variable filter 305 arranged to vary characteristics of light received from a light source 303, the variable filter 305 being arranged to emit the varied light onto a subject 20 of an image being recorded, and a processor 202 arranged to control the variable filter 305. In another the device comprises an interface 204 for receiving a communication identifying camera characteristics, and a processor 202 arranged to vary at least one characteristic of light emitted by a light source 303 in accordance with the camera characteristics. In another the device comprises an interface 204 for receiving one or more communications identifying a plurality of open periods of a camera shutter, and a controller 202 arranged to instruct a light source 303 to emit light in accordance with the camera shutter open periods. In another the device comprises a light receiving part arranged to receive a coloured light, and a light colour compensator arranged to compensate colour characteristics of light to be emitted by a light source 305 in accordance with the received light.

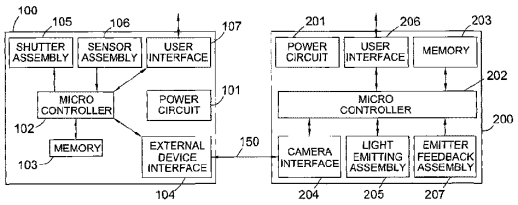


Fig. 2

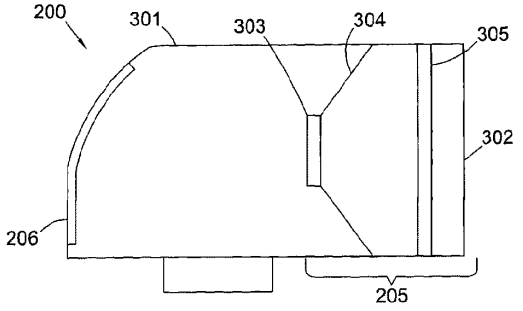


Fig. 3

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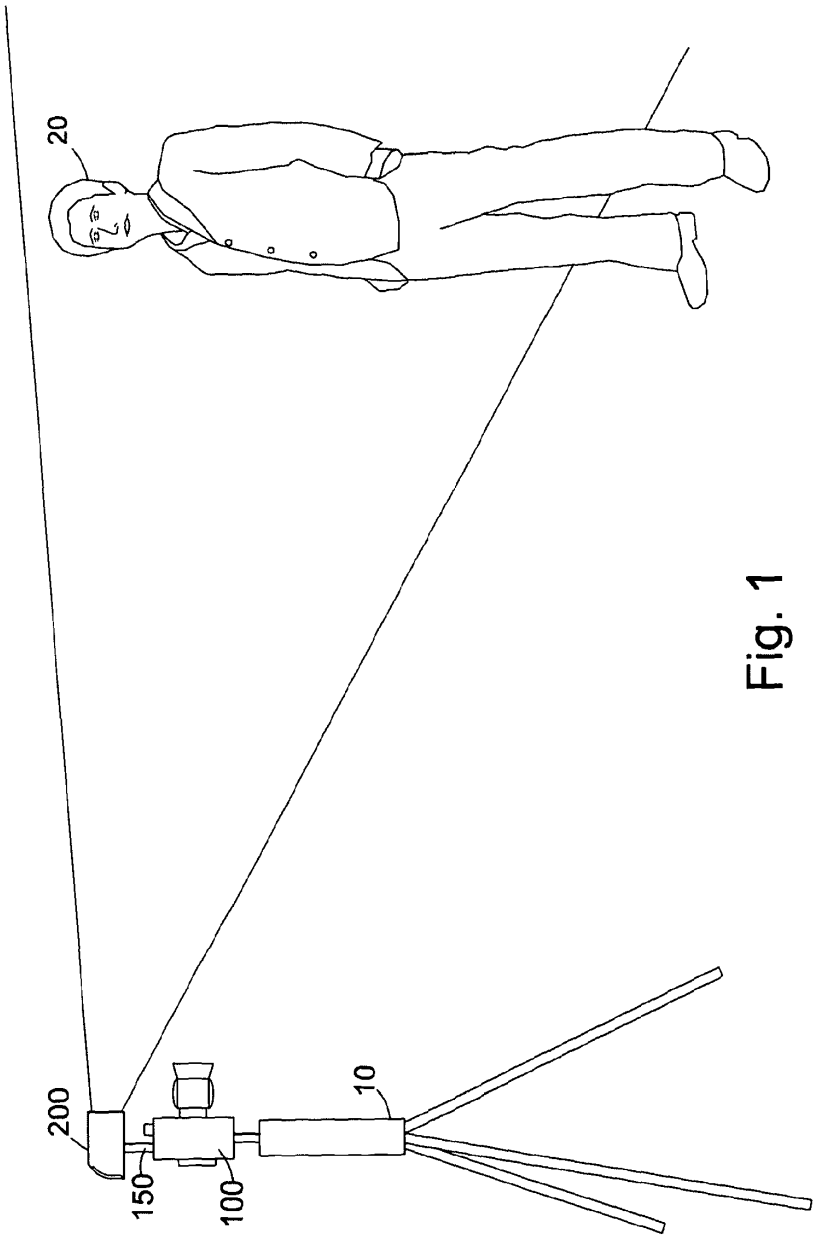


Fig. 1

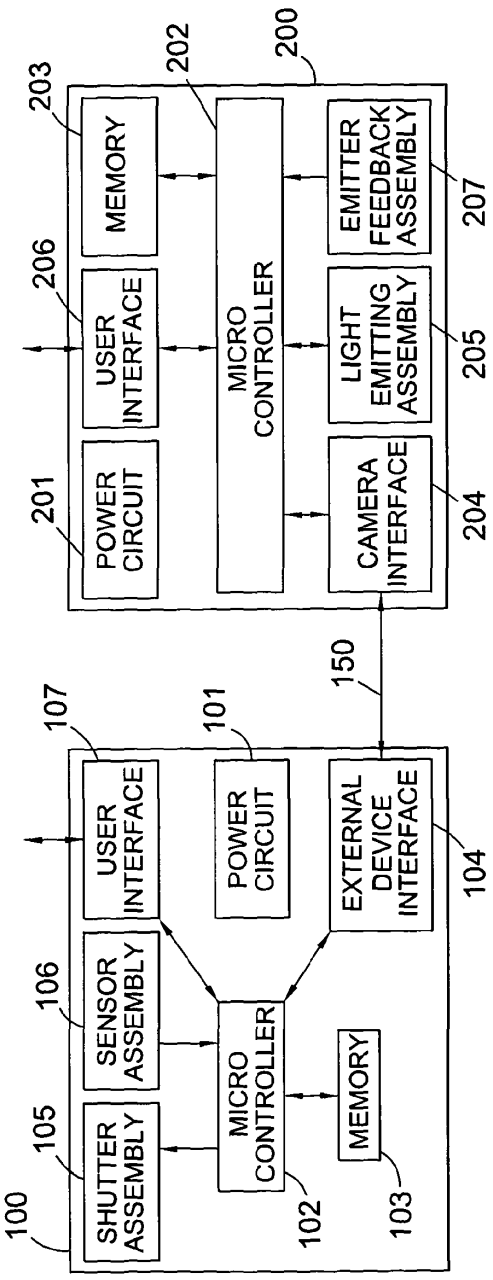

100
SHUTTER ASSEMBLY
105
SENSOR ASSEMBLY
106
USER INTERFACE
107
MICRO CONTROLLER
102
MEMORY
103
POWER CIRCUIT
101
EXTERNAL DEVICE INTERFACE
104
150
200
POWER CIRCUIT
201
USER INTERFACE
206
MEMORY
203
MICRO CONTROLLER
202
CAMERA INTERFACE
204
LIGHT EMITTING ASSEMBLY
205
EMITTER FEEDBACK ASSEMBLY
207

Fig. 2

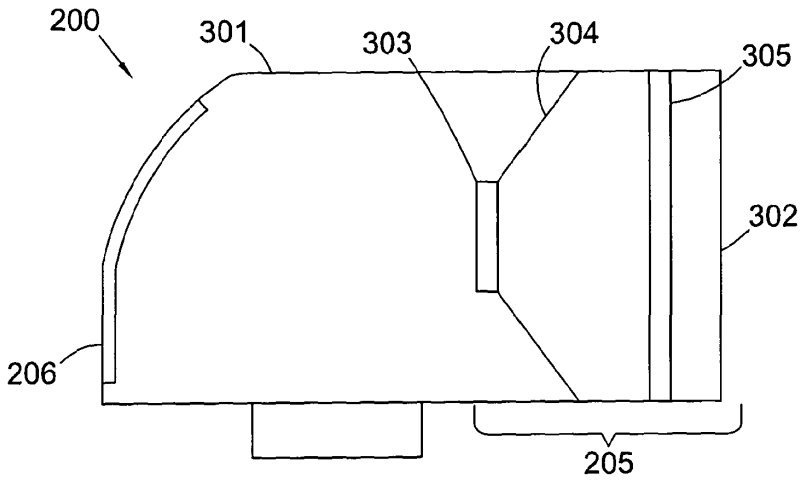


Fig. 3

Light Control Device

The present invention relates to a light control device. More specifically, the present invention relates to a device and corresponding method for controlling the emission of light by a light source used in conjunction with a camera or such like.

Photography is a technique using a camera for capturing images, which generally refers to capturing still images such that they can be viewed again after the event took place. Photography can also refer to the capturing of moving images, however, the process of capturing moving images can also be referred to as film.

In photography, both for still and moving images, the lighting of a subject being captured in the photograph is very important. When a still camera or digital video camera records an image it does this by exposing a digital sensor to light through a lens that forms an image on the sensor (or in the case of analogue photography to a film stock such as celluloid film). The amount of light that reaches the sensor is in part determined by the transmittance of the lens assembly and in part by the exposure time. The apparatus that regulates the exposure time is called the camera shutter.

The camera shutter regulates exposure time by opening and closing the light path for a precise amount of time. The most common type of shutter is the focal plane shutter, which consists of two curtains. When the exposure starts, the first curtain called the front curtain opens, and when the exposure time is over the second curtain called the rear curtain closes. In conventional cameras, the direction of travel of the curtains is vertical (or along the shortest axis). The exposure time is generally a very short instance in time. Commonly used exposure times range from 1/60 second to 1/1000 second, but the capability of many cameras typically extends well beyond these in both directions.

For exposure times longer than 1/200 second (typical), there is a period when the entire sensor is exposed with no part of the front or rear curtain covering the sensor. For exposure times shorter than 1/200 second (typical), since the curtain travel takes a finite amount of time, the rear curtain must start to close before the front curtain is fully open. In this case the entire sensor is not exposed at any one time, rather the two shutter curtains form a slit that moves across the sensor, thereby exposing light to

portions of the sensor as the slit moves across the sensor. The shorter the exposure time, the narrower the slit. The parallel movement of the curtains ensures that all areas of the sensor receive the same amount of light.

While movement of the slit controls the amount of light passing onto the photographic sensor of the camera, the light which can reach the sensor is also affected by the light which is applied to the subject being photographed. Furthermore, the lighting applied to the subject being photographed will affect how the subject looks in the photograph. Hence, lighting applied to a subject being photographed is of utmost importance in photography.

In general, lighting is used to ensure that a photograph is clear and that the subject being captured can be seen. In other words, lighting is used in order to achieve proper exposure. Furthermore, in order to achieve a desired image, photographers use a variety of means to adjust how light falls on to the subject of interest. While, altering the position of a subject in respect of natural light emitted from the sun is a common way to adjust the lighting applied to a subject being photographed it is also common practice to utilise artificial lighting, and in particular photography specific lighting, such as spot lights, flood lights, and photographic flashes. Other means for adjusting the lighting applied to a subject include use of light shaping tools like reflectors, diffusers, or gobos (items that obstruct the light) to adjust how the subject is lit.

Often spot lighting and photographic flashes are provided in order to provide light to parts of a subject that would otherwise be in shade, or insufficiently well lit. Photographic lighting can also be used in order to provide a 'mood' to a photograph, for example, by adding a light of a particular colour, or from a particular direction.

It has in recent years, particularly due to prominence of digital photography, become popular for photographers to enhance images further after the exposure by using post-production techniques. Such post-production techniques can be used in order to change the tonal qualities of the image, brighten or darken particular parts of the image and so forth. Such post-production techniques allow for the apparent lighting of the photograph to be adjusted after the exposure takes place, thus providing photographers with even more control over the photograph. These techniques allow photographers to enhance photographs, in particular, enhance the lighting of a

photograph. This may allow for interesting lighting effects to be produced which would not usually be possible by use of natural lighting or photographic lighting.

While post-processing provides photographers with a great amount of control over their images, it is a common myth that 'anything' is possible in post-processing. This is not the case. In extreme cases an image can be enhanced to such a degree that it is basically re-drawn by hand by a painter or illustrator. However, such techniques are time consuming and can therefore be financially expensive.

While current post-production techniques provide photographers with a great deal of control over the look of a final image, there is always a need amongst photographers for ways of creating new looks, and also for making effects applied to photographs more natural without having to use such expensive and time-consuming post-production techniques.

The present invention aims to at least partly mitigate some of the above mentioned problems.

In accordance with an aspect of the present invention, there is provided a device for use in photography, the device comprising: a variable filter arranged to vary characteristics of light received from a light source, the variable filter being arranged to emit the varied light onto a subject of an image being recorded; and a processor arranged to control the variable filter.

The variable filter may comprise a plurality of variable filter elements arranged in an array, each filter element arranged to vary the characteristics of the light passing therethrough.

The variable filter may be arranged to vary colour characteristics of the light.

The variable filter may be arranged to vary intensity characteristics of the light.

The device may further comprise an optical assembly arranged to focus the light emitted from the variable filter.

The processor may further comprise a tracking means arranged to track a position of a feature of the subject of the image being recorded and control the variable filter to vary the characteristics of the light in accordance with the tracking of the feature.

The processor may be arranged to control the variable filter to vary the characteristics of the light in accordance with the tracking of the feature by applying the same light characteristics to the feature when the feature moves position.

In accordance with another aspect of the present invention there is provided a device for use in photography, the device comprising an interface for receiving a communication identifying camera characteristics; and a processor arranged to vary at least one characteristic of light emitted by a light source in accordance with the camera characteristics.

The camera characteristics may include information identifying a camera shutter opening time, and the processor may be arranged to vary the at least one characteristic of the light each time new information identifying a camera shutter opening time is received.

The camera characteristics may include information identifying a camera shutter opening period and the processor may be arranged to vary the at least one characteristic of the light during the camera shutter opening period.

The at least one characteristic of the light varied by the processor may include a colour characteristic of the light.

The at least one characteristic of the light varied by the processor may include an intensity of the light.

At least one characteristic of the light may be varied spatially.

The device may further comprise a light source arranged to emit light; and a filter arranged to vary the at least one characteristic of the light.

The filter may be a matrix of variable filter elements.

In accordance with yet another aspect of the present invention there is provided a device for use in recording video images, the device comprising: an interface for receiving one or more communications identifying a plurality of open periods of a camera shutter; and a controller arranged to instruct a light source to emit light in accordance with the camera shutter open periods.

The controller may be arranged to instruct the light source to emit light throughout the period when the camera shutter is open.

The one or more communications may identify a camera shutter opening time and a camera shutter opening period.

The one or more communications may also identify a frequency of camera shutter opening.

The controller may be arranged to instruct the light source to emit light during a portion of the period that the camera shutter is closed.

In accordance with a further aspect of the present invention there is provided a device for ambient light colour compensation, the device comprising: a light receiving part arranged to receive a coloured light; and a light colour compensator arranged to compensate colour characteristics of light to be emitted by a light source in accordance with the received light.

The light colour compensator may be arranged to compensate for the colour characteristics of the light to be emitted such that the light to be emitted has the same colour characteristics as the received light.

The light receiving part may comprise: a red light sensor arranged to receive red light; a green light sensor arranged to receive green light; a blue light sensor arranged to receive blue light; and a white light sensor arranged to receive all colours of light, wherein the white light sensor is used to determine a received light intensity.

The received light may be ambient light falling on a subject to be photographed.

The light colour compensator may be arranged to apply an offset of green and/or magenta to the light to be emitted in order to further correct for the colour of light when the colour of light is defined in terms of colour temperature.

The device may be arranged to turn off the light source while taking a measurement.

In accordance with yet a further aspect of the present invention there is provided a device including two or more of the above devices.

The device may be an illumination device including a light source.

The device may be a camera.

In accordance with an aspect of the invention there is provided a method for use in photography, the method comprising: varying, at a variable filter, characteristics of light received from a light source such that the varied light is emitted onto a subject of an image being recorded; and controlling, at a processor, the variable filter.

The variable filter may comprise a plurality of variable filter elements arranged in an array, each filter element arranged to vary the characteristics of the light passing therethrough.

The varying characteristics of the light may comprise varying colour characteristics of the light.

The varying characteristics of the light may comprise varying intensity characteristics of the light.

The method may further comprise focusing, at an optical assembly, light emitted from the variable filter.

The method may further comprise tracking, at a a tracking means, a position of a feature of the subject of the image being recorded; and controlling the variable filter to vary the characteristics of the light in accordance with the tracking of the feature.

The step of controlling may comprise controlling the variable filter to vary the characteristics of the light in accordance with the tracking of the feature by applying the same light characteristics to the feature when the feature moves position.

In accordance with another aspect of the present invention there is provided a method for use in photography, the method comprising: receiving a communication identifying camera characteristics; and varying at least one characteristic of light emitted by a light source in accordance with the camera characteristics.

The camera characteristics may include information identifying a camera shutter opening time, and the method further comprises varying the at least one characteristic of the light each time new information identifying a camera shutter opening time is received.

The camera characteristics may include information identifying a camera shutter opening period and the method may further comprise varying the at least one characteristic of the light during the camera shutter opening period.

The at least one characteristic of the light which is varied may include a colour characteristic of the light.

The at least one characteristic of the light which is varied may include an intensity of the light.

The at least one characteristic of the light may be varied spatially.

In accordance with yet another aspect of the present invention there is provided a method for use in recording video images, the method comprising: receiving one or more communications identifying a plurality of open periods of a camera shutter; and instructing a light source to emit light in accordance with the camera shutter open periods.

The light source may be instructed to emit light throughout the period when the camera shutter is open.

The one or more communications may identify a camera shutter opening time and a camera shutter opening period.

The one or more communications may also identify a frequency of camera shutter opening.

The method may further comprise instructing the light source to emit light during a portion of the period that the camera shutter is closed.

In accordance with a further aspect of the present invention, there is provided a method for ambient light colour compensation, the method comprising: receiving a coloured light; and compensating colour characteristics of light to be emitted by a light source in accordance with the received light.

The step of compensating for the colour characteristics of the light to be emitted may be performed such that the light to be emitted has the same colour characteristics as the received light.

The received light may be ambient light falling on a subject to be photographed.

The method may further comprise applying an offset of green and/or magenta to the light to be emitted in order to correct for the colour of light when the colour of light is defined in terms of colour temperature.

The method may further comprise turning off the light source while taking a measurement.

In accordance with another aspect of the present invention there is provided a method including two or more of the above mentioned method steps.

In accordance with yet a further aspect of the present invention there is provided a carrier medium carrying computer readable code for configuring a suitable computer as the apparatus of any of the devices mentioned above.

In accordance with yet another aspect of the present invention there is provided a carrier medium carrying computer readable code for controlling a suitable computer to carry out the method of any of the method steps mentioned above.

Embodiments of the present invention relate to modulating a light source for use in photography. In particular, the light may be modulated spatially and/or over a period of time. Furthermore, the modulation may take place in accordance with the opening and closing of a camera shutter in order to save energy. Furthermore, the modulation may take place in order to compensate for ambient light.

Embodiments of the present invention relate to modulating the emission of light while the two shutter curtains moves across the sensor at speeds slower than or faster than 1/200 seconds (typ) in such a way that the subject is unevenly illuminated by the light source.

In accordance with embodiments of the present invention, for long exposure times, i.e. longer than 1/200 second (typ), modulating the light will allow the photographer to achieve various effects, for example capture several impressions of a moving object in a single frame, and to have the individual impressions individually exposed. The photographer may also be able to capture an impression of movement (blur) while still having the subject of interest appear sharp. This effect can be used for artistic or technical purposes.

In accordance with embodiments of the present invention, for short exposure times, i.e. shorter than 1/200 second (typ), modulating the light will allow the photographer to e.g. put a colour gradation on or behind the subject of interest, or a hairline light that varies in colour or intensity. Ambient light hitting the subject will be evenly exposed, while the emission of light from the light source can be modulated. This effect can be used for artistic or technical purposes.

Embodiments of the present invention relate to a situation where the quality of the light is made to vary at high speeds during the exposure.

Embodiments of the present invention allow for the colour of the emitted light to be modulated during the exposure.

Embodiments of the present invention allow for the colour temperature to be modulated during the exposure.

Embodiments of the present invention allow for the intensity of the light to be modulated during the exposure.

Embodiments of the present invention allow for both colour and intensity to be simultaneously and individually modulated during exposure.

Embodiments of the present invention allow for both colour temperature and intensity to be simultaneously and individually modulated during exposure.

Embodiments of the present invention allow for the modulation of light to be slow or rapid, thereby creating different effects.

Embodiments of the present invention allow for the modulation of light to be linear or non-linear across the exposure.

Embodiments of the present invention allow for the lighting to provide a strobing effect.

Embodiments of the present invention provide a system having a light source which has the ability to vary aspects of its light emission (intensity, colour or colour temperature) at high speeds, and can do this synchronised to the movement of a camera shutter.

Embodiments of the present invention relate to photographic devices, that is illumination devices, cameras, camcorders, or any other photographic equipment arranged to perform any of the above functionality.

Embodiments of the present invention are arranged to illuminate a subject to be photographed. A subject may be a person scene, object or such like. Further embodiments of the present invention are arranged to track features of the subject, for example of the subject is a traffic scene, a specific car may be the feature, or if the subject is a person the face of the person may be the feature.

The present invention shall now be described with reference to the drawings, in which:

Figure 1 illustrates a scenario for use of a first embodiment of the present invention;
Figure 2 illustrates a system provided in accordance with a first embodiment of the present invention; and
Figure 3 illustrates a cross-sectional view of an illumination device.

Throughout this specification like reference numerals refer to like parts.

Figure 1 provides an overview of a first embodiment of the present invention. In this first embodiment of the present invention a camera 100 is mounted on a tripod 10 for taking a photograph of a subject 20, which in this case is a person. It will be appreciated that the subject could be anything; for example, a person, an object, or a scene. An illumination device 200 is mounted on the camera 100. It will be appreciated that any suitable mounting means could be provided, for example, the illumination device 200 could be mounted separately from the camera 100.

The camera 100 and illumination device 200 are communicatively coupled via a communications channel 150, which in this case is a cable connector. It will be appreciated that the communications channel could take many forms, including various different types of wired connectors and wireless connection means. For example, the communication between the camera 100 and illumination device 200 may occur through connectors in the camera hotshoe. Alternatively, the communication may occur optically via a built in or separate flash mounted on the camera. In yet another embodiment the communication may occur via a separate wireless radio transmitter/receiver. In a further embodiment a separate sync wire between the camera 100 and the illumination device 200 may be used.

In operation the camera 100 is arranged to provide control signals to the illumination device 200 such that operation of the illumination device 200 is synchronised with operation of the camera 100. As a consequence, various functions of the present invention can be achieved.

Figure 2 illustrates a system provided in accordance with a first embodiment of the present invention.

In Figure 2, a representation of the functional components of camera 100 and illumination device 200 is shown. The camera 100 includes a power circuit 101, a microcontroller 102, a memory 103, an external device interface 104, a shutter assembly 105, a sensor assembly 106 and a user interface 107. The illumination device 2 is shown to include a power circuit 201, microcontroller 202, memory 203, camera interface 204, light emitting assembly 205 and user interface 206.

The arrangement of the system of this first embodiment of the present invention shall now be explained in more detail.

The power circuit 101 is arranged to provide power to each of the components of the camera 101. In this embodiment of the present invention the power circuit is a battery, however, any form of power supply, internal or external, could be utilised.

The power circuit includes, a power supply switch, a power control circuit and a power supply. The power supply switch is arranged such that when the switch is in an ON position the power control circuit can regulate the voltage from the power supply to the other components of the camera 100.

The microcontroller 102 controls the operation of the camera 100. In particular, the microcontroller 102 acts as the central processor and is capable of processing information received from the user interface, and also adjusting parameters of the shutter assembly 105 accordingly. For example, the microcontroller 102 is arranged to perform shutter speed control. Furthermore, the microcontroller 106 is arranged to receive image data from the sensor assembly and store this information in memory 103. The memory 103 represents the memory used by the camera both for data storage and for processing performed by the camera 100. It will be appreciated that separate memory components could be provided for each part of this functionality.

The external device interface 104 is arranged to provide a port through which the camera 100 can communicate with external devices such as illumination devices. The microcontroller 102 is able to send control signals via the external device interface 104

to the illumination device 200. Furthermore, image data can be streamed from camera to illumination device for certain functionalities, such as the use of multiple illumination devices, as discussed below.

The shutter assembly 105 is a standard shutter assembly as described above in respect of the prior art. In particular, it is standard dual curtain assembly. However, it will be appreciated that other types of shutter assembly could be utilised. The shutter assembly 105 also includes the necessary control circuitry for operating the curtains.

The sensor assembly 106 includes a CMOS or CCD imaging element, a microcontroller for managing the operation of the imaging element, and a memory for storing the recorded image information. The sensor assembly is arranged such that it is capable of determining characteristics of the light being photographed. Hence, the light being sensed may just be the ambient light, it may be a combination of the ambient light and light emitted from a photographic illumination device, or it may be the photographic light alone.

The user controls the camera 100 via its user interface 107. The user interface 107 is provided with a graphical user interface (GUI) thus providing the user with a display screen and controls such that the user is able to adjust parameters of the camera 100, and thus parameters of photographs to be taken by the camera 100. The user interface may also include one or more buttons, dials or such like for controlling parameters of the camera, in addition to operating the camera shutter. While the camera described in respect of this embodiment of the invention has various features including a graphical user interface, it will be appreciated that in alternative embodiments the only requirements for use with the illumination device of embodiments of the present invention is a way to adjust shutter speed and a flash hotshoe.

Now referring to the illumination device 200, the power circuit 201 takes the same form as that provided for the camera. However, it is noted that in alternative embodiments of the invention the illumination device could be powered by the camera, thus only requiring a power receiving interface instead of a full power circuit.

The microcontroller 202 of the illumination device 200 is arranged to control each of the components of the illumination device 200, and also perform any processing as necessary. In particular, the microcontroller 202 can receive control signals from the user interface 206, the camera interface 204, and the optical trigger in order to control the light emitting assembly accordingly. The functionality of the microcontroller is discussed in more detail below. It is noted that the camera interface 204 is a general purpose interface providing a communication port for connecting with various remote devices.

The memory 203 is connected to the microcontroller 202 and is used to store any data necessary for performing the operations of the illumination device.

The camera interface 204 provides a means for allowing for the illumination device to communicate with the camera 100. In particular, the camera interface 204 is arranged to receive control signals from the camera 100 and pass these on to the microcontroller 202 such that the microcontroller can transform these control signals into signals suitable for controlling the light emitting assembly 205. The camera interface 204 may receive such controls signals via a wired or wireless connection as discussed above in respect of Figure 1.

The light emitting assembly 205 includes an array of light emitting elements for emitting light. Such a light-emitting array comprises a plurality of light emitters including a red, green, blue and either amber or white emitter. The light emitters may be four or more high power LEDs (Light Emitting Diode) each of a different colour, red, green, blue and either amber or white. The relative intensity of the four colours is changed by the microcontroller in order to produce a light of any colour. The emitters are mounted in close proximity to each other. The light emitting assembly may form part of an optical assembly consisting of various lenses and diffusers designed to create an even light from the emitter array.

The LEDs are driven to about 10W in continuous mode. However, it is noted that when the LEDs are in flash mode they are in some circumstances driven with higher power. The reason for a 10W limit is primarily due to limitations in battery capacity and heat dissipation for a small portable device. As such a much higher powered device could be built by using larger and/or more emitters, a bigger case, and mains powered.

The lighting-emitting array may be provided by close mounted individual LED chips and multi-die emitters where four or more diodes sit on a common die. The advantage of multi-die is that better colour mixing can be achieved since the emitters sit closer together. A collating optical lens assembly will generally preserve the relative entrance angle of the light through the system. As the emitters have different colours, the light reaching the subject may not be a perfectly even light, but show colour fringing. The centre spot may be an even 'white', but the edges may show a colour cast reflecting the position of the individual emitters within the optic assembly. In order to mix the colours better, the light has to be diffused. Diffusion introduces a loss of optical efficiency. The closer the emitters are positioned relative to each other, the less diffusion is necessary and the better the optical efficiency can be.

Each individual LED can be driven by a switch mode current sink in order to achieve improved power efficiency and colour stability. A PWM driver circuit shunts the current sink and turns on and off the individual LED about 25000 times each second. The length of each pulse then determines the light output. Furthermore, the length of the pulses is continuously adjusted to compensate for drift in the emitters.

The current is not simply regulated through the LEDs because the colour of the LEDs shifts slightly when the current changes. Consequently, when the emitted light is dimmed, the light would become a little greener, for example, and such colour shifting is generally seen as unacceptable.

The emitter assembly also includes two sensors that feed back to the microcontroller. A temperature sensor to guard against thermal runaway, and an optical sensor that is used to compensate for drift.

Overall, the light emitting assembly is arranged to emit light powerful enough to provide improved illumination of a subject. The light emitting assembly 205 is arranged to emit light responsive to control signals from the microcontroller 202. In particular, the light emitting assembly 205 can vary its luminance levels over a period of time in accordance with the received instructions.

The light emitting assembly may also include a variable electronically controlled filter along with the light emitting device. This is discussed in more detail below, with respect to Figure 3.

The arrangement of the light emitting assembly 205 within the illumination device 200 is illustrated in the cross-sectional diagram of Figure 3.

In Figure 3, the illumination device 300 includes a casing 301, which encloses the other portions of the device except for the emission surface 302 which is transparent. The light emitting assembly 205 is all arranged inside the casing 301, such that light is emitted out from the emission surface 302.

The light emitting assembly 205 includes the emitter array 303 which is arranged to emit light as discussed above. An optical assembly 304 is provided in order assist in projection and channelling of the light through the emission surface 302. In this first embodiment of the present invention the optical assembly 304 includes a TIR optic consisting of a multitude of optical surfaces designed to collate the light and shape it into a suitable beam. The TIR optic also includes diffusion surfaces to help with colour mixing. The optical assembly 304 also includes a movable Fresnel lens, arranged in front of the TIR optic, designed to 'zoom' or alter the beam spread. Furthermore, the filter 305 is provided between the emitter array 303 and the emission surface 302, such that it can control or vary characteristics of the emitted light passing therethrough.

Also shown in Figure 3 is the user interface 206, which allows for the user to control the illumination device 200. In Figure 3 the user interface is provided on the back surface of the illumination device. However, it will be appreciated that the user interface could be provided on a separate device, either proprietary or part of another device such as a laptop. In the case where the user interface is a remote device it may be connected via wire or wireless like WiFi or Bluetooth.

The user interface 206 may be a graphical user interface which allows the user to set parameters of the illumination device 200. A display is provided along with a means for the user to input controls and information. This may be a touch screen display or alternatively some form of keypad, provided alongside a separate display screen. In particular, it is necessary that such controls are suitable for a user to select particular

light emission settings, as well as perform the necessary steps to synchronise the illumination device with the camera, in the event that such steps are not performed automatically. Furthermore, the display should, for certain embodiments, be capable of providing a graphical representation of the scene being photographed, and be able to provide the user control over the lighting applied to that scene.

The filter 305 is arranged to reduce light intensity emitted towards certain positions of the subject, as well as change the colour, or colour temperature emitted towards certain portions of the subject. Such characteristics can be varied both spatially and over time. The filter 305 may take the form of a matrix of binary shutters that can open/close to obstruct or pass light through, or could take the form of a liquid crystal construction. A liquid crystal based structure would be arranged with a gradual opacity to achieve such control of the light, in terms of position and intensity. Furthermore, in order to achieve colour variation the filter may comprise three layered liquid crystal devices, one for filtering red light, one for filtering green light and the other for filtering blue light. Alternatively, a binary state reflective type filter could be used, which would be made out of a matrix of microscopic mirrors (DLP). In any case it may be necessary to employ separate filters to deal with intensity modulation and colour modulation. A filter with gradual opacity would regulate the light by changing the opacity of each 'pixel'. In a binary state filter the apparent opacity would change by changing the duration of high-speed light pulses. Which ever system is utilised, the filter, or the combination of the light source and the filter, allows for the intensity of each of the red, green and blue colours to be varied for each pixel.

Since the filter may be capable of altering colour characteristics of the emitted light, in alternative embodiments of the invention a white light source replaces the coloured LED array. As such, all control over the light is carried out at the filter. In such embodiments it is possible for the filter to be separate from the light source. For example, a standard light source could be provided and utilised alongside the filter, along with the required control circuitry. Such embodiments may allow for a brighter and/or more energy efficient light sourse to be utilised.

Since the filter can be a separate item, a large liquid crystal based filter could be utilised in order to provide a single large light source. For example, the filter could form a $3m^2$ panel. In order to illuminate the panel it would be possible to use a high power

light source directly behind the panel, or in order to reduce the space required by the device, a reflector could be used in order to expand or spread the width of the light emitted from the light source.

In yet a further embodiment of the invention, the aforementioned light source may vary characteristics of the light it emits, such as the colour, and as such the filter may not be required.

In a further embodiment of the invention an LED panel is utilised in place of the above mentioned light source and filter. As such a coloured LED array can be used to represent each individual pixel of the light source. The modulation effects can then be applied across the pixels of the LED panel. In order to improve performance it may be necessary to include a specialist optical assembly, such as a lens arrangement, in order to ensure that the LED panel provides a focussed light source, as required for lighting up a subject in photography.

The various uses and functionalities of the first mentioned embodiment of the present invention shall now be described with reference to the figures.

The first parameter of light that can be controlled by the light emitting assembly is the intensity. For photography, the intensity of emitted light can be regulated in exposure value (EV) steps. Full steps, half steps, 1/3 steps, or 1/10 steps where each full step corresponds to a full step increase or decrease of camera aperture or shutter speed. One full step equals a halving or doubling of light intensity. Alternatively, for video it is quite common to use a continuous 0-100 scale. The photographer can then choose the preferred scale according to his or her preferences.

The overall intensity of light emitted can be varied by changing the intensity of light emitted by the light emitters themselves. However, the filter allows for positional intensity changes to be provided in addition to universal changes, as discussed below.

The filter can act to block or reduce the intensity of light emitted by the light emitting assembly such that certain areas of the light projected onto a subject have reduced light levels. In particular, certain portions of the filter can be arranged to block light while others are arranged to pass light. In further embodiments, some of the light can

be partially passed or partially blocked. As such the filter can provide different levels of light intensity to different areas of the scene being photographed.

An example of a useful application of variations in positional intensity shall now be discussed. Control of the variations in light intensity can be achieved by using a light sensor, which may be provided from the camera or on the device itself, which receives light from the exact same area as the area that the light emitted by the light emitting assembly is projected onto. Alternatively, the device can receive an image feed from the camera used for capturing the image. Hence, this camera can take in an image of the scene to be photographed. Some parts of the scene will be lighter, some will be darker. The photographer can then brighten dark areas without affecting the brightness of the light areas. The image from the light sensor can be used to determine which areas are dark and which areas are bright. Based on this information the microcontroller of the device can control the emitted light such that the intensity of light projected onto the parts of the scene that are dark is greater than the intensity of light projected onto those parts that are already light. In order to achieve this, the microcontroller can take the image from the image sensor invert the image intensity and emit light accordingly. Thus, the dark areas are illuminated more than the light areas. As such the dark areas of the scene can be brightened without adding unwanted glare or brightness to other areas of the scene.

The light emitting assembly is also capable of varying colour. As mentioned above, the emitting elements are capable of emitting light of any colour by selecting a ratio of the different coloured LEDs. Furthermore, the intensity of each colour can be controlled by controlling each LED individually. The user can apply an overall colour setting, which is applied universally to the light source. Colour can be changed by entering a set of colour coordinates in one of common colour spaces like RGB, Lab, HLS, etc. Colour can also be selected from a list of named colours like "Summer Green", "Dark orange", etc. Obviously, in alternative embodiments, these colours could be varied by the filter. Furthermore, as mentioned above, the intensity of each colour for each pixel can be controlled independently.

Another colour parameter that the user can set is the colour temperature, CT (or more technically accurate, the Correlated Colour Temperature). CT is also called white balance. The colour temperature can be regulated by entering the desired colour

temperature along a continuous scale. The scale boundary depends somewhat on the colour coordinates for the particular emitters used, but would typically be from 2000 to 10000 Kelvin. The CT can also be regulated by selecting from a list of predefined named values, for example Daylight, Cloudy, Fluorescent and so forth, where the Daylight setting would be a CT of 5600 Kelvin. The CT can also be changed by adding an electronic 'compensating gel'. Many photographers are accustomed to adding gelatine filters to their lights, and to accommodate those who are accustomed to working this way, the device lets the photographer select from a list of common filters like CTO, CTB, or Plusgreen. The device will then adjust the CT of the emitted light to a value equal to the effect of adding a physical gelatine filter. The colour can be changed either by adjusting the colour emitted by the emitter array 303 or by applying a universal colour adjustment to the filter 305.

In respect of both the overall colour and colour temperature, the selected colour can be achieved by varying either the light emitters or the filter 305.

The filter allows for further control over the emitted light, in particular, in respect of colour positioning. Such colour positioning is also achievable if a light source panel array, as discussed above, is utilised in place of the light source and filter combination. For example, a colour gradient can be applied which varies the colour across the image. It may be that the colour is set up to gradually change from top to bottom or left to right, in order provide the effect of a light source from a particular direction. It is noted that light intensity gradation can be applied in a similar way. Further examples of more complex uses of the colour variation capabilities provided by the filter are set out below.

The filter array can provide specific positional coloured light. For example, if it is desired to provide a blue line of light across the subject this can be achieved in accordance with an embodiment of the present invention.

The user display can be used in order to control the 'painting' of light onto the position of the scene as desired. In particular, the image sensor records an image of the scene, and the position of the light source(s) with respect to the scene has thus been determined. The microcontroller is then able to allow input from a user onto the user display, or any other user interface, to identify regions where the line of blue light

should be provided. In such a case the microcontroller is able to control both the light emitters and the filter such that the blue light is provided. This can be achieved by the emitters emitting a white light, and the filter providing a blue filter to specific portions of the light such that the blue line specified by the user is project onto the scene.

While the above example of 'painting light' is applied to blue light, it will be appreciated that any light parameter, such as colour and intensity with respect to position, could be altered using this technique.

Another parameter adjustable by the user is the light mode. A video mode can be selected where the device emits a continuous light suited to recording of moving images. The meaning of continuous light also includes the case where the light is turned off during the time when the camera shutter is closed, for the purpose of saving energy. The other light mode is flash, where the device emits a flash. In flash mode the device may emit a constant low power modelling light used to aid the photographer in positioning the light.

The emitter feedback assembly 207 may include a light sensing device, which is used for calibrating the light emitting assembly, in addition to providing feedback useful for certain processes performed by the illumination device 200. This light sensing device could be the same light sensing device as that used above in respect of recording the image for user control over the projected light. However, separate sensors for the specific applications could also be provided. Such a light sensing device may be a broad-spectrum high-speed photodiode that produces a current relative to the amount of light that hits the sensor surface. This current is converted to a voltage, amplified and fed to an analogue-digital converter on the microcontroller. In order to perform a reading the microcontroller turns on one single emitter, for example the red one, reads the voltage from the sensor, then turns on the green, reads the voltage from the sensor and so on. Since this is a high-speed sensor, the entire measurement cycle can be performed in less than 100µs. This measurement cycle can form part of the general PWM control, in a way that the output can be continuously monitored without affecting the quality of the light. Such feedback is useful because the luminance and the colour (the centre wavelength) of each emitter change with age and temperature in a highly non-linear fashion. The feedback sensor helps to stabilise such a high-quality light source.

The emitter feedback assembly may also include the circuitry necessary to process the emitter feedback functionality, however, in this first embodiment of the invention such functionality is integrated within the microcontroller.

The operation of the system illustrated in the Figures shall now be described.

The microcontroller 202 is the main processor and controller of the illumination device 200. The microcontroller 202 is arranged to initialise each of the circuits of the illumination device such that they are in a ready state, that is in a state ready to perform any functionality provided by the illumination device 200. Once the illumination device 200 is initialised it awaits input from the user via the user interface 206 or from the camera via the camera interface 204. The camera 100 can be initialised in a similar way.

Periodically, the illumination device may be calibrated. In particular, because luminance of light emitting sources can vary, and generally degrade overtime, it is advantageous to regularly perform a calibration such that a user of the illumination device obtains expected luminance levels. In this embodiment of the present invention the luminance calibration is performed every time that the illumination device 200 is initialised. However, in alternative embodiments this calibration could be limited to an automatic weekly or monthly occurrence, or alternatively only take place upon specific instructions from the user. Furthermore, calibration could be performed whenever there is a change in a monitored parameter, such as temperature, which could affect the device performance. It will be appreciated that in some circumstances a calibration may not be necessary.

When the calibration takes place the microcontroller 202 instructs the light emitting assembly to cycle through each emitter. That is, each light emitting element of the the light emitting array emits light on its own, with each light emitting element of the emitter array doing this sequentially. The emitter feedback assembly 207 is arranged to capture a part of the emitted light and this captured light is used to calibrate the light emitting elements. In particular, the emitter feedback assembly 207 feeds back the luminance level to the microcontroller 202, which in turn compares the received light level with the expected light level. Furthermore, the microcontroller is able to relate

each light level received from the emitter feedback assembly 207 with a particular emitter of the emitter array of the light emitting assembly 205. Hence, if any of the luminance levels are deemed incorrect then the microcontroller 202 can reset the luminance by adjusting the ON time of the specific light emitting element. Consequently, a fully calibrated emitter array is achieved which emits a stable and constant light.

When the calibration is complete and no instructions to emit light from the light source are received, the light emitting assembly 205 keeps the light emitting elements, or emitters, in an OFF state. At this point the camera interface 204 and the user interface 206 are set to listen for commands from the camera. The state of the device can be displayed for the user via the user interface 206.

At this point the user is able to set the parameters of both the camera 100 and the illumination device 200 via the respective user interfaces. Such settings will control the appearance of the photo taken. The type of settings available were discussed in detail with respect to Figure 1, however, further detail is provided below. It will be appreciated that these settings may include a plurality of preset functions, or may provide specific control for the user to set individual parameters.

At a time when a camera shutter button of the user interface 107 of the camera 100 is engaged, the camera 100 sends a light emission control signal to the illumination device via the external device interface 104 and the camera interface 204. This light emission control signal is a request for the illumination device 200 to control emission of light from the emitters of the light emitting assembly 205. This first control signal is simply a pre-flash message, and instructs the illumination device to emit a short flash. During this pre-flash, the camera measures how much light is reflected from the scene and determines the appropriate exposure. The pre-flash, relay of information ready for re-calculation for the main flash, and the main flash itself all occur very quickly and as such only a single flash would be observed in most cases. It is noted that the sensor assembly 106 of the camera 100 can detect the emitted light. In alternative embodiments of the invention the pre-flash is not carried out.

Once the settings for the photograph are determined by the camera 100, the camera 100 will send a communication message to the illumination device 200. The

communication message may contain a channel number, a shutter speed, a flash duration, a guide number (GN) and/or a variety of other commands from the camera to exchange information about the intended exposure.

When the illumination device 200 receives a communication message from the camera indicating that the camera shutter is opening, the microcontroller of the illumination device instructs the light emitting assembly to start emitting light according to the settings made by the photographer and/or the camera.

The sensor assembly 106 of the camera is then able to receive light including light originating from the illumination device and reflected from the subject 20. The overall photograph taken by the camera can then be stored in memory 103.

In accordance with this first embodiment of the present invention the functionality of the light emitting assembly 205, and the different types of emission possible via the light emitting assembly 205 shall be discussed.

As mentioned above, prior to the exposure the photographer will have entered instructions into the illumination device 200, which include specific control signals and parameters to be applied to the light emitting assembly.

The light emitting assembly 205 is arranged such that it is able to modulate the colour of the light emitted by the emitter array over the exposure time. Furthermore, the light emitting assembly 205 is arranged such that it is able to modulate the colour temperature or the light intensity of the light emitted by the emitter array spatially across the image during the exposure time, or any combination thereof. Such modulation was discussed in more detail with respect to Figure 1.

The illumination device is set up so that the user may individually control the parameters of the above-mentioned functions. For example, the user may control the modulation rate, the range of colour modulation or colour temperature modulation. The illumination device also provides a set of predefined effects having each of these characteristics pre-set. The user may then select one or more of these effects accordingly. Also, the user may apply or 'paint' light onto specific areas of the scene to be photographed, as discussed in more detail above.

In use, prior to exposure, the illumination device 200 receives a communication from the camera 100 as to what amount of light is required to achieve the desired exposure value. This exposure value will have been determined as mentioned above. The microprocessor unit uses this information to calculate an equivalent relative light level. Consequently, when such a time comes that the camera sends a trigger signal to the device indicating that the exposure is starting, the device may not emit a single shot flash, but may emit a changing light during the time period when the shutter is open. When the exposure is over, the illumination device 200 returns to its standby ready mode.

The affect that these effects of the present invention have on the resulting image varies depending on the settings entered by the photographer, the shutter speed of the camera, the relative positioning of the camera 100 and illumination device 200 in relation to the subject 20. The actual perceived effects include but are not limited to: colour gradation effects, strobe effects, a combination of blur and sharpness, and a variation in exposure across the image.

The above-mentioned first embodiment of the present invention talks specifically about use of the present invention when taking still photographs. While such techniques could be applied constantly across a plurality of frames of a moving image, in accordance with a second embodiment of the invention uses specific to video recording shall be described. All those parts of the invention not described herein can be assumed to be the same as the first embodiment.

Video images are the result of a series of still images, taken at a rate such that when played back at the rate they were taken a smooth constant image stream is observed. The frequency of images taken for video images is typically between 24 and 30 frames per second.

When used in video embodiments of the present invention are able to modulate the light over a series of video frames. Different modulation or variation of light characteristics can be provided between each frame, and this modulation may be linear or non-linear, repeating or non-repeating. Some of these effects are discussed below.

A short ramp-up of light intensity with a slow decay during the exposure of each individual frame gives a restlessness and disharmony to, for example, a city scene. Such techniques are great for scenes that portray urgency. Furthermore, a casual viewer may experience the scene as having higher intensity or uneasiness, but will probably not be able point to the exact cause.

A slow-strobing effect can be achieved by, for example, strobing on every other or third frame. Hence, strobing involves varying the light intensity between consecutive frames, or for example on 1 of every x frames. When such a technique is used in lighting something moving through a scene the subject will look unnatural, out of place, on the verge of flickering.

Combining intra-frame modulation techniques with modulation over many frames enables the photographer to, for example, smoothly fade in or out an effect on any part of the scene that is lit by the device.

The above described techniques are a selection of many such techniques which could be applied in accordance with embodiments of the present invention.

This second embodiment of the present invention is, therefore, able to provide a photographer with further available effects. In particular, effects such as simulation of flickering light from a campfire, a TV-set, or a neon tube can be achieved. Furthermore, a number of other lighting effects that may be desirable when recording moving images can be achieved.

While this second embodiment discusses the use of changing modulation characteristics between frames of a video, the same techniques could be used for a series or sequence of still images.

In accordance with a third embodiment of the present invention several illumination devices are used in conjunction. In particular, the illumination devices can be spaced apart and operated together in synchronisation in order to simulate a moving or larger light source. Hence, the photographer may use more than one device to achieve improved or alternative effects.

For example, take the simple example of a campfire. The photographer wants to record a video scene with a couple of actors around a campfire. The natural light from the campfire itself is not suitable for illuminating the actors; it is not strong enough for a proper exposure in camera. So for the actual close-ups, the photographer arranges for a stronger light source. The colour of the light coming from a campfire will vary slightly over time. This effect is possible to simulate well with a single device set to vary the colour gradually within a range with some amount of stochastic motion similar to an actual campfire. A campfire also has a certain physical size; it is not a point sized light source as the device is. If the actors were placed around a campfire in such a way that they cast a shadow onto something, their shadow would flicker somewhat depending on how large the campfire is and how windy it is. A single point sized light source would not be able to simulate the moving shadows, but two or more lights would. Two or more lights could be set to simulate a campfire independently, or they might be synchronised through the external interface.

In practice, this embodiment of the invention can be implemented by a photographer having a laptop where he or she can see the image from the camera. This is a constant feed, like a video feed. The laptop is also connected to a plurality of illumination devices. One of the microcontrollers or microprocessors in this system acts as a master. For example, the microprocessor of the laptop may act as a master, with the equivalent component of the camera / illumination device acting as a slave.

Each of the light sources provided can have an associated light sensor or device camera. By combining the images received from the device cameras, the system is able to determine which parts of the subject are lit by which illumination device. The user is then able to view a representation of the illuminated scene, and the affect of each of the light sources on a single user display screen. Each illumination device can then control the intensity, colour and position of light emitted onto the scene. As such embodiments of the present invention allow for a very finely grained control over the emitted light.

The master can determine how each illumination device affects the scene or subject of interest by any combination of three methods:

1. A diagram of the relative positioning of the illumination devices with respect to the subject, as entered into the system by the operator. In alternative embodiments of the invention the positioning of the illumination devices may be automatically determined by triangulating via wireless radio or such like.

2. By evaluating the images from the cameras built into the illumination devices. Each device sees the scene from a different angle and these images are combined to build a three dimensional representation of the scene.

3. The master commands each device in turn to illuminate the scene or subject by scanning a spot of light from e.g. left to right and/or top to bottom or vice versa. The scanning is done by changing the opacity of the filters correspondingly. The master then sees how each spot of light affects the scene or subject.

The master then has an internal representation of the scene where it is known how each 'pixel of light' from each emitter affects the lighting. The operator can then alter any aspect of the lighting by interacting with the display. Light in areas that form hotspots can be toned down. Unwanted reflections from the forehead of a subject is an example of such an unwanted hotspot. Other typical uses are to increase or decrease the illumination of the background and change its colour. Also, the device may be used to 'paint light' onto a subject in order to change the dynamics and mood of the lighting.

While the above example provides a laptop as the master, it will be appreciated that a laptop is not required. One of the plurality of illumination devices used could act as the master and the user could control all of the illumination devices from the master illumination device.

When an illumination device, or a plurality of illumination devices, is used to illuminate an object that may move, for example a person, feature tracking may be used to constantly correct the internal representation of the scene. If a particular lighting is applied to a particular part of the subject, say a shoulder, feature tracking can help the system maintain the same lighting of the shoulder even when the person moves.

The embodiments of the invention described above, therefore, provide the photographer with control over an image at the point of taking the photo. While post-

production techniques can be used to provide some of these effects, such techniques are expensive to provide because they require specialised technical personnel to carry them out. Hence, an image that requires substantial work in post-production is typically of less value to the customer. The above described embodiments of the invention thus provide means for providing lighting effects without the need for extensive and costly post-production techniques.

In accordance with yet another embodiment of the present invention the emission of light by the illumination device can be synchronised with the opening and closing of the camera shutter in order to save energy.

When a camera records video, it records a number of frames in quick succession. As mentioned previously, the frequency is typically between 24 and 30 frames per second for normal video, but may go significantly slower or faster depending on technical or artistic factors. If the frame rate is, say, 24 frames per second, there is approximately 42 ms between each individual exposure. The exposure time for each individual frame must be shorter than the time between each frame, but is otherwise independent of the frame rate.

The exposure time is set by the camera or by the photographer to a suitable value in order to get the desired exposure based on the available light, in addition to other factors. Typical exposure times may be 1/60 s, 1/125 s or 1/250 s. So in a typical scenario the shutter may be open for 4 to 16 ms during each 42 ms period.

This embodiment of the present invention thus provides an illumination device arranged to only emit light when the shutter is open. Given that when recording video a constant light source is provided, this embodiment saves significant amounts of energy compared to known techniques because light is only emitted during those periods that the shutter is open. As a consequence, the illumination device can be emitting light for much less of the time than systems that employ a constant light source. Energy saving is equal to the ratio of frame rate to exposure time. For a frame rate of 24 fps and a shutter time of 1/60 second, the energy saving is roughly 59%. Hence, for a shutter time of 1/250 second, the energy saving is roughly 88%.

One problem with this energy saving technique is that the frequency at which the illumination device is turned ON/OFF may be visible to the human eye. Humans have individual and varying sensitivity to light flicker. In order to prevent the illumination device causing a flicker, which may be seen as a nuisance by some people, a further embodiment of the present invention involves the device emitting one or more additional light emissions, or blind fires, during the time when the camera shutter is closed. That is, light is emitted for a period shorter than the amount of time the camera shutter is shut, but a significant amount of time such that the frequency of emitted light is increased. This so called flicker reduction mode of the illumination device therefore increases rate at which the flashes take place, thus increasing to the frequency to a rate, for example 48Hz, 72Hz or 96Hz for a 24Hz frame rate, which will not be observable by the human eye. This flicker reduction mode eradicates flicker problems without unduly increasing the time the illumination device is ON.

It will be appreciated that the concept of turning ON/OFF of the light source in synchronisation with the camera shutter can be applied with or without use of the modulation effects and features of previously discussed embodiments. In particular, this energy saving technique could be applied to any technique in order to help reduce energy consumption.

In yet another embodiment of the present invention an ambient light colour compensation mechanism is provided which includes an ambient light sensor and a colour adjusting means. In particular, this embodiment of the present invention relates to adjusting colour temperature in order to correct for photographic discrepancies that can occur when artificial lighting is used, as discussed in more detail below.

Colour temperature is a characteristic of visible light that has important applications in photography and related fields. The colour temperature of a light source is the temperature of an ideal black-body radiator that radiates light of comparable hue to that light source. The temperature is conventionally stated in units of absolute temperature, Kelvin (K). Higher colour temperatures (5,000 K or more) are called cool colours (blueish white); lower colour temperatures (2,700–3,000 K) are called warm colours (yellowish white through red). Domestic light sources, like an incandescent lamp that emits light as a result of thermal radiation, behaves for practical purposes like a black-body radiator in the context of colour temperature.

The absolute or specific colour temperature of the light source that illuminates a scene is not usually critical. Cameras may automatically find the correct white balance, or if not, the photographer can easily do it in post production. However, a problem arises when a scene is lit by two or more light sources with differing colour temperatures. If a warm (low CT) light falls on a person from one side and a cold (high CT) light from the other side, then there is no white balance to be found where all the colours in the image will be correct or natural looking. If the white balance is adjusted such that anything illuminated by the warm light have natural colours, then anything illuminated by the cold light will look pale and ghostly. If the correct colour balance is set for the cold light, then anything lit by the warm light will turn orange and red.

The abovementioned problem limits the conditions under which photographers can take successful pictures when out on location. It is also a severe problem for video recording such as reporting or news gathering.

This embodiment of the present invention provides an illumination device having additional features to compensate for such ambient light problems. In particular, the ambient light colour compensation mechanism of the illumination device has the ability to

a) vary the colour temperature of light emitted by the luminance device,

b) measure the colour temperature of the existing ambient light, and

c) perform the necessary compensation automatically or manually, wherein automatic compensation involves varying of the colour temperature of the emitted light in response to the measured colour temperature.

The ambient light colour compensation mechanism can be provided as a separate processing device or alternatively its functionality can be provided by the microcontroller 202 of the illumination device 200.

The features of the illumination device in accordance with this embodiment of the present invention shall now be described in detail.

The ambient light colour compensation mechanism of the illumination device has a built in colorimeter. This is an assembly of four light sensors, having a red, a blue, a green

and a clear filter respectively. The colour sensor assembly will typically point in the same direction as the light emitter such that it receives light from where the light emitter will be emitting light. The colour sensor measures the red, green and blue components of the existing or ambient light, and the microcontroller uses this information to calculate a corresponding colour temperature. The clear channel is used to measure the overall light level.

The microcontroller receives information regarding the amount of red, green and blue light from the colour sensor assembly. The microcontroller then combines this into an RGB value. The microcontroller uses a 3x3 correlation matrix to transform these values to CIE XYZ tristimulus values. CIE XYZ colour space is a mathematical representation of the human visual system as it relates to colour. The CIE tristimulus values correspond to the sensitivity of a normalized human eye. The human eye has three types of cone cells for colour vision. These cone cells are sensitive to red, green and blue. The XYZ tristimulus values are the relative amounts of red green and blue that makes up a particular colour, adjusted for the sensitivity of the human eye. The correlation matrix is a formula that is used to transform the light values from the ambient light sensor, which does not precisely match the sensitivity of a human eye, into values that correspond to the sensitivity of a human eye.

From the XYZ tristimulus values a further 3:2 transformation is performed to map the values on to a standard 2-dimensional CIE 1931 colour coordinate system. Lastly a calculation is performed in order to find the correlated colour temperature point on the CIE plancian locus, and the offset in the green or magenta direction.

The green/magenta offset is a value used to correct for the effect that is often present when the existing light is not a result of thermal radiation. For example, the sun or an incandescent light bulb emits light as a result of being heated. Light emitted as a result of thermal radiation falls along the plancian locus and ranges from red-ish white through yellowish to blue-ish white. The plancian locus is the range of colours that a black body emits as its temperature rises. These colours lies along a curve in the CIE colour coordinate system.

White light that is not generated as a result of heating, like e.g fluorescent light which is generated by exiting a gas, typically does not fall exactly on the plancian locus but

somewhere nearby. This light will have an additional green or magenta colour component to it. A fluorescent light may for example have a green tint. Similar to above, this tint may not be noticed by a human eye, but may strongly influence a photographic image. This offset from the plancian locus is taken into account by the illumination device in order to mimic the colour of the existing light as closely as possible.

It will be appreciated that while Colour Temperature is the most common way to describe light specifically intended for illumination, the device can measure light of any colour and emit light of any colour (within the constraints of the particular emitters and sensors used).

In alternative embodiments of the present invention a colour sensor of a different construction is utilised. In particular, a diffraction spectrometer is utilised in order to perform the measurements needed to arrive at the correlated colour temperature.

Once the colour sensor measurement values and the calculated values are obtained, these can be used to adjust the light emitter to emit light with the same correlated colour temperature as measured by the colour sensor. The green/magenta offset calculated by the microprocessor is then added.

As the device is capable of emitting light of any colour (within the constraints of the particular emitters used), the device could also mimic a light source with an emission spectrum that falls outside the definition of white light. For example, a pure red light.

In order to be able to measure the existing or ambient light while simultaneously emitting light, the ambient light colour compensation mechanism of the illumination device instructs all the emitters to be turned off for a short period of time. This can be repeated at regular intervals in order to compensate for variations in ambient colour when recording video or a sequence of photographs. The turn off duration is usually about 40µs (typ). This duration is so short that the human eye or camera will not notice that the emitters were turned off, but is sufficiently long for a measurement to be taken. The resulting small loss in average light output due to such turning off of the emitters can be compensated by increasing the light output by an equal amount in the periods between the measurements. The turn off duration is too short for the analog-digital

(AD) converter to perform a complete measurement, so a sample-and hold circuitry is employed in order for the AD converter to complete the integration over several measurement cycles.

The ambient light colour compensation mechanism can also be used to perform further functionality. For example, a photographer using the device may point the illumination device at another light source such that the device mirrors the colour temperature of the other light source. This may, for example, allow for good natural light colour to be achieved because the ambient light colour compensation mechanism can provide light which is an exact copy of natural day light.

Another functionality of the ambient light colour compensation mechanism is that it allows for a photographer to set the illumination device to automatically adjust its correlated colour temperature to the dominant colour temperature in the scene. Alternatively, the photographer could set the device to accentuate a prominent colour temperature in a scene, such the colour emitted by an open fire.

In the following, photography should be taken to mean both still photography and moving images (video). Photographer should be taken to mean both still photographer and videographer.

The camera 100 may be any type of camera which is capable of linking up with an external illumination device or flash. In particular, the camera must have an interface circuit such that the operation of the camera and device can be synchronised. A HDSLR may be preferable, but any camera could be used.

Each of the components of the camera and illumination device may be provided on a respective circuit board or integrated within the individual device. Furthermore, while certain components have been described as separate entities, and other components as performing multiple functions, it will be appreciated that many functionalities could be combined within a single component, or separated into distinct components as appropriate. Furthermore, the overall functionality of the camera and illumination device could be combined into a single unit.

While the invention has primarily been described with respect to use with a digital camera it will be appreciated that the invention would work equally well with an analogue based photographic recording means.

While the above described embodiments of the invention disclose that the functionality of the present invention is incorporated within an illumination device, it will be appreciated that the functionality could also be incorporated within a camera, video camera, or stand alone device. The functionality of the above described invention could be integrated within a camera with or without an illumination device such as a flash. If the camera does not include an illumination device the camera incorporating the functionality of the present invention is arranged to instruct the illumination device when to illuminate. The functionality could also be provided in a stand alone device separate from a camera and an illumination device. Such a stand alone device is arranged to receive control signals from a camera and convert these control signals into new control signals to control the illumination device in accordance with the various embodiments of the present invention set-out above. Hence, the stand alone device acts as an interface between the camera and illumination device.

The term illumination device refers to a camera flash or any other suitable lighting device for use with a camera, video camera, camcorder, mobile phone camera, or any other image recording device.

The present invention can be implemented in dedicated hardware, using a programmable digital controller suitably programmed, or using a combination of hardware and software.

Alternatively, the present invention can be implemented by software or programmable computing apparatus. This includes any computer, or such like. The code for each process in the methods according to the invention may be modular, or may be arranged in an alternative way to perform the same function.

Each of the functionalities of the invention can in whole, or in part, be implemented by the combination of a processor and associated memory, or by a standard computer system. Furthermore, functions described herein as being implemented as part of a single unit may be provided separately, communicatively coupled across a network.

The present invention can encompass a carrier medium carrying machine readable instructions or computer code for controlling a programmable controller, computer or number of computers as the apparatus of the invention. The carrier medium can comprise any storage medium such as a floppy disk, CD ROM, DVD ROM, hard disk, magnetic tape, or programmable memory device, or a transient medium such as an electrical, optical, microwave, RF, electromagnetic, magnetic or acoustical signal. An example of such a signal is an encoded signal carrying a computer code over a communications network, e.g. a TCP/IP signal carrying computer code over an IP network such as the Internet, or an intranet, or a local area network.

It is appreciated that various features of the invention which are, for clarity, described in the contexts of separate embodiments may also be provided in combination in a single embodiment. Conversely, various features of the invention which are, for brevity, described in the context of a single embodiment may also be provided separately or in any suitable subcombination.

It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described hereinabove. Rather the scope of the invention is defined only by the claims.

CLAIMS:

1. A device for use in photography, the device comprising:

a variable filter arranged to vary characteristics of light received from a light source, the variable filter being arranged to emit the varied light onto a subject of an image being recorded; and

a processor arranged to control the variable filter.

2. The device according to claim 1, wherein

the variable filter comprises a plurality of variable filter elements arranged in an array, each filter element arranged to vary the characteristics of the light passing therethrough.

3. The device according to claim 1 or 2, wherein the variable filter is arranged to vary colour characteristics of the light.

4. The device according to any preceding claim, wherein the variable filter is arranged to vary intensity characteristics of the light.

5. The device according to any preceding claim, further comprising:

an optical assembly arranged to focus the light emitted from the variable filter.

6. The device according to any preceding claim, wherein the processor further comprises:

a tracking means arranged to track a position of a feature of the subject of the image being recorded and control the variable filter to vary the characteristics of the light in accordance with the tracking of the feature.

7. The device according to claim 6, wherein the processor is arranged to control the variable filter to vary the characteristics of the light in accordance with the tracking of the feature by applying the same light characteristics to the feature when the feature moves position.

8. A device for use in photography, the device comprising:

an interface for receiving a communication identifying camera characteristics; and

a processor arranged to vary at least one characteristic of light emitted by a light source in accordance with the camera characteristics.

9. The device according to claim 8, wherein the camera characteristics include information identifying a camera shutter opening time, and the processor is arranged to vary the at least one characteristic of the light each time new information identifying a camera shutter opening time is received.

10. The device according to claim 8 or 9, wherein the camera characteristics include information identifying a camera shutter opening period and the processor is arranged to vary the at least one characteristic of the light during the camera shutter opening period.

11. The device according to any one of claims 8 to 10, wherein the at least one characteristic of the light varied by the processor includes a colour characteristic of the light.

12. The device according to any one of claims 8 to 11, wherein the at least one characteristic of the light varied by the processor includes an intensity of the light.

13. The device according to any one of claims 8 to 12, wherein at least one characteristic of the light is varied spatially.

14. The device according to any one of claims 8 to 13, further comprising:

a light source arranged to emit light; and

a filter arranged to vary the at least one characteristic of the light.

15. The device according to claim 14, wherein the filter is a matrix of variable filter elements.

16. A device for use in recording video images, the device comprising:

an interface for receiving one or more communications identifying a plurality of open periods of a camera shutter; and

a controller arranged to instruct a light source to emit light in accordance with the camera shutter open periods.

17. The device according to claim 16, wherein the controller is arranged to instruct the light source to emit light throughout the period when the camera shutter is open.

18. The device according to claim 16 or 17, wherein the one or more communications identifies a camera shutter opening time and a camera shutter opening period.

19. The device according to claim 18, wherein the one or more communications also identifies a frequency of camera shutter opening.

20. The device according to any one of claims 16 to 19, wherein the controller is arranged to instruct the light source to emit light during a portion of the period that the camera shutter is closed.

21. A device for ambient light colour compensation, the device comprising:

a light receiving part arranged to receive a coloured light; and

a light colour compensator arranged to compensate colour characteristics of light to be emitted by a light source in accordance with the received light.

22. The device according to claim 21, wherein the light colour compensator is arranged to compensate for the colour characteristics of the light to be emitted such that the light to be emitted has the same colour characteristics as the received light.

23. The device according to claim 21 or 22, wherein the light receiving part comprises:

a red light sensor arranged to receive red light;

a green light sensor arranged to receive green light;

a blue light sensor arranged to receive blue light; and

a white light sensor arranged to receive all colours of light, wherein the white light sensor is used to determine a received light intensity.

24. The device according to any one of claims 21 to 23, wherein the received light is ambient light falling on a subject to be photographed.

25. The device according to any one of claims 21 to 24, wherein the light colour compensator is arranged to apply an offset of green and/or magenta to the light to be emitted in order to further correct for the colour of light when the colour of light is defined in terms of colour temperature.

26. The device according to any one of claims 21 to 25, wherein the device is arranged to turn off the light source while taking a measurement.

27. A device including two or more of:
the device of any one of claims 1 to 7;
the device of any one of claims 8 to 16;
the device of any one of claims 16 to 20; and
the device of any one of claim 21 to 26.

28. The device according to any preceding claim, wherein the device is an illumination device including a light source.

29. The device according to any preceding claim, wherein the device is a camera.

30. A method for use in photography, the method comprising:
varying, at a variable filter, characteristics of light received from a light source such that the varied light is emitted onto a subject of an image being recorded; and
controlling, at a processor, the variable filter.

31. The method according to claim 30, wherein
the variable filter comprises a plurality of variable filter elements arranged in an array, each filter element arranged to vary the characteristics of the light passing therethrough.

32. The method according to claim 30 or 31, wherein the varying characteristics of the light comprises varying colour characteristics of the light.

33. The method according to any one of claim 30 to 32, wherein the varying characteristics of the light comprises varying intensity characteristics of the light.

34. The method according to any one of claims 30 to 33, further comprising:

focusing, at an optical assembly, light emitted from the variable filter.

35. The method according to any one of claims 30 to 34, further comprising:

tracking, at a a tracking means, a position of a feature of the subject of the image being recorded; and

controlling the variable filter to vary the characteristics of the light in accordance with the tracking of the feature.

36. The method according to claim 35, wherein the step of controlling comprises controlling the variable filter to vary the characteristics of the light in accordance with the tracking of the feature by applying the same light characteristics to the feature when the feature moves position.

37. A method for use in photography, the method comprising:

receiving a communication identifying camera characteristics; and

varying at least one characteristic of light emitted by a light source in accordance with the camera characteristics.

38. The method according to claim 37, wherein the camera characteristics include information identifying a camera shutter opening time, and the method further comprises varying the at least one characteristic of the light each time new information identifying a camera shutter opening time is received.

39. The method according to claim 37 or 38, wherein the camera characteristics include information identifying a camera shutter opening period and the method further comprises varying the at least one characteristic of the light during the camera shutter opening period.

40. The method according to any one of claim 37 to 39, wherein the at least one characteristic of the light which is varied includes a colour characteristic of the light.

41. The method according to any one of claims 37 to 40, wherein the at least one characteristic of the light which is varied includes an intensity of the light.

42. The method according to any one of claims 37 to 41, wherein the at least one characteristic of the light is varied spatially.

43. A method for use in recording video images, the method comprising:

receiving one or more communications identifying a plurality of open periods of a camera shutter; and

instructing a light source to emit light in accordance with the camera shutter open periods.

44. The method according to claim 43, wherein the light source is instructed to emit light throughout the period when the camera shutter is open.

45. The method according to claim 43 or 44, wherein the one or more communications identifies a camera shutter opening time and a camera shutter opening period.

46. The method according to claim 45, wherein the one or more communications also identifies a frequency of camera shutter opening.

47. The method according to any one of claims 43 to 46, further comprising instructing the light source to emit light during a portion of the period that the camera shutter is closed.

48. A method for ambient light colour compensation, the method comprising:

receiving a coloured light; and

compensating colour characteristics of light to be emitted by a light source in accordance with the received light.

49. The method according to claim 48, wherein the step of compensating for the colour characteristics of the light to be emitted is performed such that the light to be emitted has the same colour characteristics as the received light.

50. The method according to claim 48 or 49, wherein the received light is ambient light falling on a subject to be photographed.

51. The method according to any one of claims 48 to 50, further comprising applying an offset of green and/or magenta to the light to be emitted in order to correct for the colour of light when the colour of light is defined in terms of colour temperature.

52. The method according to any one of claims 48 to 51, further comprising turning off the light source while taking a measurement.

53. A method including two or more of:
the method steps of any one of claims 30 to 36;
the method steps of any one of claims 37 to 42;
the method steps of any one of claims 43 to 47; and
the method steps of any one of claim 48 to 52.

54. A carrier medium carrying computer readable code for configuring a suitable computer as the apparatus of any of claims 1 to 29.

55. A carrier medium carrying computer readable code for controlling a suitable computer to carry out the method of any one of claims 30 to 53.

Application No:	GB1013323.9	**Examiner:**	Richard Nicholls
Claims searched:	1-7,27-29,30-36,53-55	**Date of search:**	30 December 2010

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1 and 30 at least	JP2010085952 A (HITACHI) see especially the abstract
X	1 and 30 at least	JP2003207825 A (FUJI) see especially the abstract
X	1 and 30 at least	JP2002244181 A (NIKON) see especially the abstract
X	1 and 30 at least	EP0678701 A1 (PANAVISION) see especially variable filter 50
X	1 and 30 at least	WO93/24786 A1 (PANAVISION) see especially variable filter 50

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

F21V; G03B

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

International Classification:

Subclass	Subgroup	Valid From
None		

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Further Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	16 and 43 at least	JP2006349833 A (CANON) see especially the abstract

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Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

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Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	21 and 48 at least	EP2148503 A1 (RIM) see especially figure 6
X	21 and 48 at least	US2003/007800 A1 (FUJI) see especially figure 11
X	21 and 48 at least	GB2292498 A (SAMSUNG) see whole document
X	21 and 48 least	US5815204 A (ASAHI) see especially the abstract

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

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G03B; H04N

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International Classification:

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Category	Relevant to claims	Identity of document and passage or figure of particular relevance
		None

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G03B

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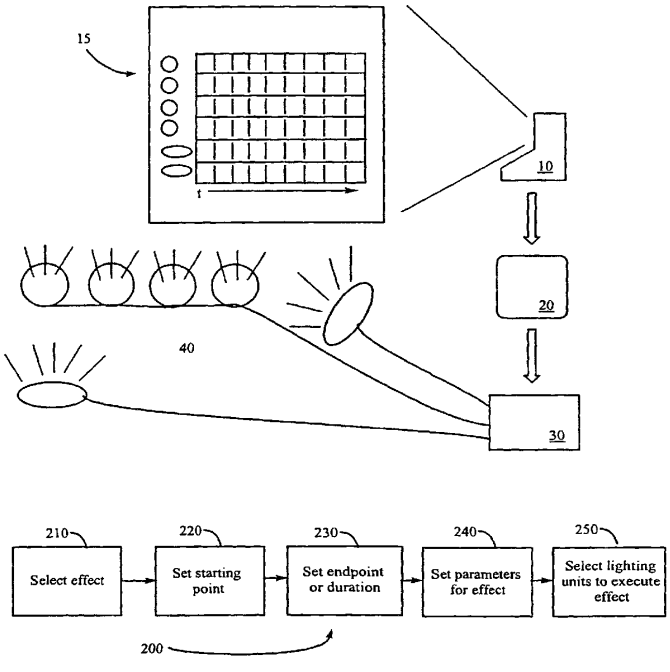
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(54) Title: SYSTEMS AND METHODS FOR AUTHORING LIGHTING SEQUENCES



(57) Abstract: The system and methods described herein relate in part to intuitive methods for creation and design of lighting sequences, e.g., for theatrical, entertainment, or advertising purposes, using a software interface. Additionally, the lighting sequences can be coordinated with control of additional devices. Also described herein is a controller capable of executing programs for lighting sequences and modifying the output and/or execution of the program based on external signals. In this way, the final output can be made responsive to external stimuli, or even interactive.

WO 01/05195 A1

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SYSTEMS AND METHODS FOR AUTHORING LIGHTING SEQUENCES

This application is based on, and claims the benefit of, U.S. Provisional Application No. 60/143,790, filed July 14, 1999.

Field of the Invention

The present invention relates generally to systems and methods for controlling lighting systems, and more particularly to computerized systems and methods for designing lighting sequences and executing such sequences on lighting systems.

Background of the Invention

Most modern-day lighting controllers are designed to control white light (or monochromatic light) in a theatrical or high-end business setting. A light producing monochromatic light, such as white, blue, or red, can be changed primarily along a single dimension – brightness – from off to a maximum brightness. Current controllers permit a user to specify a brightness for each light over time.

This method becomes increasingly more complicated for lights capable of changing the color of emitted light, because the resulting color and intensity is a combination of the intensity of three component primary colors, each of which can be set independent of the others for a particular light. Thus, the output is a function of three dimensions, rather than one, to be specified for each point in time, greatly increasing the effort and time involved in creating an effect. U.S. Patent No. 5,307,295 to Taylor et al. describes a system for creating lighting sequences which simplifies some aspects of creating a lighting sequence, but many of the parameters still need to be specified for each light, much as they would be on a standard lighting console. A more intuitive method for designing lighting sequences would not only simplify and speed up the designing process, but would permit users to design lighting sequences with less training and experience than is often necessary today.

Furthermore, although sequences can be created and played back by traditional methods, the content of the sequences typically progresses with time and is not subject to modification during playback. For example, if a dramatic scene requires a flash of lightning to be simulated at a certain time, this effect is typically achieved either by

meticulously timing the staging to make the programmed flash and the critical moment coincide, or by manually effecting the flash at the critical moment. Such techniques either require considerable reliance on chance or preclude reliance on automation.

A technique that permits an intuitive approach to designing lighting sequences would reduce the time and training required to achieve a desired effect, and would permit colored lights to be operated with a minimal impact on efficiency. Additionally, a method for executing such lighting sequences that promotes flexibility in the reproduction of the sequence will permit increased freedom in an associated performance, or allow use of programmed lighting sequences in situations which are inherently unpredictable.

Summary of the Invention

The systems and methods described herein relate to an intuitive interface for the design of lighting sequences, such as by providing a visual representation of a sequence as it is being designed. Additionally, the systems and methods described herein relate to reproduction of programmed lighting sequences such that the sequence can be modified during playback, e.g., based on external stimuli or cues.

A system for preparing a light sequence according to the principles of the invention may include an authoring interface displaying information representative of a plurality of lighting effects, and a sequence authoring module to permit a user to select a lighting effect, a lighting unit to execute the lighting effect, a start time for the lighting effect, and a stop time for the lighting effect.

A method for preparing a lighting sequence capable of being executed by a processor according to the principles of the invention may include providing a processor interface including information representative of a plurality of lighting effects, receiving information representative of a lighting unit, receiving information representative of a first lighting effect to be executed by the lighting unit, receiving information representative of a start time for the first lighting effect, and receiving information representative of a stop time for the first lighting effect.

In another aspect, a system for controlling a plurality of lighting units according to the principles of the invention may include a data interface for receiving instructions

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for controlling a plurality of lighting units, a signal interface for receiving external signals, a processor for converting said instructions to a data stream and for altering the conversion of said instructions based on the external signals received, and a data output for transmitting the data stream to a plurality of lighting units.

In another aspect, a method for controlling a plurality of lighting units according to the principles of the invention may include receiving instructions for controlling a plurality of lighting units, receiving external signals, converting said instructions to a data stream based on the external signals received, and transmitting the data stream to a plurality of lighting units.

In another aspect, a method for controlling a plurality of lighting units according to the principles of the invention may include receiving instructions including a primary lighting effect and a secondary lighting effect, the secondary lighting effect designated to be executed instead of the primary lighting effect upon a predetermined condition, sending instructions to a lighting unit to execute the primary lighting effect, receiving a signal indicative of the predetermined condition, and sending instructions to the lighting unit to execute the secondary lighting effect.

In another aspect, a method for controlling a plurality of lighting units according to the invention may include receiving instructions for executing a timed sequence of lighting effects, executing the sequence of lighting effects utilizing a plurality of lighting units, receiving an external signal, and altering the execution of the sequence of lighting effects.

Brief Description of the Figures

The following figures depict certain illustrative embodiments of the invention in which like reference numerals refer to like elements. These depicted embodiments are to be understood as illustrative of the invention and not as limiting in any way.

Figure 1 illustrates a system for creating a lighting sequence and executing the lighting sequence on a plurality of lighting units as described herein.

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Figure 2 presents an exemplary method for creating a lighting effect as described herein.

Figure 3 depicts a representative interface for describing an arrangement of lighting units.

Figure 4 represents an alternate interface for graphically reproducing a lighting sequence.

Figure 5 portrays a representative interface for creating a lighting sequence as described herein.

Figure 6 shows one embodiment of a controller for executing a lighting sequence as described herein.

Detailed Description of the Illustrated Embodiments

The description below pertains to several illustrative embodiments of the invention. Although many variations of the invention may be envisioned by one skilled in the art, such variations and improvements are intended to fall within the compass of this disclosure. Thus, the scope of the invention is not to be limited in any way by the disclosure below. The terms "sequence" or "light sequence", as used herein, are intended to refer to sequential displays, as well as non-sequential displays, flow-controlled displays, interrupt driven or event driven displays, or any other controlled, overlapping, or sequential displays with one or more lights.

The systems and methods described herein relate to a system, such as a processor 10 supporting a software application having an interface 15, as depicted in Figure 1, with which a user may create a lighting program 20, which may include one or more lighting sequences, capable of being executed by a lighting controller 30 which controls one or more lighting units 40. The term "sequence" in the context of this disclosure is used to refer to any pattern, show, sequence, arrangement or collection of commands used to operate lighting units or other devices through the system. One of skill in the art would recognize that a sequence would also not need to be an ordered sequence or have a linear design. Sequences comprising non-linear, priority-based, and/or overlapping commands may still comprise a sequence. The software application may be a stand-alone application, such as an executable image of a C++ or Fortran program or other

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executable code and/or libraries, or may be implemented in conjunction with or accessible by a Web browser, e.g., as a Java applet or one or more HTML web pages, etc. Processor 10 may be any system for processing in response to a signal or data and should be understood to encompass microprocessors, microcontrollers, other integrated circuits, computer software, computer hardware, electrical circuits, application-specific integrated circuits, personal computers, chips, and other devices alone or in combination capable of providing processing functions. For example, processor 10 can be any suitable data processing platform, such as a conventional IBM PC workstation operating the Windows operating system, or a SUN workstation operating a version of the Unix operating system, such as Solaris, or any other suitable workstation. Controller 30 may communicate with lighting units 40 by radio frequency (RF), ultrasonic, auditory, infrared (IR), optical, microwave, laser, electromagnetic, or any other transmission or connection method or system. Any suitable protocol may be used for transmission, including pulse-width modulated signals such as DMX, RS-485, RS-232, or any other suitable protocol. Lighting units 40 may be incandescent, LED, fluorescent, halogen, laser, or any other type of light source, e.g., configured so that each lighting unit is associated with a predetermined assigned address either unique to that lighting unit or overlapping the address of other lighting units. In certain embodiments, a single component may be capable both of permitting a user to create a lighting program and controlling the lighting units, and the present invention is intended to encompass this and other variations on the system depicted in Figure 1 which can be used to implement the methods described below. In certain embodiments, the functions of the software application may be provided by a hardware device, such as a chip or card, or any other system capable of providing any of the functions described herein.

According to a method 200 for creating a lighting sequence set forth in Figure 2, a user may select from among a set of predetermined 'stock' effects 210. The stock effects function as discrete elements or building blocks useful for assembling a sequence. Additionally, a user may compose a particular sequence and include that sequence in the stock effects to eliminate the need for creating repeated elements *de novo* each time the effect is desired. For example, the set of stock effects may include a dimming effect and a brightening effect. A user may compose a pulse effect by specifying the alternation of the dimming and brightening effects, and include the pulse effect in the set of stock effects. Thus, each time a pulse effect is thereafter required, the

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stock effect can be utilized without the need for repeatedly selecting dimming and brightening effects to achieve the same goal. In certain embodiments, stock effects may also be created by a user via any programming language, such as Java, C, C++, or any other suitable language. Effects may be added to the set of stock effects by providing the effects as plug-ins, by including the effects in an effects file, or by any other technique suitable for organizing effects in a manner that permits adding, deleting, and altering the set of effects.

Additionally, a user may select an effect and indicate a time at which that effect should begin 220. For example, the user may indicate that a brightening effect should start three minutes after a sequence commences. Additionally, the user may select an ending time or duration for the effect 230. Thus, by indicating that the effect should end five minutes after the sequence commences, or equivalently by indicating that the effect should last for two minutes, a user may set the time parameters of the brightening effect. Additional parameters may be specified by the user, as may be appropriate for the particular effect 240. For example, a brightening or dimming effect may be further defined by an initial brightness and an ending brightness. The rate of change may be predetermined, i.e., the dimming effect may apply a linear rate of dimming over the assigned timespan, or may be alterable by the user, e.g., may permit slow dimming at the beginning followed by a rapid drop-off, or by any other scheme the user specifies. Similarly, a pulse effect, as described above, might instead by characterized by a maximum brightness, a minimum brightness, and a periodicity, or rate of alternation. Additionally, the mode of alternation may be alterable by the user, e.g., the changes in brightness may reflect a sine function or alternating linear changes. In embodiments wherein color-changing lights are employed, parameters such as initial color, final color, rate of change, etc. may be specified by the user. Many additional effects and suitable parameters therefor are known or will be apparent to those of skill in the art, and fall within the scope of this disclosure.

In certain embodiments, a user may specify a transition between two effects which occur in sequence. For example, when a pulse effect is followed by a dimming effect, the pulse effect may alternate less rapidly, grow gradually dimmer, or vary less between maximum and minimum brightness towards the termination of the effect. Techniques for transitioning between these or other may be determined by the user for

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each transition, e.g., by selecting a transition effect from a set of predetermined transition effects, or by setting transition parameters for the beginning and/or end of one or both effects.

In a further embodiment, users may specify multiple lighting effects for the same lighting unit that place effects overlapping in time or in location. These overlapping effects may be used in an additive or subtractive manner such that the multiple effects interact with each other. For example, a user could impose a brightening effect on a pulsing effect the brightening effect imposing the minimum brightness parameter of the pulse to give the effect of pulsing slowly growing to a steady light.

In another embodiment, the overlapping lighting effects could have priorities or cues attached to them which could allow a particular lighting unit to change effect on the receipt of a cue. This cue could be any type of cue, received externally or internally to the system, and includes, but is not limited to, a user-triggered cue such as a manual switch or bump button; a user-defined cue such as a certain keystroke combination or a timing key allowing a user to tap or pace for a certain effect; a cue generated by the system such as an internal clocking mechanism, an internal memory one, or a software based one; a mechanical cue generated from an analog or digital device attached to the system such as a clock, external light sensor, music synchronization device, sound level detection device, or a manual device such as a switch; a cue received over a transmission medium such as an electrical wire or cable, RF signal or IR signal; or a cue received from a lighting unit attached to the system. The priority could allow the system to choose a default priority effect that is the effect used by the lighting unit unless a particular cue is received, at which point the system instructs the use of a different effect. This change of effect could be temporary occurring only while the cue occurs or defined for a specified period, could be permanent not allowing for further receipt of other effects or cues, or could be priority based, waiting for a new cue to return to the original effect or select a new one. Alternatively, the system could select effects based on the state of a cue and the importance of a desired effect. For instance, if a sound sensor sensed sudden noise, it could trigger a high priority alarm lighting effect overriding all the effects otherwise present or awaiting execution. The priority could also be state dependent where a cue selects an alternative effect or is ignored depending on the current state of the system.

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In certain embodiments, the outcome of one effect may be programmed to depend upon a second effect. For example, an effect assigned to one lighting unit may be a random color effect, and an effect assigned to a second lighting unit may be designated to match the color of the random color effect. Alternatively, one lighting unit may be programmed to execute an effect, such as a flashing effect, whenever a second lighting unit meets a certain condition, such as being turned off. Even more complex arrangements, such as an effect which is initiated upon a certain condition of one effect, matches the color of another effect, the rate of a third effect, can be created by this scheme. Other combinations of effects wherein at least one parameter or occurrence of an effect is dependent on a parameter or occurrence of a second effect will be apparent to those of skill in the art and are intended to fall within the scope of this disclosure.

In still other embodiments, the systems and methods described herein permit a lighting sequence to be influenced by external inputs during performance. For example, a lighting sequence or effect may be programmed to start upon receipt of a trigger signal, a sequence or effect may take precedence if a signal is received, a sequence or effect may be designated to repeat or continue until a signal is received, etc. Thus, instead of assigning a discrete start time to an effect or sequence, a user may instead designate that effect or sequence to begin when a certain stimulus is received. Furthermore, during creation, a user may designate two or more effects for overlapping or concurrent time periods and assign the effects different priorities or conditions to determine which effect is executed upon playback. In yet another embodiment, a user may link a parameter for an effect to an external input, including analog, digital and manual inputs, such that the color, speed, or other attribute of an effect may depend on a signal from an external device, measuring, for example, volume, brightness, temperature, pitch, inclination, wave length, or any other appropriate condition. Thus, the selection of a lighting sequence, the selection of an effect, or the selection of a parameter may be determined or influenced by input from an external source, such as a user, chronometer, device, or sensor.

In event-driven embodiments, such as those using external inputs and those using outputs of other effects as inputs, a menu may be provided to define inputs and the consequences thereof. For example, a palette of predetermined inputs may be provided to a user. Each input, such as a specified transducer or the output of another effect, may

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be selected and placed within an authored lighting sequence as a trigger for a new effect, or as a trigger to a variation in an existing effect. Known inputs may include, for example, thermistors, clocks, keyboards, numeric keypads, Musical Instrument Digital Interface ("MIDI") inputs, DMX control signals, TTL or CMOS logical signals, other visual or audio signals, or any other protocol, standard, or other signaling or control technique having a predetermined form whether analog, digital, manual, or any other form. The palette may also include a custom input, represented as, for example, an icon in a palette, or an option in a drop-down menu. The custom input may allow a user to define the voltage, current, duration, and/or form (i.e., sinusoid, pulse, step, modulation) for an input signal that will operate as a control or trigger in a sequence.

For instance, a theatrical lighting sequence may include programmed lighting sequences and special effects in the order in which they occur, but requiring input at specified points before the next sequence or portion thereof is executed. In this way, scene changes may take place not automatically as a function of timing alone, but at the cue of a director, producer, stage hand, or other participant. Similarly, effects which need to be timed with an action on the stage, such as brightening when an actor lights a candle or flips a switch, dramatic flashes of lightning, etc., can be indicated precisely by a director, producer, stage hand, or other participant - even an actor - thereby reducing the difficulty and risk of relying on preprogrammed timing alone.

Input from sensors can also be used to modify lighting sequences. For example, a light sensor may be used to modify the brightness of the lights, for example, to maintain a constant lighting level regardless of the amount of sunlight entering a room, or to make sure a lighting effect is prominent despite the presence of other sources of light. A motion sensor or other detector may be used as a trigger to start or alter a lighting sequence. For example, a user may program a lighting sequence for advertising or display purposes to change when a person approaches a sales counter or display. Temperature sensors may also be used to provide input. For example, the color of light in a freezer may be programmed to be dependent on temperature, e.g., providing blue light to indicate cold temperature, changing gradually to red as the temperature rises, until a critical temperature is reached, whereupon a flashing or other warning effect may begin. Similarly, an alarm system may be used to provide a signal that triggers a lighting sequence or effect for providing a warning, distress signal, or other indication. An

interactive lighting sequence may be created, e.g., wherein the executed effect varies according to a person's position, movements, or other actions.

In certain embodiments, a user may provide information representative of the number and types of lighting units and the spatial relationships between them. For example, an interface 300 may be provided as depicted in Figure 3, such as a grid or other two-dimensional array, that permits the user to arrange icons or other representative elements to represent the arrangement of the lighting units being used. In one embodiment, depicted in Figure 3, the interface 300 provides to a user a selection of standard types of lighting units 310, e.g., cove lights, lamps, spotlights, etc., such as by providing a selection of types of lighting units in a menu, on a palette, on a toolbar, etc. The user may then select and arrange the lighting units on the interface, e.g., within layout space 320 in an arrangement which approximates the physical arrangement of the actual lighting units.

In certain embodiments, the lighting units may be organized into different groups, e.g., to facilitate manipulation of a large number of lighting units. Lighting units may be organized into groups based on spatial relationships, functional relationships, types of lighting units, or any other scheme desired by the user. Spatial arrangements can be helpful for entering and carrying out lighting effects easily. For example, if a group of lights are arranged in a row and this information is provided to the system, the system can then implement effects such as a rainbow or a sequential flash without need for a user to specify a separate and individual program for each lighting unit. All the above types of implementation or effects could be used on a group of units as well as on single lighting units. The use of groups can also allow a user to enter a single commend or cue to control a predetermined selection of lighting units.

A lighting sequence can be tested or executed on a lighting system to experience the effects created by the user. Additionally, the interface 300 may be capable of reproducing a lighting sequence created by the user, for example, by recreating the programmed effects as though the icons on the interface were the lighting units to be controlled. Thus, if a lighting sequence specified that a certain lighting unit gradually brightens to a medium intensity, upon playback, the icon representing that lighting unit may start black and gradually lighten to gray. Similarly, color changes, flashing, and other effects can be visually represented on the interface. This function may permit a

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user to present a wholly or partially created lighting sequence on a monitor or other video terminal, pause playback, and modify the lighting sequence before resuming playback, to provide a highly interactive method for show creation. In a further embodiment, the system could allow fast-forwarding, reversing, rewinding, or other functions to allow editing of any portion of the lighting sequence. In a still further embodiment, the system could use additional interface features like those known in the art. This can include, but is not limited to, non-linear editing such as that used in the Adobe or such devices or controls as scrolls, drag bars, or other devices and controls.

An alternate interface 400 for reproducing a lighting sequence is presented in Figure 4. Interface 400 includes representations of lighting elements 410 and playback controls 420. Other techniques for visualizing a lighting sequence will be apparent to those of skill in the art and may be employed without departing from the scope and spirit of this disclosure.

An interface capable of representing the lighting sequence may also be used during entry of the lighting sequence. For example, a grid, such as interface 15 of Figure 1, may be employed, wherein available lighting units are represented along one axis and time is represented along a second axis. Thus, when a user specifies that a certain lighting unit gradually brightens to a medium intensity, the portion of the grid defined by that lighting unit, the start time, and the ending time may appear black at one end of the grid portion and gradually lighten to gray at the other end of the grid portion. In this way, the effect can be visually represented to the user on the interface as the lighting sequence is being created. In certain embodiments, effects that are difficult to represent with a static representation, such as flashing, random color changes, etc., can be represented kinetically on the interface, e.g., by flashing or randomly changing the color of the defined grid portion. An example of an interface 500 representing a sequence for an assortment of three lighting units are shown in Figure 5. Time chart 510 visually depicts the output of each of the three lights at each moment in time according to the temporal axis 515. At a glance, the user can readily determine what effect is assigned to any lighting unit at any point in time, simplifying the coordination of effects across multiple lighting units and allowing rapid review of the lighting sequence.

Additionally, Figure 5 depicts a palette 520 which includes the stock effects from which a user may select lighting effects, although other techniques for providing the set

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of stock effects, such as by a menu, toolbar, etc., may be employed in the systems and methods described herein. In palette 520 there are provided icons for stock effects for the lighting of a fixed color effect 552, a cross fade between two color effects 554, a random color effect 558, a color high effect 560, a chasing rainbow effect 565, a strobe effect 564, and a sparkle effect 568. This list is by no means exhaustive and other types of effects could be included as would be obvious to one of skill in the art. To assign an effect to a lighting unit, the user may select an effect from the palette and select a region of the grid corresponding to the appropriate lighting unit or units and the desired time interval for the effect. Additional parameters may be set by any suitable technique, such as by entering numerical values, selecting options from a palette, menu, or toolbar, drawing a vector, or any other technique known in the art, such as the parameter entry field 525. Other interfaces and techniques for entry of lighting sequences suitable for performing some or all of the various functions described herein may be used and are intended to be encompassed by the scope of this disclosure.

The methods described above can be readily adapted for controlling units other than lighting units. For example, in a theatrical setting, fog machines, sound effects, wind machines, curtains, bubble machines, projectors, stage practicals, stage elevators, pyrotechnical devices, backdrops, and any other features capable of being controlled by a computer may be controlled by a sequence as described herein. In this way, multiple events can be automated and timed. For example, the user may program the lights to begin to brighten as the curtain goes up, followed by the sound of a gunshot as the fog rolls over the stage. In a home, for example, a program can be used to turn on lights and sound an alarm at 7:00 and turn on a coffee maker fifteen minutes later. Holiday lighting arrays, e.g., on trees or houses, can be synchronized with the motion of mechanical figurines or musical recordings. An exhibit or amusement ride can coordinate precipitation, wind, sound, and lights in a simulated thunderstorm. A greenhouse, livestock barn, or other setting for growing living entities can synchronize ambient lighting with automated feeding and watering devices. Any combination of electromechanical devices can be timed and/or coordinated by the systems and methods described herein. Such devices may be represented on an interface for creating the sequence as additional lines on a grid, e.g., one line for each separate component being controlled, or by any other suitable means. Effects of these other devices can also be visually represented to the user. For instance, continued use of a smoke machine could

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slowly haze out other grids, a coffee maker could be represented by a small representation of a coffee maker that appears to brew coffee on the interface as the action occurs at the device or the interface can show a bar slowing changing color as feed is dispensed in a livestock barn. Other such static or dynamic effects would be readily apparent to one of skill in the art and are all incorporated within this disclosure.

In certain embodiments, wherein the lighting units are capable of motion, e.g., by sliding, pivoting, rotating, tilting, etc., the user may include instructions for the motion or movement of lighting units. This function may be accomplished by any means. For example, if the lighting unit includes a motor or other system capable of causing movement, the desired movement may be effected by selecting a motion effect from a set of motion effects, as described for lighting effects above. Thus, for example, a lighting unit capable of rotating on its base may be selected, and a rainbow wash effect may be programmed to occur simultaneously with a rotating motion effect. In other embodiments, lighting units may be mounted on movable platforms or supports which can be controlled independently of the lights, e.g., by providing an additional line on a grid interface as described above. Motion effects may also have parameters, such as speed and amount (e.g., an angle, a distance, etc.), that can be specified by the user. Such light/motion combinations may be useful in a wide variety of situations, such as light shows, planetarium presentations, moving spotlights, and any other scenario in which programmable moving lights may be desirable.

Similarly, instructions for controlling objects placed between a lighting unit and an object being illuminated, such as gobos, stencils, filters, lenses, irises and other objects through which light may pass, can be provided by a user according to the systems and methods described herein. In this manner, an even wider array of lighting effects may be designed and preprogrammed for later execution.

One embodiment of the systems and methods described herein is a computer system, such as processor 10 depicted in Figure 1, configured to design or create a lighting sequence according to the systems and methods described herein, e.g., by executing a computer program in a computer language either interpreted or compiled, e.g., Fortran, C, Java, C++, etc. In an additional embodiment, the systems and methods described herein relate to a disk, CD, or other permanent computer-readable storage medium that encodes a computer program capable of performing some or all of the

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functions described above which enable a user to create or design a lighting sequence which can be used to control a plurality of lighting units.

A lighting sequence may be recorded on a storage medium, such as a compact disk, floppy disk, hard drive, magnetic tape, volatile or non-volatile solid state memory device, or any other permanent computer-readable storage medium. The lighting sequence may be stored in a manner that records the effects and their parameters as created by a user, in a manner that converts that format into a format which represents the final data stream, e.g., suitable for directly controlling lighting units or other devices, or in any other format suitable for executing the lighting sequence. In embodiments wherein the sequence is stored as a data stream, the system may permit a user to choose from a selection of data formats such as DMX, RS-485, RS-232, etc. Additionally, lighting sequences may be linked to each other, e.g., such that at the conclusion of one sequence, another sequence is executed, or a master sequence may be created for coordinating the execution of a plurality of subsequences, e.g., based on external signals, conditions, time, randomly, etc. In certain embodiments, a lighting sequence 20 may be executed directly from a processor 10, although in other embodiments, a lighting sequence 20 may be executed using a controller 30 as described below.

A controller 30, as depicted in Figure 6, may be used to execute lighting sequences 20 which have been programmed, designed, or created on a different apparatus. Because the controller 30 may provide a narrower range of functions than the processor used to create the sequence, the controller 30 may contain less hardware and be less expensive than a more complex system which permits authoring, includes a video monitor, or has other auxiliary functionality. The controller 30 may employ any suitable loader interface 610 for receiving a lighting program 20, e.g., an interface for reading a lighting program 20 from a storage medium such as a compact disk, diskette, magnetic tape, smart card, or other device, or an interface for receiving a transmission from another system, such as a serial port, USB port, parallel port, IR receiver, or other connection for receiving a lighting program 20. In certain embodiments, the lighting program 20 may be transmitted over the Internet. The controller 30 may also include an interface for communicating with a plurality of lighting units 40.

A controller 30 may begin execution of a lighting sequence 20 upon loading the lighting sequence 20, upon receiving a command or signal from a user or a device or

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sensor, at a specified time, or upon any other suitable condition. The condition for initiation may be included in the lighting sequence 20, or may be determined by the configuration of the controller 30. Additionally, in certain embodiments, the controller may begin execution of a lighting sequence 20 starting from a point in the middle of the lighting sequence 20. For example, the controller 30 may, upon receiving a request from the user, execute a lighting sequence 20 starting from a point three minutes from the beginning of the sequence, or at any other specified point, e.g., from the fifth effect, etc. The controller 30 may, upon receiving a signal from a user or a device or sensor, pause the playback, and, upon receiving a suitable signal, resume playback from the point of pausing. The controller may continue to execute the lighting sequence 20 until the sequence terminates, until a command or signal is received from a user or a device or sensor, until a specified time, or until any other suitable condition.

A controller 30 may include a memory unit, database, or other suitable module 620 for storing a plurality of predetermined stock effects and instructions for converting those effects into a data format, such as DMX, RS-485, or RS-232, suitable for controlling a plurality of lighting units. The memory module 620 may be preconfigured for a set of stock effects, the memory module 620 may receive effects and instructions from the lighting sequence 20, or the memory module 620 may include a preconfigured set of stock effects which can be supplemented by additional effects stored in lighting sequence 20. Preconfiguring the memory module 620 with a set of stock effects permits a reduction in the memory required to store a lighting sequence 20, because the lighting sequence 20 may omit conversion instructions for effects preconfigured into the controller 30. In embodiments wherein the lighting sequence 20 includes stock effects designed by the author, suitable instructions may be included in lighting sequence 20 and stored in memory module 620, e.g., upon loading or execution of the lighting sequence 20.

The controller 30 may include an external interface 650 whereby the controller 30 can receive external signals useful for modifying the execution of the lighting sequence 20. For example, the external interface 650 may include a user interface, which may in turn include switches, buttons, dials, sliders, a console, a keyboard, or any other device, such as a sensor, whereby a user may provide a command or signal to the controller 30 or otherwise influence the execution or output of the lighting sequence 20.

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The external interface 650 may receive temporal information from one or more chronometers, such as a local time module 660 which functions as a counter for measuring time from a predetermined starting point, such as when the controller 30 is turned on or when the counter is reset, or a date time module 665 which calculates the current date and time. Additionally, the controller 30 may receive commands or signals from one or more external devices or sensors through external input 668. Such devices may be coupled to controller 30 directly, or signals may be received by the controller through an IR sensor or other suitable interface. Signals received by the controller 30 may be compared to or interpreted by a cue table 630, which may contain information relating to the various inputs or conditions designated by the author of the lighting sequence 20 to affect the execution or output of the lighting sequence 20. Thus, if the controller 30 compares an input to the cue table 630 and determines that a condition has been satisfied or a designated signal has been received, the controller 30 may then alter the execution or output of the lighting sequence 20 as indicated by the program.

In certain embodiments, the controller may respond to external signals in ways that are not determined by the contents and instructions of the lighting sequence 20. For example, the external interface 650 may include a dial, slider, or other feature by which a user may alter the rate of progression of the lighting sequence 20, e.g., by changing the speed of the local time counter 660, or by altering the interpretation of this counter by the controller 30. Similarly, the external interface 650 may include a feature by which a user may adjust the brightness, color, or other characteristic of the output. In certain embodiments, a lighting sequence 20 may include instructions to receive a parameter for an effect from a feature or other user interface on the external interface 650, permitting user control over specific effects during playback, rather than over the output or system of lighting units as a whole.

The controller 30 may also include a transient memory 640. The transient memory 640 may store temporary information, such as the current state of each lighting unit under its control, which may be useful as a reference for the execution of the lighting sequence 20. For example, as described above, some effects may use output of another effect to define a parameter; such effects may retrieve the output of the other effect as it is stored in the transient memory 640. Those of skill in the art will recognize

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other situations in which a transient memory 640 may be useful, and such uses are intended to be encompassed by the present disclosure.

The controller 30 may send the data created by the execution of lighting sequence 20 to lighting units by providing the data to a network output 680, optionally through the intermediacy of an output buffer 670. Signals to additional devices may be transmitted through the network out put 680, or through a separate external output 662, as convenient or desirable. The data may be transmitted through data connections such as wires or cables, as IR or RF transmissions, other suitable methods for data transfer, or any combination of methods capable of controlling lighting units and/or other devices.

In certain embodiments, the controller 30 may not communicate directly with the lighting units, but may instead communicate with one or more subcontrollers which, in turn, control the lighting units or another level of subcontrollers, etc. The use of subcontrollers permits distributive allocation of computational requirements. An example of such a system which uses this sort of distributional scheme is disclosed in U.S. Patent No. 5,769,527 to Taylor, described therein as a "master/slave" control system. For the systems and methods described herein, communication between the various levels may be unidirectional, wherein the controller 30 provides instructions or subroutines to be executed by the subcontrollers, or bidirectional, where subcontrollers relay information back to the controller 30, for example, to provide information useful for effects which rely on the output of other effects as described above, for synchronization, or for any other conceivable purpose.

Although the description above illustrates one particular configuration of a controller 30, other configurations for achieving the same or similar functions will be apparent to those of skill in the art, and such variations and modifications are intended to be encompassed by the present invention. The example below more particularly describes an embodiment of a controller 30 such as described above.

The following describes one embodiment of a controller according to the systems and methods described herein, as exemplified in Figure 6, including the design and format of a show representation, management of external inputs and outputs, interpretation and execution of shows, and generation of DMX compliant output. The controller architecture of this embodiment uses a Java-based object-oriented design;

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however, other object-oriented, structured, or other programming languages may be used with the invention.

The controller architecture permits effects to be based on external environmental conditions or other input. An effect is a predetermined output involving one or more lighting units. For example, fixed color, color wash, and rainbow wash are all types of effects. An effect may be further defined by one or more *parameters,* which specify, for example, lights to control, colors to use, speed of the effect, or other aspects of an effect. The *environment* refers to any external information that may be used as an input to modify or control an effect, such as the current time or external inputs such as switches, buttons, or other transducers capable of generating control signals, or events generated by other software or effects. Finally, an effect may contain one or more *states*, so that the effect can retain information over the course of time. A combination of the state, the environment, and the parameters may be used to fully define the output of an effect at any moment in time, and over the passage of time

In addition, the controller may implement effect priorities. For example, different effects may be assigned to the same lights. By utilizing a priority scheme, only the highest priority effect will determine the light output. When multiple effects control a light at the same priority the final output may be an average or other combination of the effect outputs.

A lighting sequence as described above may be deployed as a program fragment. Such fragments may be compiled in an intermediate format, such as by using an available Java compiler to compile the program as byte codes. In such a byte code format, the fragment may be called a sequence. A sequence may be interpreted or executed by the controller 30. The sequence is not a stand-alone program, and adheres to a defined format, such as an instantiation of an object from a class, that the controller 30 may use to generate effects. When downloaded into the controller 30 (via serial port, infrared port, smart card, or some other interface), the controller 30 interprets the sequence, executing portions based on time or input stimuli.

A building block for producing a show is an effect object. The effect object includes instructions for producing one specific effect, such as color wash, cross fade, or fixed color, based on initial *parameters* (such as which lights to control, start color, wash

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period, etc.) and inputs (such as time, environmental conditions, or results from other effect objects). The sequence contains all of the information to generate every effect object for the show. The controller 30 instantiates all of the effect objects one time when the show is started, then periodically sequentially activates each one. Based on the state of the entire system, each effect object can programmatically decide if and how to change the lights it is controlling.

The run-time environment software running on the controller 30 may be referred to as a conductor. The conductor may be responsible for downloading sequences, building and maintaining a list of effect object instances, managing the interface to external inputs and outputs (including DMX), managing the time clock, and periodically invoking each effect object. The conductor also maintains a memory that objects can use to communicate with each other.

The controller 30 may maintain two different, but synchronized, representations of time. The first is LocalTime, which is the number of milliseconds since the controller 30 has been turned on. LocalTime may be represented as a 32-bit integer that will roll over after reaching its maximum value. The other time representation is DateTime, which is a defined structure maintaining the time of day (to seconds resolution) as well as the day, month, and year.

LocalTime may be used by effects for computing relative changes, such as a hue change since last execution in a color wash effect. LocalTime roll-over should not cause effects to fail or malfunction. The conductor may provide utility functions for common operations like time deltas.

An effect object may be an instance of an Effect class. Each effect object may provide two public methods which are subclassed from Effect to produce the desired effect. These are the constructor and the run() methods.

The constructor method may be called by a sequence when an instance of the effect is created. It can have any number and type of parameters necessary to produce the desired effect variations. The authoring software may be responsible for producing the proper constructor parameters when creating the sequence.

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The first argument to the constructor may be an integer identifier (ID). The ID may be assigned by the show authoring software, and may be unique.

The constructor may call super() to perform any conductor-specific initializations.

The effect class may also contain next and prev members, which are used by the sequence and conductor to maintain a linked list of effects. These members may not be accessed internally by the effect methods.

Certain typical effects may be used over and over again. These typical effects may be provided by the conductor, minimizing the storage/download size of sequences. The typical effects may, if desired, be further sub-classed.

A sequence is a convenient means of bundling together all of the information necessary to produce a show. The sequence may have only one required public method, init(), which is called once by the conductor prior to running the show. The init() method may instantiate every effect used by the show, passing the ID and any parameters as constructor arguments. The init() method may then link the effect objects together into a linked list, and return the list to the conductor.

The linked list is maintained through the next and prev members of the effect objects. The prev member of the first object is nil, and the next member of the last object is nil. The first effect is returned as the value of init().

The optional dispose() method will be called when the sequence is deactivated. This method can be used to clean up any resources allocated by the sequence. Automatic processes may be used independently to handle any allocated memory. The base class dispose() will pass through the linked list and free the effect objects, so when dispose() is subclassed, it may be necessary to call super().

The optional public method String getSequenceInfo() can be used to return version and copyright information. It may be desirable to implement some additional getSequence*() routines to return information that may be useful for the controller/user interface.

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A sequence may require additional supporting classes. These may be included, along with the sequence object, in a file such as a JAR (Java ARchive) file. The JAR file may then be downloaded to the conductor. Tools for JAR files are part of the standard Java development tools.

Any DMX communication may be handled by a DMX_Interface class. Each instance of a DMX_Interface controls one DMX universe. The DMX_Interface base class may be sub-classed to communicate over a specific type of hardware interface (serial, parallel, USB).

A *channel* may be a single data byte at a particular location in the DMX universe. A *frame* may be all of the channels in the universe. The number of channels in the universe is specified when the class is instantiated.

Internally, DMX_Interface maintains three buffers, each the length of the number of channels: the last frame of channels that was sent, the next frame of channels waiting to be sent, and the most recent priority of the data for each channel. Effect modules may modify the channel data waiting to be sent via the SetChannel() method, and the conductor may ask for the frame to be sent via SendFrame().

When an effect object sets the data for a particular channel it may also assign that data a priority. If the priority is greater than the priority of the last data set for that channel, then the new data may supercede the old data. If the priority is lesser, then the old value may be retained. If the priorities are equal, then the new data value may be added to a running total and a counter for that channel may be incremented. When the frame is sent, the sum of the data values for each channel may be divided by the channel counter to produce an average value for the highest priority data.

After each frame has been sent, the channel priorities may all be reset to zero. The to-be-sent data may be retained, so if no new data is written for a given channel it will maintain its last value, and also copied to a buffer in case any effect objects are interested.

An exemplary DMX_Interface may implement the following methods:

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A DMX_Interface(int num_channels) method is a constructor that sets up a DMX universe of num_channels (24 .. 512) channels. When subclassed, the method may take additional arguments to specify hardware port information.

A void SetChannel(int channel, int data, int priority) method sets the to-be-sent data (0 .. 255) for the channel if the priority is greater than the current data priority. The method can throw error handling exceptions, such as ChannelOutOfRange and DataOutOfRange exceptions.

A void SetChannels(int first_channel, int num_channels, int data[], int priority) method sets num_channels of to-be-sent data for starting with first_channel from the array data. The method can throw error handling exceptions, such as ChannelOutOfRange, DataOutOfRange, and ArrayIndexOutOfBounds exceptions.

A int GetChannelLast(int channel) method returns the last data sent for the channel. The method can throw error handling exceptions, such as ChannelOutOfRange or NoDataSent exceptions.

A void SendFrame(void) method causes the current frame to be sent. This is accomplished through a separate thread so processing by the conductor will not pause. If a frame is already in progress, it is terminated and the new frame started.

A int FrameInProgress(void), if no frame is currently being sent, returns zero. If a frame is in progress, it returns the number of the last channel sent.

The conductor is the run-time component of the controller that unites the various data and input elements. The conductor may download sequences, manage the user interface, manage the time clock and other external inputs, and sequence through the active effect objects.

The technique for downloading the sequence JAR file into the conductor can vary depending on the hardware and transport mechanism. Various Java tools can be utilized for interpreting the JAR format. In an embodiment, the sequence object and various required classes may be loaded into memory, along with a reference to the sequence object.

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In an embodiment, more than one sequence object may be loaded into the conductor, and only one sequence may be active. The conductor can activate a sequence based on external inputs, such as the user interface or the time of day.

If a sequence is already active, then prior to activating a new sequence, the dispose() method is invoked for the already active sequence.

To activate a sequence, the sequence's init() method is called and run to completion.

Controllers may invoke some method for measuring time. Time values may be accessed via GetLocalTime() and GetDateTime() methods. Other inputs may be enumerated and accessed by a reference integer. The values of all inputs may also be mapped to integers. A GetInput(int ref) method returns the value of input ref, and can throw exceptions, such as a NoSuchInput exception.

The effect list may be created and returned by the sequence's init() method. At fixed intervals the conductor may sequentially call the run() method of each effect object in the list.

The interval may be specific to the particular controller hardware, and may be alterable, e.g., by an external interface. If the effect list execution does not finish in one interval period, the next iteration may be delayed until the following interval time. Effect objects may not need to run every interval to compute changes, but may use a difference between the current time and the previous time.

Effects may be designed to minimize the use of processing power, so the entire effect list can be run quickly. If an effect requires a large amount of computation, it may initiate a low priority thread to do the task. While the thread is running, the run() method may return right away, so the lights will remain unchanged. When the run() method detects that the thread has finished, it may use the results to update the light outputs.

The memory allows different effects to communicate with each other. Like external inputs, memory elements may be integers. Memory elements may be referenced by two pieces of information: the ID of the effect that created the information, and a reference integer which is unique to that effect. The accessor methods are:

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void SetScratch(int effect_id, int ref_num, int value)

int GetScratch(int effect_id, int ref_num)

Both methods can throw error handling exceptions, such as NoSuchEffect and NoSuchReference exceptions.

Effects may run in any order. Effects that use results from other effects may anticipate receiving results from the previous iteration.

Additional routines may include the following.

An int DeltaTime(int last) method computes the change in time between the current time and last.

A DMX_Interface GetUniverse(int num) method returns the DMX_Interface object associated with universe number num. This value should not change while a sequence is running, so it can be cached. The method can throw error handling exceptions, such as NoSuchUniverse exceptions.

An int[] HSBtoRGB(int hue, int sat, int bright) method converts hue (0 - 1535), saturation (0 - 255), and brightness (0 - 255) in to red/green/blue values, which are written to the first three elements of the resulting array. The method can throw error handling exceptions, such as ValueOutOfRange exceptions.

An int LightToDMX(int light) method returns the DMX address of a light with a logical number of light. The method can throw error handling exceptions, such as DMXAddressOutOfRange exceptions.

A void LinkEffects(Effect a, Effect b) method sets a.next = b; b.prev = a.

Each controller may have a configuration file used by the show authoring software. The configuration file may contain mappings between the input reference integers and more useful descriptions of their functions and values, for example, something like: Input 2 = "Slider" range = (0 - 99). The configuration file can also contain other useful information, such as a number of DMX universes.

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The following is an example of code illustrating a lighting sequence authored according to the principles of the invention. It will be understood that the following example is in no way limiting:

Example 1:

```
// An example sequence.
// Runs one strip of 12 cove lights, sequentially numbered starting at address 1
// Input #1 is a binary switch
// The cove runs a continuous color wash
// When the switch is opened, a chaser strobe effect is triggered, which runs a
// white strobe down cove. The effect won't be repeated until the switch is reset.

import java.sequence.*

public class ExampleSequence extends Sequence {
  private int CoveGroup[] = {
    LightToDMX(1), LightToDMX(2), LightToDMX(3), LightToDMX(4),
    LightToDMX(5), LightToDMX(6), LightToDMX(7), LightToDMX(8),
    LightToDMX(9), LightToDMX(10), LightToDMX(11), LightToDMX(12)
  };

  public String getSequenceInfo() {
    return "Example sequence version 1.0";
  }

  public Effect init() {
    super.init();                          // Call base class init

    // Create the effect objects with the appropriate variation params
    washEff = new WashEffect(
      1,                                   // ID
      CoveGroup, 1, 1,                     // Which lights, universe 1, priority 1
      true,                                // Direction = forward
```

```
        20000);                          // Speed (20 seconds)

      strobeEff = new ChaseStrobeEffect(
        2,                               // ID
        CoveGroup, 1, 2,                 // Which lights, universe 1, priority 2
        1,                               // Trigger input
        true,                            // Direction = forward
        100,                             // Duration of strobe (100 ms)
        400,                             // Time between strobes (400 ms)
        255, 255, 255);                  // Strobe color (white)

      // Link the effects
      LinkEffects(washEff, strobeEff);   // Sets next and prev

      // Return the effect list to the conductor
      return(washEff);
    }

    // Declare all of the effects
    WashEffect washEff;
    ChaseStrobeEffect strobeEff;
}

// WashEffect may be implemented as a stock effect, but we'll implement a simple
// version here for illustration.

public class WashEffect extends Effect {
    private int hue, sat, bright;
    private int last_time;               // Last time we ran
    private int lights[];
    private DMX_Interface universe;
    private int priority;
    private boolean direction;
```

```
    private int speed;

    public WashEffect(int id, int lights[], int univ, int prio, boolean dir, int speed) {
      // make copies of variation params and initialize any
      // other variables
      this.lights = lights;
      this.universe = GetUniverse(univ);
      this.priority = prio;
      this.direction = dir;
      this.speed = speed;
      hue = 0;
      sat = 255;
      bright = 255;
      last_time = 0;
      super(id);
    }
```

All articles, patents, and other references set forth above are hereby incorporated by reference. While the invention has been disclosed in connection with the embodiments shown and described in detail, various equivalents, modifications, and improvements will be apparent to one of ordinary skill in the art from the above description. Such equivalents, modifications, and improvements are intended to be encompassed by the following claims.

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CLAIMS

What is claimed is:

1. A system for preparing a light sequence, comprising

an authoring interface displaying information representative of a plurality of lighting effects, and

a sequence authoring module to permit a user to select a lighting effect, a lighting unit to execute the lighting effect, a start time for the lighting effect, and a stop time for the lighting effect.

2. The system of claim 1, further comprising

a lighting set-up module to receive information representative of an arrangement of a plurality of lighting units, and

a set-up interface to visually display the arrangement of the plurality of lighting units.

3. The system of claim 2, wherein, upon initiation of a playback function, the set-up interface displays a selected lighting effect, as defined by a start time and a stop time associated therewith, on a portion thereof defined by a lighting unit associated with the selected lighting effect.

4. The system of claim 2, wherein each lighting unit is associated with a unique address.

5. The system of claim 2, wherein the plurality of lighting units include an LED lighting unit capable of emitting light of any of a range of different colors.

6. The system of claim 1, wherein the authoring interface includes a grid, wherein a plurality of lighting units are represented along one axis and wherein time is represented along a second axis.

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7. The system of claim 5, wherein the authoring interface visually represents the selected lighting effect on a region of the grid defined by a lighting unit, start time, and stop time associated with the selected lighting effect.

8. The system of claim 1, further comprising

a recorder to store user selections on an electronic storage medium.

9. The system of claim 1, wherein the sequence authoring module includes a coloring unit to permit a user to select a color for the selected lighting effect.

10. The system of claim 1, wherein the sequence authoring module includes a coloring unit to permit a user to select a starting color and an ending color for the selected lighting effect.

11. The system of claim 1, wherein the sequence authoring module includes a transitioning unit to permit a user to select a transition effect for a transition between a first lighting effect and a second lighting effect.

12. The system of claim 1, wherein the sequence authoring module includes a prioritizing unit to permit a user to determine a priority for a first lighting effect which shares a temporal overlap with a second lighting effect.

13. The system of claim 1, wherein the sequence authoring module includes an intensity unit to permit a user to determine a brightness for the selected lighting effect.

14. The system of claim 1, wherein the sequence authoring module includes a cue unit to permit the user to provide instructions to start the selected lighting effect upon receiving an external stimulus.

15. The system of claim 1, wherein the sequence authoring module includes a motion unit to permit the user to determine a motion of a lighting unit.

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16. The system of claim 1, further comprising a lighting effect creator to permit a user to design lighting effects using the sequence authoring module and to include the user-designed effects on the authoring interface.

17. A method for preparing a lighting sequence capable of being executed by a processor, comprising

providing a processor interface including information representative of a plurality of lighting effects,

receiving information representative of a lighting unit,

receiving information representative of a first lighting effect to be executed by the lighting unit,

receiving information representative of a start time for the first lighting effect, and

receiving information representative of a stop time for the first lighting effect.

18. The method of claim 17, further comprising

receiving information representative of an arrangement of a plurality of lighting units, and

providing a processor interface representative of the arrangement of the plurality of lighting units.

19. The method of claim 18, further comprising

visually representing the first lighting effect on the portion of the interface representative of an arrangement of a plurality of lighting units as defined by the lighting unit, the start time, and the stop time.

20. The method of claim 17, further comprising

repeating the method for a second lighting unit.

21. The method of claim 17 wherein providing a processor interface includes providing an interface which displays a grid, wherein a plurality of lighting units are represented along one axis and wherein time is represented along a second axis.

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22. The method of claim 20 further comprising

visually representing the first lighting effect on the region of the grid defined by the lighting unit, the start time, and the stop time.

23. The method of claim 23, further comprising

storing the received information on an electronic storage medium.

24. The method of claim 17, further comprising

receiving information representative of a color for the first lighting effect.

25. The method of claim 17, further comprising

receiving information representative of a second lighting effect to be executed by the lighting unit,

receiving information representative of a start time for the second lighting effect, and

receiving information representative of a stop time for the second lighting effect.

26. The method of claim 25, further comprising

receiving information representative of a transition effect between the first lighting effect and the second lighting effect.

27. The method of claim 25, further comprising

receiving information representative of a priority for the second lighting effect.

28. The method of claim 17, further comprising

receiving information representative of a brightness for the first lighting effect.

29. The method of claim 17, wherein receiving information representative of a lighting unit includes receiving information representative of a plurality of lighting units, and receiving information representative of a first lighting effect includes receiving information representative of a first lighting effect to be executed by the plurality of lighting units.

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30. The method of claim 17, wherein receiving information representative of a lighting unit includes receiving information representative of an LED lighting unit capable of emitting light of any of a range of colors.

31. The method of claim 17, wherein receiving information representative of a start time includes receiving instructions to start the first lighting effect upon receiving an external stimulus.

32. The method of claim 17, wherein receiving information representative of a lighting unit includes receiving an address of the lighting unit.

33. The method of claim 17, further comprising

receiving information representative of a first motion of the lighting unit.

34. A system for controlling a plurality of lighting units, comprising

a data interface for receiving instructions for controlling a plurality of lighting units,

a signal interface for receiving external signals,

a processor for converting said instructions to a data stream and for altering the conversion of said instructions based on the external signals received, and

a data output for transmitting the data stream to a plurality of lighting units.

35. The system of claim 34, wherein said signal interface includes a mechanical interface for receiving an input.

36. The system of claim 34, wherein said signal interface includes a port for receiving an electromagnetic signal.

37. The system of claim 34, wherein said data output includes a port for transmitting data to a mechanical device.

38. The system of claim 34, wherein said data output includes a port for transmitting data to a device for reproducing an audio signal.

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39. The system of claim 34, wherein said data output includes a port for transmitting data to a device for reproducing a video image.

40. The system of claim 34, wherein said data interface is a data connection for receiving instructions from another processor.

41. The system of claim 40, wherein said data connection comprises an infrared port, a serial port, a parallel port, an RF port, a wireless port or a USB port.

42. The system of claim 34, wherein said data interface is capable of reading instructions from a storage medium.

43. The system of claim 42, wherein said storage medium is selected from a magnetic disk, magnetic tape, smart card, volatile solid state memory, non-volatile solid state memory and compact disk.

44. The system of claim 34, further comprising

a database to store directions for converting predetermined lighting effects having parameters associated therewith into data suitable for controlling a plurality of lighting units.

45. The system of claim 34, further comprising

a memory module for storing information representative of effects being executed by a plurality of lighting units.

46. The system of claim 34, further comprising

a timing mechanism for measuring intervals of time.

47. The system of claim 34, further comprising

a first timing mechanism for measuring elapsed time, and

a second timing mechanism for determining the date and time of day.

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48. The system of claim 34, wherein the data output includes a color mechanism for setting the color of an LED lighting unit capable of emitting light of any of a range of colors.

49. A method for controlling a plurality of lighting units, comprising
receiving instructions for controlling a plurality of lighting units,
receiving external signals,
converting said instructions to a data stream based on the external signals received, and
transmitting the data stream to a plurality of lighting units.

50. The method of claim 49, wherein receiving external signals includes receiving input from a mechanical interface

51. The method of claim 49, wherein receiving external signals includes receiving an electromagnetic signal.

52. The method of claim 49, wherein transmitting the data stream includes transmitting data to a mechanical device.

53. The method of claim 49, wherein transmitting the data stream includes transmitting data to a device for reproducing an audio signal.

54. The method of claim 49, wherein transmitting the data stream includes transmitting data to a device for reproducing a video image.

55. The method of claim 49, wherein receiving instructions includes receiving instructions from another processor.

56. The method of claim 55, wherein receiving instructions from another processor includes using an infrared port, a serial port, a parallel port, or a USB port.

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57. The method of claim 40, wherein receiving instructions includes reading instructions from a storage medium.

58. The method of claim 58, wherein reading instructions from a storage medium includes reading data from a medium selected from a magnetic disk, magnetic tape, smart card, and compact disk.

59. The method of claim 49, wherein receiving instructions includes receiving a plurality of lighting effects having parameters associated therewith.

60. The method of claim 59, further comprising

utilizing directions for converting predetermined lighting effects to convert said plurality of lighting effects into data suitable for controlling a plurality of lighting units.

61. The method of claim 49, further comprising

storing information representative of effects being executed by a plurality of lighting units in a transient memory.

62. The method of claim 49, wherein receiving external signals includes receiving data from a timing mechanism.

63. The method of claim 49, wherein receiving external signals includes receiving data from a first timing mechanism for measuring elapsed time, and a second timing mechanism for determining the date and time of day.

64. The method of claim 49, wherein receiving external signals includes receiving data from a sensor.

65. The method of claim 49, wherein receiving external signals includes receiving an alarm signal.

66. The method of claim 49, wherein transmitting the data stream setting the color of an LED lighting unit capable of emitting light of any of a range of colors.

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67. The method of claim 49, wherein converting said instructions to a data stream based on the external signals received includes repeating an effect until an external signal is received.

68. The method of claim 49, wherein converting said instructions to a data stream based on the external signals received includes modifying the rate of a lighting sequence.

69. The method of claim 49, wherein converting said instructions to a data stream based on the external signals received includes switching from a high priority effect to a low priority effect.

70. The method of claim 49, wherein converting said instructions to a data stream based on the external signals received includes interrupting a lighting sequence to execute a different effect.

71. A method for controlling a plurality of lighting units, comprising

receiving instructions including a primary lighting effect and a secondary lighting effect, the secondary lighting effect designated to be executed instead of the primary lighting effect upon a predetermined condition,

sending instructions to a lighting unit to execute the primary lighting effect,

receiving a signal indicative of the predetermined condition, and

sending instructions to the lighting unit to execute the secondary lighting effect.

72. A method for controlling a plurality of lighting units, comprising

receiving instructions for executing a timed sequence of lighting effects,

executing the sequence of lighting effects utilizing a plurality of lighting units,

receiving an external signal, and

altering the execution of the sequence of lighting effects.

73. The method of claim 72, wherein altering the execution of the sequence of lighting effects includes altering the rate of the timed sequence.

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74. The method of claim 72, wherein altering the execution of the sequence of lighting effects includes executing a different sequence of lighting effects.

75. The method of claim 72, wherein altering the execution of the sequence of lighting effects includes pausing during the sequence.

76. The method of claim 72, wherein altering the execution of the sequence of lighting effects includes changing the brightness of the light emitted by the plurality of lighting units.

77. The method of claim 72, wherein altering the execution of the sequence of lighting effects includes changing the color of the light emitted by the plurality of lighting units.

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Figure 1

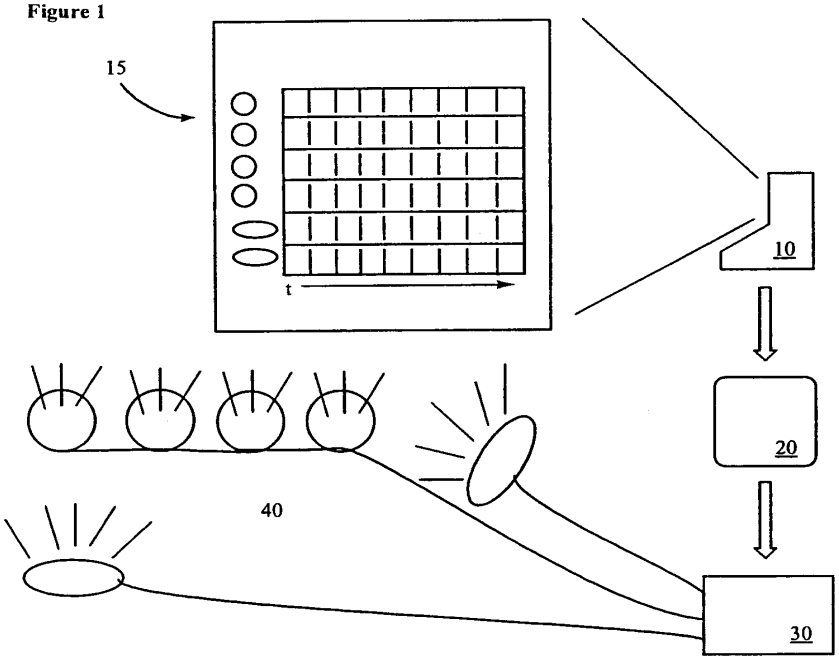
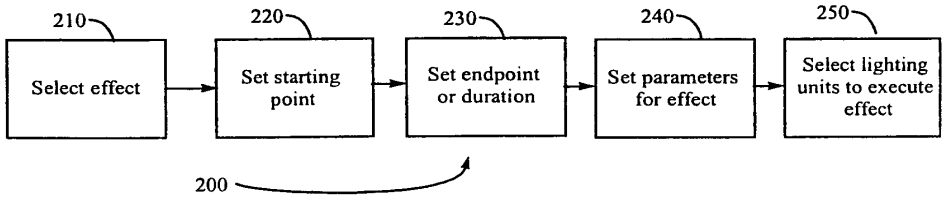


Figure 2



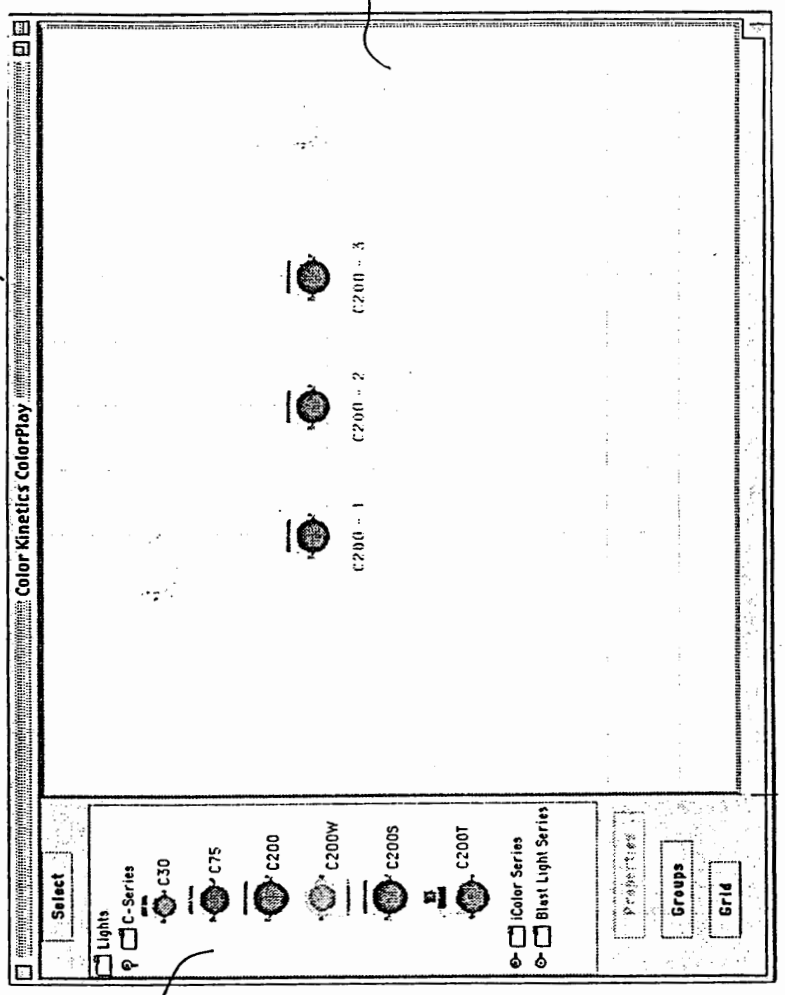

300
320
310
Color Kinetics ColorPlay
Select
Lights
C-Series
C30
C75
C200
C200W
C200S
C200T
iColor Series
Blast Light Series
Groups
Grid
C200 - 1
C200 - 2
C200 - 3

Fig. 3

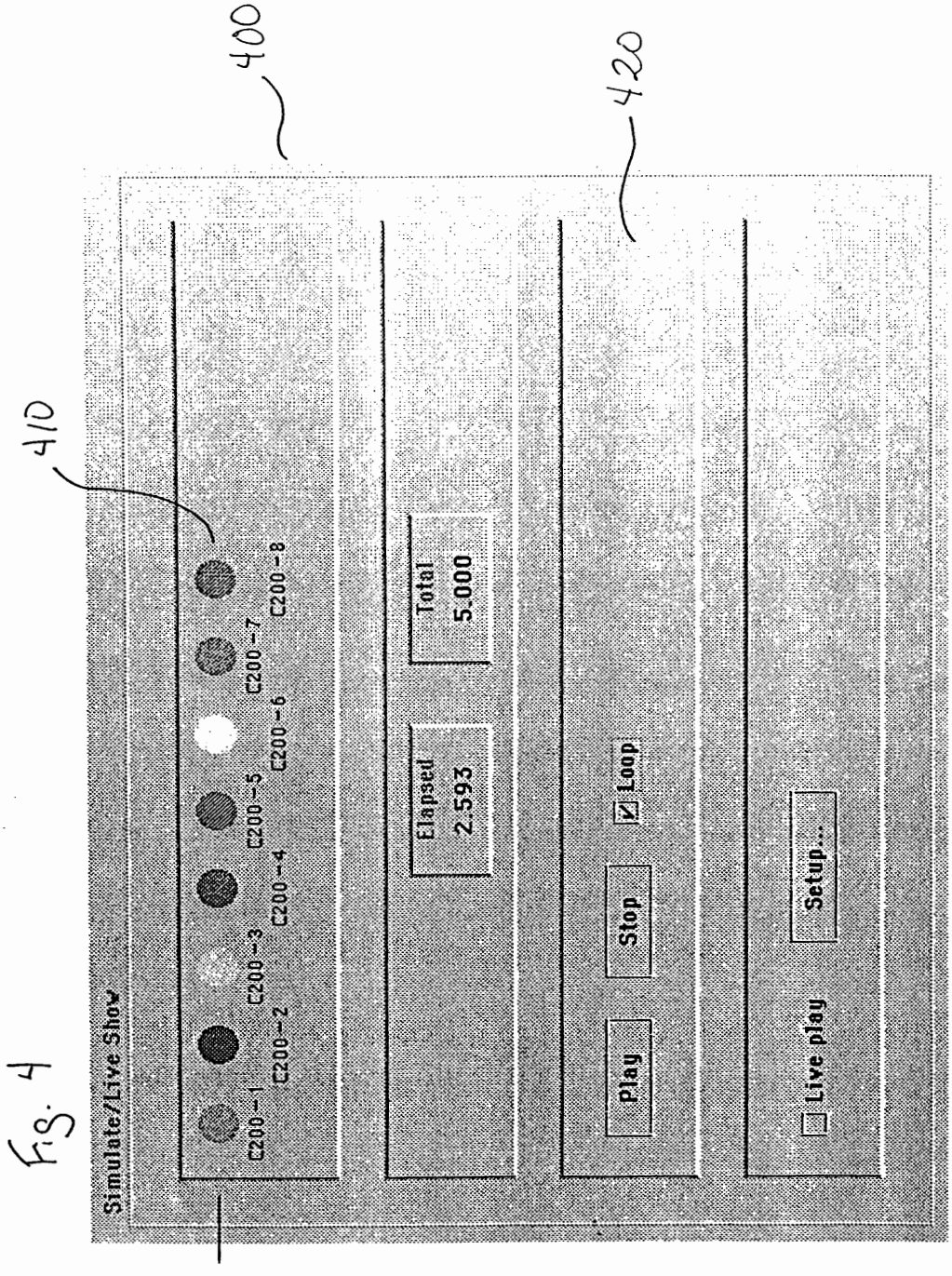

400
420
410
Simulate/Live Show
C200-1
C200-2
C200-3
C200-4
C200-5
C200-6
C200-7
C200-8
Elapsed
2.593
Total
5.000
Play
Stop
Loop
Setup...
Live play

Fig. 4

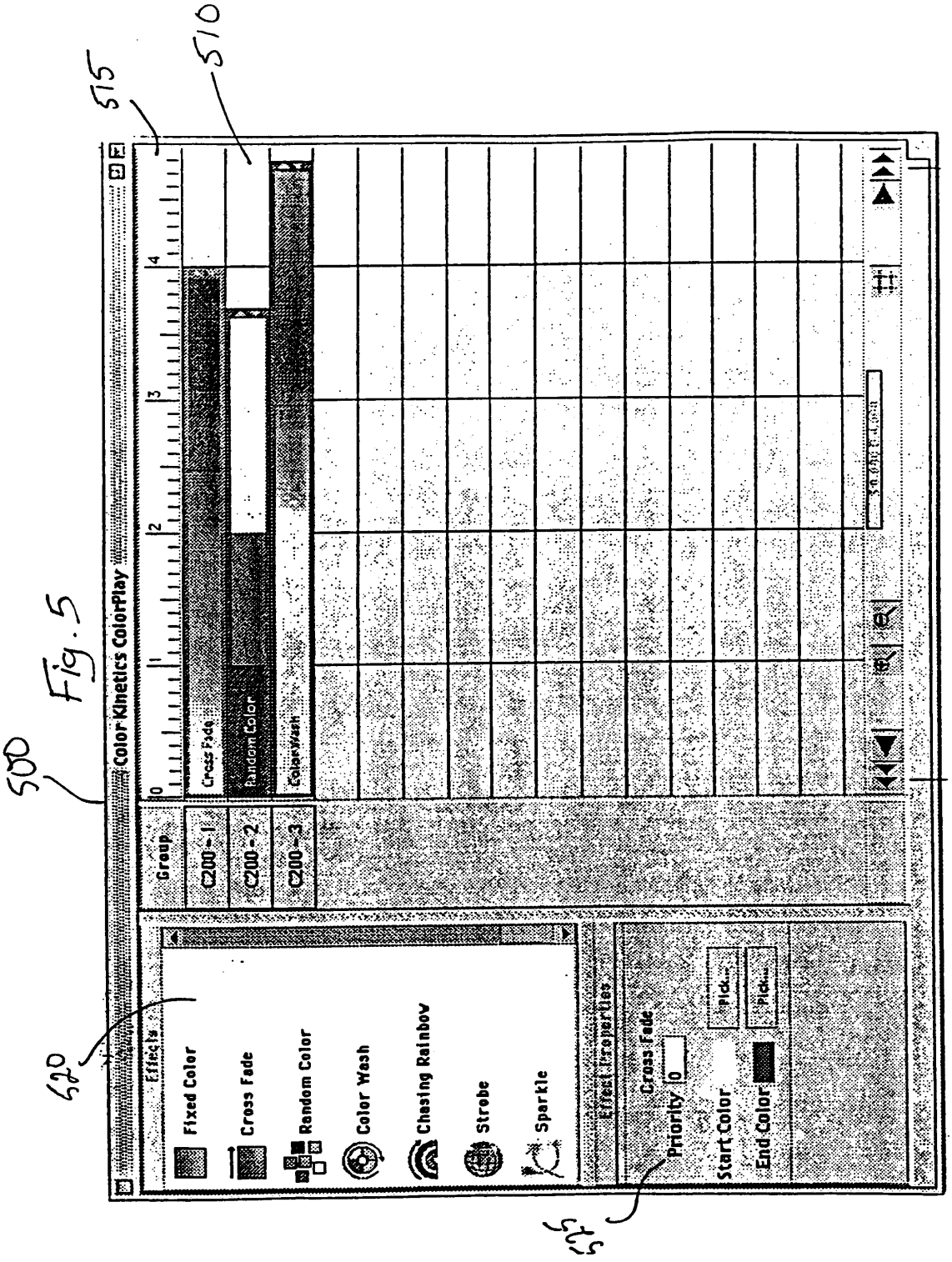

500
515
510
520
525
Color Kinetics ColorPlay
Group
C200-1
C200-2
C200-3
Cross Fade
Random Color
Color Wash
Effects
Fixed Color
Cross Fade
Random Color
Color Wash
Chasing Rainbow
Strobe
Sparkle
Effect Properties
Cross Fade
Priority
Start Color
End Color
Pick...
Pick...

Fig. 5

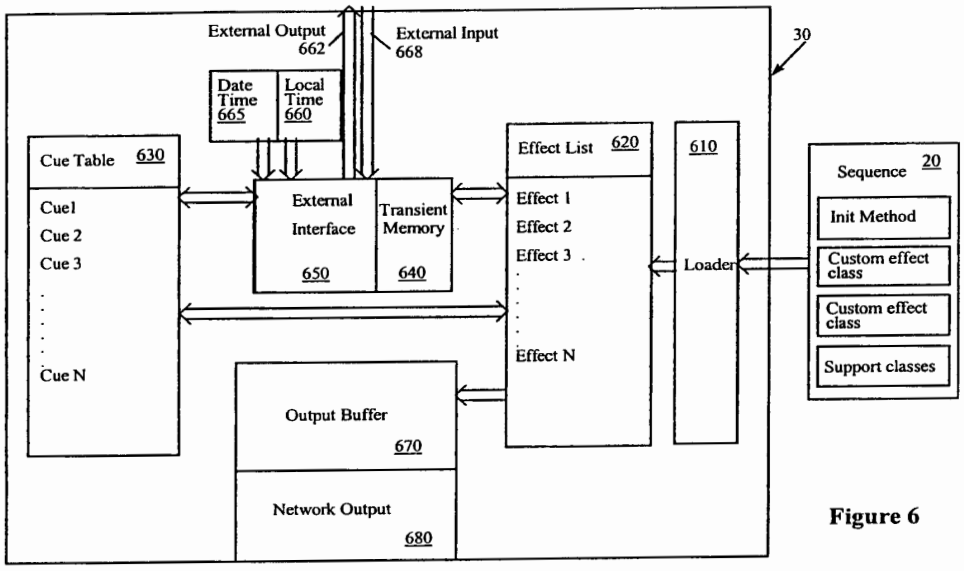

External Output
662
External Input
668
30
Date Time
665
Local Time
660
Cue Table
630
Cue1
Cue 2
Cue 3
Cue N
External Interface
650
Transient Memory
640
Effect List
620
Effect 1
Effect 2
Effect 3
Effect N
610
Loader
Sequence
20
Init Method
Custom effect class
Custom effect class
Support classes
Output Buffer
670
Network Output
680

Figure 6

INTERNATIONAL SEARCH REPORT

Interna al Application No
PCT/US 00/19274

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H05B37/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 752 632 A (VARI LITE INC) 8 January 1997 (1997-01-08) abstract column 2, line 11 -column 4, line 56 column 7, line 13 -column 7, line 15 column 10, line 13 -column 10, line 27 column 71, line 34 -column 71, line 44 column 72, line 40 -column 74, line 57 column 76, line 51 -column 77, line 43 column 78, line 33 -column 80, line 9 claims --- -/--	1,17,34, 49,71,72

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 October 2000	19/10/2000

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INTERNATIONAL SEARCH REPORT

Internat al Application No
PCT/US 00/19274

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 495 305 A (VARI LITE INC) 22 July 1992 (1992-07-22) page 3, line 46 -page 12, line 5 page 20, line 32 -page 23, line 35 claims	1,17,34, 49,71,72
A	& US 5 307 295 A 26 April 1994 (1994-04-26) cited in the application	
A	FR 2 628 335 A (UNIV ALSACE) 15 September 1989 (1989-09-15) the whole document	1,17,34, 49,71,72
A	US 3 898 643 A (ETTLINGER ADRIAN) 5 August 1975 (1975-08-05) abstract column 1, line 6 -column 1, line 11 column 2, line 62 -column 3, line 30	1,17
A	WO 99 31560 A (COLOR KINETICS INC) 24 June 1999 (1999-06-24) abstract; figure 1	5

3

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

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INTERNATIONAL SEARCH REPORT

...ormation on patent family members

Internal Application No
PCT/US 00/19274

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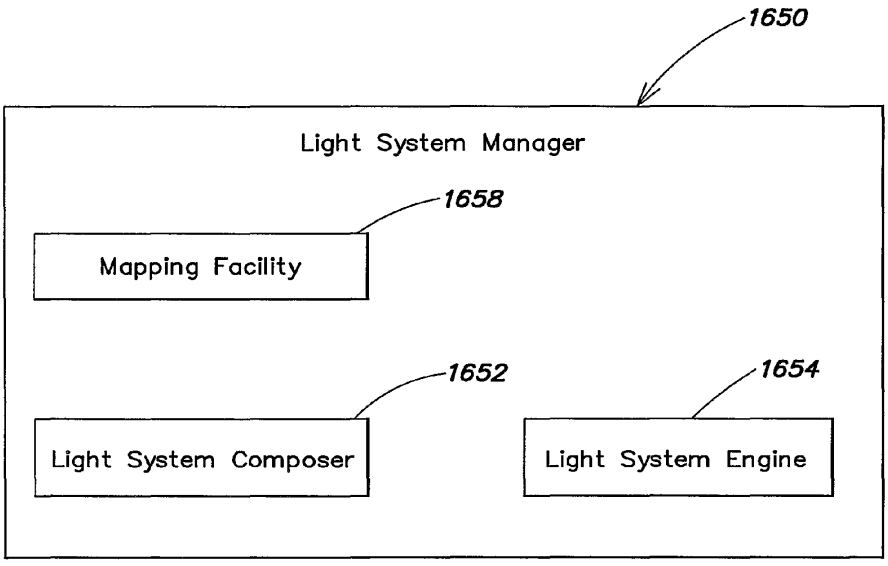
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(54) Title: LIGHT SYSTEM MANAGER



(57) Abstract: Methods and systems are provided for lighting control, including a lighting system manager, a light show composer, a light system engine, and related facilities for the convenient authoring and execution of lighting shows using semiconductor-based 5 illumination units.

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LIGHT SYSTEM MANAGER

Background

Methods and systems for semiconductor illumination have been provided, such as by Color Kinetics Incorporated of Boston, Massachusetts, as described in documents, patent applications incorporated by reference herein. The existence of processor control enables the creation of illumination effects, such as color changes. When more than one lighting system is provided, coordination effects can also be created, such as having lighting units light in sequence, such as to create a color-chasing rainbow. Creating coordinated lighting effects presents many challenges, particularly in how to create complex effects that involve multiple lighting units in unusual geometries. A need exists for improved systems for creating and deploying lighting shows.

Summary

Provided herein are methods and systems for managing control instructions for a plurality of light systems. The methods and systems may include providing a light system manager for mapping locations of a plurality of light systems. The methods and systems may include providing a light system composer for composing a lighting show. The methods and systems may include providing a light system engine for playing a lighting show on a plurality of light systems.

In embodiments the light system engine is connected to a network. In embodiments shows composed using the light system composer are delivered via the network to the light system engine. In embodiments, methods and systems are provided for providing a mapping facility of the light system manager for mapping locations of a plurality of light systems. In embodiments the mapping facility discovers lighting systems in an environment. In embodiments the mapping facility maps lights in a two-dimensional space. In embodiments the lighting systems are selected from the group consisting of an architectural lighting system, an entertainment lighting system, a restaurant lighting system, a stage lighting system, a theatrical lighting system, a concert lighting system, an arena lighting system, a signage system, a building exterior lighting

system, a landscape lighting system, a pool lighting system, a spa lighting system, a transportation lighting system, a marine lighting system, a military lighting system, a stadium lighting system, a motion picture lighting system, photography lighting system, a medical lighting system, a residential lighting system, a studio lighting system, and a television lighting system. In embodiments light systems can be mapped into separate zones, such as separate DMX zones. In embodiments zones are located in different rooms of a building. In embodiments zones are located in the same location within an environment. In embodiments the environment is a stage lighting environment.

Methods and systems are included for providing a grouping facility for grouping light systems, wherein grouped light systems respond as a group to control signals. In embodiments the grouping facility is a directed graph, a drag and drop user interface, a dragging line interface. In embodiments the grouping facility permits grouping of any selected geometry, such as a two-dimensional representation of a three-dimensional space. In embodiments the two-dimensional representation is mapped to light systems in a three-dimensional space. In embodiments the grouping facility groups lights into groups of a predetermined conventional configuration, such as a rectangular, two-dimensional array, a square, a curvilinear configuration, a line, an oval, an oval-shaped array, a circle, a circular array, a triangle, a triangular array, a serial configuration, a helix, or a double helix.

Methods and systems are provided for providing a light system composer for allowing a user to author a lighting show using a graphical user interface. In embodiments, the light system composer includes an effect authoring system for allowing a user to generate a graphical representation of a lighting effect. In embodiments the effect authoring system allows a user to set parameters for a plurality of predefined types of lighting effects. In embodiments the effect authoring system allows a user to create user-defined effects. In embodiments the effect authoring system allows a user to link effects to other effects. In other embodiments the effect authoring system allows a user to set a timing parameter for a lighting effect. In embodiments the effect authoring system allows a user to generate meta effects comprised of more than

one lighting effect. In embodiments the light system composer allows the user to generate shows comprised of more than one meta effect. In embodiments, the user can link meta effects. In embodiments the user may assign an effect to a group of light systems. In embodiments the effect is selected from the group consisting of a color chasing rainbow, a cross fade effect, a custom rainbow, a fixed color effect, an animation effect, a fractal effect, a random color effect, a sparkle effect, a streak effect, and a sweep effect. In embodiments the effect is an animation effect and the animation effect corresponds to an animation generated by an animation facility. In embodiments the animation effect is loaded from an animation file, such as a flash animation facility. In embodiments the animation facility is a multimedia animation facility. In embodiments the animation facility is a video animation facility. In embodiments the animation facility is a three-dimensional simulation animation facility. In embodiments the lighting show composer facilitates the creation of meta effects that comprise a plurality of linked effects. In embodiments the lighting show composer generates an XML file containing a lighting show. In embodiments, the lighting show composer includes stored effects that are designed to run on a predetermined configuration of lighting systems. The user can apply a stored effect to a configuration of lighting systems.

In embodiments the lighting system composer includes a graphical simulation of a lighting effect on a lighting configuration. In embodiments, the simulation reflects a parameter set by a user for an effect. The simulation may be an animation window of a graphical user interface.

In embodiments the light show composer allows synchronization of effects between different groups of lighting systems that are grouped using the grouping facility. In embodiments the lighting show composer includes a wizard for adding a predetermined configuration of light systems to a group and for generating effects that are suitable for the predetermined configuration. In embodiments the predetermined configuration is a rectangular array or a string.

Methods and systems are included for providing a light system engine for relaying control signals to a plurality of light systems, wherein the light system engine plays back shows. The light system engine may include a processor, a data facility, an operating system and/or a communication facility. The light system engine may be configured to communicate with a lighting control facility. In embodiments the lighting control facility may be a DALI facility or a DMX facility. In embodiments the lighting control facility operates with a serial communication protocol. In embodiments the lighting control facility is a power/data supply.

In embodiments the light system engine executes lighting shows downloaded from the light system composer. In embodiments shows are delivered as XML files from the lighting show composer to the light system engine. In embodiments shows are delivered to the light system engine over a network, Ethernet facility, wireless facility, Firewire facility, the Internet, or a different facility.

In embodiments, the lighting shows composed by the lighting show composer are combined with other files from another computer system. In embodiments the lighting shows are combined by adding additional elements to an XML file that contains a lighting show. In embodiments the other computer system includes an XML parser for handling XML files. In embodiments the other computer system is selected from the group consisting of a sound system, and entertainment system, a multimedia system, a video system, an audio system, a sound-effect system, a smoke effect system, a vapor effect system, a dry-ice effect system, another lighting system, a security system, an information system, a sensor-feedback system, a sensor system, a browser, a network, a server, a wireless computer system, a building information technology system, and a communication system. In embodiments the other computer system comprises a browser, wherein the user of the browser can edit the XML file using the browser to edit the lighting show generated by the lighting show composer. In embodiments, the light system engine includes a server, wherein the server is capable of receiving data over the Internet.

In embodiments, the light system engine is capable of handling multiple zones of light systems, wherein each zone of light systems has a distinct mapping. In embodiments the multiple zones are synchronized using the internal clock of the light system engine.

Methods and systems are included for providing a user interface for triggering shows downloaded on a light system engine. In embodiments the user interface is a knob, a dial, a button, a touch screen, a serial keypad, a slide mechanism, a switch, a sliding switch, a switch/slide combination, a sensor, a decibel meter, an inclinometer, a thermometer, an anemometer, a barometer, or another item capable of generating a signal. In embodiments the user interface is a serial keypad and wherein initiating a button on the keypad initiates a show in at least one zone of a lighting system governed by a light system engine connected to the keypad.

In embodiments, the light system engine comprises a personal computer with a Linux operating system. In embodiments the light system engine is associated with a bridge to a DMX system or a DALI system.

It should be appreciated that all combinations of the foregoing concepts and additional concepts discussed in greater detail below are contemplated as being part of the inventive subject matter disclosed herein. In particular, all combinations of claimed subject matter appearing at the end of this disclosure are contemplated as being part of the inventive subject matter disclosed herein.

Definitions used herein are for purposes of illustration and are not intended to be limiting in any way.

As used herein for purposes of the present disclosure, the term "LED" should be understood to include any electroluminescent diode or other type of carrier injection / junction-based system that is capable of generating radiation in response to an electric

signal. Thus, the term LED includes, but is not limited to, various semiconductor-based structures that emit light in response to current, light emitting polymers, electroluminescent strips, and the like.

In particular, the term LED refers to light emitting diodes of all types (including semi-conductor and organic light emitting diodes) that may be configured to generate radiation in one or more of the infrared spectrum, ultraviolet spectrum, and various portions of the visible spectrum (generally including radiation wavelengths from approximately 400 nanometers to approximately 700 nanometers). Some examples of LEDs include, but are not limited to, various types of infrared LEDs, ultraviolet LEDs, red LEDs, blue LEDs, green LEDs, yellow LEDs, amber LEDs, orange LEDs, and white LEDs (discussed further below). It also should be appreciated that LEDs may be configured to generate radiation having various bandwidths for a given spectrum (e.g., narrow bandwidth, broad bandwidth).

For example, one implementation of an LED configured to generate essentially white light (e.g., a white LED) may include a number of dies which respectively emit different spectra of electroluminescence that, in combination, mix to form essentially white light. In another implementation, a white light LED may be associated with a phosphor material that converts electroluminescence having a first spectrum to a different second spectrum. In one example of this implementation, electroluminescence having a relatively short wavelength and narrow bandwidth spectrum "pumps" the phosphor material, which in turn radiates longer wavelength radiation having a somewhat broader spectrum.

It should also be understood that the term LED does not limit the physical and/or electrical package type of an LED. For example, as discussed above, an LED may refer to a single light emitting device having multiple dies that are configured to respectively emit different spectra of radiation (e.g., that may or may not be individually controllable). Also, an LED may be associated with a phosphor that is considered as an integral part of the LED (e.g., some types of white LEDs). In general, the term LED

may refer to packaged LEDs, non-packaged LEDs, surface mount LEDs, chip-on-board LEDs, T-package mount LEDs, radial package LEDs, power package LEDs, LEDs including some type of encasement and/or optical element (e.g., a diffusing lens), etc.

The term "light source" should be understood to refer to any one or more of a variety of radiation sources, including, but not limited to, LED-based sources (including one or more LEDs as defined above), incandescent sources (e.g., filament lamps, halogen lamps), fluorescent sources, phosphorescent sources, high-intensity discharge sources (e.g., sodium vapor, mercury vapor, and metal halide lamps), lasers, other types of electroluminescent sources, pyro-luminescent sources (e.g., flames), candle-luminescent sources (e.g., gas mantles, carbon arc radiation sources), photo-luminescent sources (e.g., gaseous discharge sources), cathode luminescent sources using electronic satiation, galvano-luminescent sources, crystallo-luminescent sources, kine-luminescent sources, thermo-luminescent sources, triboluminescent sources , sonoluminescent sources, radioluminescent sources, and luminescent polymers.

A given light source may be configured to generate electromagnetic radiation within the visible spectrum, outside the visible spectrum, or a combination of both. Hence, the terms "light" and "radiation" are used interchangeably herein. Additionally, a light source may include as an integral component one or more filters (e.g., color filters), lenses, or other optical components. Also, it should be understood that light sources may be configured for a variety of applications, including, but not limited to, indication and/or illumination. An "illumination source" is a light source that is particularly configured to generate radiation having a sufficient intensity to effectively illuminate an interior or exterior space.

The term "spectrum" should be understood to refer to any one or more frequencies (or wavelengths) of radiation produced by one or more light sources. Accordingly, the term "spectrum" refers to frequencies (or wavelengths) not only in the visible range, but also frequencies (or wavelengths) in the infrared, ultraviolet, and other areas of the overall electromagnetic spectrum. Also, a given spectrum may have a

relatively narrow bandwidth (essentially few frequency or wavelength components) or a relatively wide bandwidth (several frequency or wavelength components having various relative strengths). It should also be appreciated that a given spectrum may be the result of a mixing of two or more other spectra (e.g., mixing radiation respectively emitted from multiple light sources).

For purposes of this disclosure, the term "color" is used interchangeably with the term "spectrum." However, the term "color" generally is used to refer primarily to a property of radiation that is perceivable by an observer (although this usage is not intended to limit the scope of this term). Accordingly, the terms "different colors" implicitly refer to multiple spectra having different wavelength components and/or bandwidths. It also should be appreciated that the term "color" may be used in connection with both white and non-white light.

The term "color temperature" generally is used herein in connection with white light, although this usage is not intended to limit the scope of this term. Color temperature essentially refers to a particular color content or shade (e.g., reddish, bluish) of white light. The color temperature of a given radiation sample conventionally is characterized according to the temperature in degrees Kelvin (K) of a black body radiator that radiates essentially the same spectrum as the radiation sample in question. The color temperature of white light generally falls within a range of from approximately 700 degrees K (generally considered the first visible to the human eye) to over 10,000 degrees K.

Lower color temperatures generally indicate white light having a more significant red component or a "warmer feel," while higher color temperatures generally indicate white light having a more significant blue component or a "cooler feel." By way of example, fire has a color temperature of approximately 1,800 degrees K, a conventional incandescent bulb has a color temperature of approximately 2848 degrees K, early morning daylight has a color temperature of approximately 3,000 degrees K, and overcast midday skies have a color temperature of approximately 10,000 degrees K. A color image viewed under white light having a color temperature of approximately 3,000

degree K has a relatively reddish tone, whereas the same color image viewed under white light having a color temperature of approximately 10,000 degrees K has a relatively bluish tone.

The terms "lighting unit" and "lighting fixture" are used interchangeably herein to refer to an apparatus including one or more light sources of same or different types. A given lighting unit may have any one of a variety of mounting arrangements for the light source(s), enclosure/housing arrangements and shapes, and/or electrical and mechanical connection configurations. Additionally, a given lighting unit optionally may be associated with (e.g., include, be coupled to and/or packaged together with) various other components (e.g., control circuitry) relating to the operation of the light source(s). An "LED-based lighting unit" refers to a lighting unit that includes one or more LED-based light sources as discussed above, alone or in combination with other non LED-based light sources.

The terms "processor" or "controller" are used herein interchangeably to describe various apparatus relating to the operation of one or more light sources. A processor or controller can be implemented in numerous ways, such as with dedicated hardware, using one or more microprocessors that are programmed using software (e.g., microcode) to perform the various functions discussed herein, or as a combination of dedicated hardware to perform some functions and programmed microprocessors and associated circuitry to perform other functions.

In various implementations, a processor or controller may be associated with one or more storage media (generically referred to herein as "memory," e.g., volatile and non-volatile computer memory such as RAM, PROM, EPROM, and EEPROM, floppy disks, compact disks, optical disks, magnetic tape, etc.). In some implementations, the storage media may be encoded with one or more programs that, when executed on one or more processors and/or controllers, perform at least some of the functions discussed herein. Various storage media may be fixed within a processor or controller or may be transportable, such that the one or more programs stored thereon can be loaded into a

processor or controller so as to implement various aspects of the present invention discussed herein. The terms "program" or "computer program" are used herein in a generic sense to refer to any type of computer code (e.g., software or microcode) that can be employed to program one or more processors or controllers.

The term "addressable" is used herein to refer to a device (e.g., a light source in general, a lighting unit or fixture, a controller or processor associated with one or more light sources or lighting units, other non-lighting related devices, etc.) that is configured to receive information (e.g., data) intended for multiple devices, including itself, and to selectively respond to particular information intended for it. The term "addressable" often is used in connection with a networked environment (or a "network," discussed further below), in which multiple devices are coupled together via some communications medium or media.

In one network implementation, one or more devices coupled to a network may serve as a controller for one or more other devices coupled to the network (e.g., in a master / slave relationship). In another implementation, a networked environment may include one or more dedicated controllers that are configured to control one or more of the devices coupled to the network. Generally, multiple devices coupled to the network each may have access to data that is present on the communications medium or media; however, a given device may be "addressable" in that it is configured to selectively exchange data with (i.e., receive data from and/or transmit data to) the network, based, for example, on one or more particular identifiers (e.g., "addresses") assigned to it.

The term "network" as used herein refers to any interconnection of two or more devices (including controllers or processors) that facilitates the transport of information (e.g. for device control, data storage, data exchange, etc.) between any two or more devices and/or among multiple devices coupled to the network. As should be readily appreciated, various implementations of networks suitable for interconnecting multiple devices may include any of a variety of network topologies and employ any of a variety of communication protocols. Additionally, in various networks according to the present

invention, any one connection between two devices may represent a dedicated connection between the two systems, or alternatively a non-dedicated connection. In addition to carrying information intended for the two devices, such a non-dedicated connection may carry information not necessarily intended for either of the two devices (e.g., an open network connection). Furthermore, it should be readily appreciated that various networks of devices as discussed herein may employ one or more wireless, wire/cable, and/or fiber optic links to facilitate information transport throughout the network.

The term "user interface" as used herein refers to an interface between a human user or operator and one or more devices that enables communication between the user and the device(s). Examples of user interfaces that may be employed in various implementations of the present invention include, but are not limited to, switches, potentiometers, buttons, dials, sliders, a mouse, keyboard, keypad, various types of game controllers (e.g., joysticks), track balls, display screens, various types of graphical user interfaces (GUIs), touch screens, microphones and other types of sensors that may receive some form of human-generated stimulus and generate a signal in response thereto.

Brief Description of the Drawings

Fig. 1 is a diagram illustrating a lighting unit according to one embodiment of the invention;

Fig. 2 is a diagram illustrating a networked lighting system according to one embodiment of the invention;

Fig. 3 is a schematic diagram showing elements for generating a lighting control signal using a configuration facility and a graphical representation facility.

Fig. 4 is a schematic diagram showing elements for generating a lighting control signal from an animation facility and light management facility.

Fig. 5 illustrates a configuration file for data relating to light systems in an environment.

Fig. 6 illustrates a virtual representation of an environment using a computer screen.

Fig. 7 is a representation of an environment with light systems that project light onto portions of the environment.

Fig. 8 is a schematic diagram showing the propagation of an effect through a light system.

Fig. 9 is a flow diagram showing steps for using an image capture device to determine the positions of a plurality of light systems in an environment.

Fig. 10 is a flow diagram showing steps for interacting with a graphical user interface to generate a lighting effect in an environment.

Fig. 11 is a schematic diagram depicting light systems that transmit data that is generated by a network transmitter.

Fig. 12 is a flow diagram showing steps for generating a control signal for a light system using an object-oriented programming technique.

Fig. 13 is a flow diagram for executing a thread to generate a lighting signal for a real world light system based on data from a computer application.

Fig. 15 is a schematic diagram setting out high-level system elements for a light system manager for a plurality of elements.

Fig. 16 provides a schematic diagram with system elements for a light system manager.

Fig. 17 is a schematic diagram with additional system elements for the light system manager of Fig. 16.

Fig. 18 is a schematic diagram with additional system elements for the light system manager of Fig. 16.

Fig. 19 shows a representation of a plurality of lighting units in a coordinate system.

Fig. 20 shows a representation of a string of lighting units formed into an array.

Fig. 21 shows a string of lighting units in a rectangular perimeter configuration.

Fig. 22 shows a string of lighting units in a triangular array.

Fig. 23 shows a string of lighting units used to form a character.

Fig. 24 shows a string of lighting units in a three-dimensional configuration.

Fig. 25 shows a user interface for a mapping facility for a light system manager.

Fig. 26 shows additional aspects of the user interface of Fig. 25.

Fig. 27 shows additional aspects of the user interface of Fig. 25.

Fig. 28 shows additional aspects of the user interface of Fig. 25.

Fig. 29 shows additional aspects of the user interface of Fig. 25.

Fig. 30 shows additional aspects of the user interface of Fig. 25.

Fig. 31 shows additional aspects of the user interface of Fig. 25.

Fig. 32 shows additional aspects of the user interface of Fig. 25.

Fig. 33 shows groupings of lights within an array.

Fig. 34 shows additional aspects of the user interface of Fig. 25.

Fig. 35 shows additional aspects of the user interface of Fig. 25.

Fig. 36 shows a dragging line interface for forming groups of lighting units.

Fig. 37 shows additional aspects of the user interface of Fig. 25.

Fig. 38 shows additional aspects of the user interface of Fig. 25.

Fig. 39 is a flow diagram that shows steps for using a mapping facility of a light system manager.

Fig. 40 shows a user interface for a light show composer.

Fig. 41 shows parameters for an effect that can be composed by the light system composer of Fig. 40.

Fig. 42 shows aspects of linking of effects in a light system composer.

Fig. 43 shows additional aspects of linking of effects.

Fig. 44 shows additional aspects of a user interface for a light show composer.

Fig. 45 shows additional aspects of a user interface for a light show composer.

Fig. 46 shows additional aspects of a user interface for a light show composer.

Fig. 47 shows additional aspects of a user interface for a light show composer.

Fig. 48 shows additional aspects of a user interface for a light show composer.

Fig. 49 shows additional aspects of a user interface for a light show composer.

Fig. 50 shows additional aspects of a user interface for a light show composer.

Fig. 51 shows additional aspects of a user interface for a light show composer.

Fig. 52 shows additional aspects of a user interface for a light show composer.

Fig. 53 shows additional aspects of a user interface for a light show composer.

Fig. 54 shows additional aspects of a user interface for a light show composer.

Fig. 55 shows additional aspects of a user interface for a light show composer.

Fig. 56 shows additional aspects of a user interface for a light show composer.

Fig. 57 shows additional aspects of a user interface for a light show composer.

Fig. 58 shows additional aspects of a user interface for a light show composer.

Fig. 59 shows additional aspects of a user interface for a light show composer.

Fig. 60 shows additional aspects of a user interface for a light show composer.

Fig. 61 shows additional aspects of a user interface for a light show composer.

Fig. 62 shows additional aspects of a user interface for a light show composer.

Fig. 63 is a schematic diagram showing elements for a user interface for a light system engine.

Fig. 64 shows a user interface for a configuration system for a light system manager.

Fig. 65 shows a user interface for a playback system for a light system manager.

Fig. 66 shows a user interface for a download system for a light system manager.

Fig. 67 is a schematic diagram for a web-based interface for supplying control to a light system engine.

Fig. 68 shows an input to a light system mangager in the form of video from video source.

Fig. 69 shows a light system manager including a personal computer configured to receive a high-speed serial data stream.

Fig. 70 shows a video source comprising a storage medium.

Fig. 71 shows that video manipulation software may be configured to receive input from any type of video source.

Detailed Description

Methods and systems are provided herein for supplying control signals for lighting systems, including methods and systems for authoring effects and shows for lighting systems.

Various embodiments of the present invention are described below, including certain embodiments relating particularly to LED-based light sources. It should be appreciated, however, that the present invention is not limited to any particular manner of implementation, and that the various embodiments discussed explicitly herein are primarily for purposes of illustration. For example, the various concepts discussed herein may be suitably implemented in a variety of environments involving LED-based light sources, other types of light sources not including LEDs, environments that involve both LEDs and other types of light sources in combination, and environments that involve non-lighting-related devices alone or in combination with various types of light sources.

Fig. 1 illustrates one example of a lighting unit 100 that may serve as a device in a lighting environment according to one embodiment of the present invention. Some examples of LED-based lighting units similar to those that are described below in connection with Fig. 1 may be found, for example, in U.S. Patent No. 6,016,038, issued January 18, 2000 to Mueller et al., entitled "Multicolored LED Lighting Method and Apparatus," and U.S. Patent No. 6,211,626, issued April 3, 2001 to Lys et al, entitled "Illumination Components," which patents are both hereby incorporated herein by reference.

In various embodiments of the present invention, the lighting unit 100 shown in Fig. 1 may be used alone or together with other similar lighting units in a system of lighting units (e.g., as discussed further below in connection with Fig. 2). Used alone or in combination with other lighting units, the lighting unit 100 may be employed in a variety of applications including, but not limited to, interior or exterior space illumination in general, direct or indirect illumination of objects or spaces, theatrical or other entertainment-based / special effects illumination, decorative illumination, safety-oriented illumination, vehicular illumination, illumination of displays and/or merchandise (e.g. for advertising and/or in retail/consumer environments), combined illumination and communication systems, etc., as well as for various indication and informational purposes.

Additionally, one or more lighting units similar to that described in connection with Fig. 1 may be implemented in a variety of products including, but not limited to, various forms of light modules or bulbs having various shapes and electrical/mechanical coupling arrangements (including replacement or "retrofit" modules or bulbs adapted for use in conventional sockets or fixtures), as well as a variety of consumer and/or household products (e.g., night lights, toys, games or game components, entertainment components or systems, utensils, appliances, kitchen aids, cleaning products, etc.).

In one embodiment, the lighting unit 100 shown in Fig. 1 may include one or more light sources 104A, 104B, and 104C (shown collectively as 104), wherein one or more of the light sources may be an LED-based light source that includes one or more light emitting diodes (LEDs). In one aspect of this embodiment, any two or more of the light sources 104A, 104B, and 104C may be adapted to generate radiation of different colors (e.g. red, green, and blue, respectively). Although Fig. 1 shows three light sources 104A, 104B, and 104C, it should be appreciated that the lighting unit is not limited in this respect, as different numbers and various types of light sources (all LED-based light sources, LED-based and non-LED-based light sources in combination, etc.) adapted to generate radiation of a variety of different colors, including essentially white light, may be employed in the lighting unit 100, as discussed further below.

As shown in Fig. 1, the lighting unit 100 also may include a processor 102 that is configured to output one or more control signals to drive the light sources 104A, 104B, and 104C so as to generate various intensities of light from the light sources. For example, in one implementation, the processor 102 may be configured to output at least one control signal for each light source so as to independently control the intensity of light generated by each light source. Some examples of control signals that may be generated by the processor to control the light sources include, but are not limited to, pulse modulated signals, pulse width modulated signals (PWM), pulse amplitude modulated signals (PAM), pulse code modulated signals (PCM) analog control signals (e.g., current control signals, voltage control signals), combinations and/or modulations of the foregoing signals, or other control signals. In one aspect, the processor 102 may

control other dedicated circuitry (not shown in Fig. 1) which in turn controls the light sources so as to vary their respective intensities.

In one embodiment of the lighting unit 100, one or more of the light sources 104A, 104B, and 104C shown in Fig. 1 may include a group of multiple LEDs or other types of light sources (e.g., various parallel and/or serial connections of LEDs or other types of light sources) that are controlled together by the processor 102. Additionally, it should be appreciated that one or more of the light sources 104A, 104B, and 104C may include one or more LEDs that are adapted to generate radiation having any of a variety of spectra (i.e., wavelengths or wavelength bands), including, but not limited to, various visible colors (including essentially white light), various color temperatures of white light, ultraviolet, or infrared. LEDs having a variety of spectral bandwidths (e.g., narrow band, broader band) may be employed in various implementations of the lighting unit 100.

In another aspect of the lighting unit 100 shown in Fig. 1, the lighting unit 100 may be constructed and arranged to produce a wide range of variable color radiation. For example, the lighting unit 100 may be particularly arranged such that the processor-controlled variable intensity light generated by two or more of the light sources combines to produce a mixed colored light (including essentially white light having a variety of color temperatures). In particular, the color (or color temperature) of the mixed colored light may be varied by varying one or more of the respective intensities of the light sources (e.g., in response to one or more control signals output by the processor 103). Furthermore, the processor 102 may be particularly configured (e.g., programmed) to provide control signals to one or more of the light sources so as to generate a variety of static or time-varying (dynamic) multi-color (or multi-color temperature) lighting effects.

Thus, the lighting unit 100 may include a wide variety of colors of LEDs in various combinations, including two or more of red, green, and blue LEDs to produce a color mix, as well as one or more other LEDs to create varying colors and color temperatures of white light. For example, red, green and blue can be mixed with amber, white, UV, orange, IR or other colors of LEDs. Such combinations of differently

colored LEDs in the lighting unit 100 can facilitate accurate reproduction of a host of desirable spectrums of lighting conditions, examples of which includes, but are not limited to, a variety of outside daylight equivalents at different times of the day, various interior lighting conditions, lighting conditions to simulate a complex multicolored background, and the like. Other desirable lighting conditions can be created by removing particular pieces of spectrum that may be specifically absorbed, attenuated or reflected in certain environments. Water, for example tends to absorb and attenuate most non-blue and non-green colors of light, so underwater applications may benefit from lighting conditions that are tailored to emphasize or attenuate some spectral elements relative to others.

As shown in Fig. 1, the lighting unit 100 also may include a memory 114 to store various information. For example, the memory 114 may be employed to store one or more lighting programs for execution by the processor 103 (e.g., to generate one or more control signals for the light sources), as well as various types of data useful for generating variable color radiation (e.g., calibration information, discussed further below). The memory 114 also may store one or more particular identifiers (e.g., a serial number, an address, etc.) that may be used either locally or on a system level to identify the lighting unit 100. In various embodiments, such identifiers may be pre-programmed by a manufacturer, for example, and may be either alterable or non-alterable thereafter (e.g., via some type of user interface located on the lighting unit, via one or more data or control signals received by the lighting unit, etc.). Alternatively, such identifiers may be determined at the time of initial use of the lighting unit in the field, and again may be alterable or non-alterable thereafter.

One issue that may arise in connection with controlling multiple light sources in the lighting unit 100 of Fig. 1, and controlling multiple lighting units 100 in a lighting system (e.g., as discussed below in connection with Fig. 2), relates to potentially perceptible differences in light output between substantially similar light sources. For example, given two virtually identical light sources being driven by respective identical control signals, the actual intensity of light output by each light source may be

perceptibly different. Such a difference in light output may be attributed to various factors including, for example, slight manufacturing differences between the light sources, normal wear and tear over time of the light sources that may differently alter the respective spectrums of the generated radiation, etc. For purposes of the present discussion, light sources for which a particular relationship between a control signal and resulting intensity are not known are referred to as "uncalibrated" light sources.

The use of one or more uncalibrated light sources in the lighting unit 100 shown in Fig. 1 may result in generation of light having an unpredictable, or "uncalibrated," color or color temperature. For example, consider a first lighting unit including a first uncalibrated red light source and a first uncalibrated blue light source, each controlled by a corresponding control signal having an adjustable parameter in a range of from zero to 255 (0-255). For purposes of this example, if the red control signal is set to zero, blue light is generated, whereas if the blue control signal is set to zero, red light is generated. However, it both control signals are varied from non-zero values, a variety of perceptibly different colors may be produced (e.g., in this example, at very least, many different shades of purple are possible). In particular, perhaps a particular desired color (e.g., lavender) is given by a red control signal having a value of 125 and a blue control signal having a value of 200.

Now consider a second lighting unit including a second uncalibrated red light source substantially similar to the first uncalibrated red light source of the first lighting unit, and a second uncalibrated blue light source substantially similar to the first uncalibrated blue light source of the first lighting unit. As discussed above, even if both of the uncalibrated red light sources are driven by respective identical control signals, the actual intensity of light output by each red light source may be perceptibly different. Similarly, even if both of the uncalibrated blue light sources are driven by respective identical control signals, the actual intensity of light output by each blue light source may be perceptibly different.

With the foregoing in mind, it should be appreciated that if multiple uncalibrated light sources are used in combination in lighting units to produce a mixed colored light as discussed above, the observed color (or color temperature) of light produced by different lighting units under identical control conditions may be perceivably different. Specifically, consider again the "lavender" example above; the "first lavender" produced by the first lighting unit with a red control signal of 125 and a blue control signal of 200 indeed may be perceptibly different than a "second lavender" produced by the second lighting unit with a red control signal of 125 and a blue control signal of 200. More generally, the first and second lighting units generate uncalibrated colors by virtue of their uncalibrated light sources.

In view of the foregoing , in one embodiment of the present invention, the lighting unit 100 includes calibration means to facilitate the generation of light having a calibrated (e.g., predictable, reproducible) color at any given time. In one aspect, the calibration means is configured to adjust the light output of at least some light sources of the lighting unit so as to compensate for perceptible differences between similar light sources used in different lighting units.

For example, in one embodiment, the processor 103 of the lighting unit 100 is configured to control one or more of the light sources 104A, 104B, and 104C so as to output radiation at a calibrated intensity that substantially corresponds in a predetermined manner to a control signal for the light source(s). As a result of mixing radiation having different spectra and respective calibrated intensities, a calibrated color is produced. In one aspect of this embodiment, at least one calibration value for each light source is stored in the memory 114, and the processor is programmed to apply the respective calibration values to the control signals for the corresponding light sources so as to generate the calibrated intensities.

In one aspect of this embodiment, one or more calibration values may be determined once (e.g., during a lighting unit manufacturing/testing phase) and stored in the memory 114 for use by the processor 103. In another aspect, the processor 103 may

be configured to derive one or more calibration values dynamically (e.g. from time to time) with the aid of one or more photosensors, for example. In various embodiments, the photosensor(s) may be one or more external components coupled to the lighting unit, or alternatively may be integrated as part of the lighting unit itself. A photosensor is one example of a signal source that may be integrated or otherwise associated with the lighting unit 100, and monitored by the processor 103 in connection with the operation of the lighting unit. Other examples of such signal sources are discussed further below, in connection with the signal source 124 shown in Fig. 1.

One exemplary method that may be implemented by the processor 103 to derive one or more calibration values includes applying a reference control signal to a light source, and measuring (e.g., via one or more photosensors) an intensity of radiation thus generated by the light source. The processor may be programmed to then make a comparison of the measured intensity and at least one reference value (e.g., representing an intensity that nominally would be expected in response to the reference control signal). Based on such a comparison, the processor may determine one or more calibration values for the light source. In particular, the processor may derive a calibration value such that, when applied to the reference control signal, the light source outputs radiation having an intensity the corresponds to the reference value (i.e., the "expected" intensity).

In various aspects, one calibration value may be derived for an entire range of control signal/output intensities for a given light source. Alternatively, multiple calibration values may be derived for a given light source (i.e., a number of calibration value "samples" may be obtained) that are respectively applied over different control signal/output intensity ranges, to approximate a nonlinear calibration function in a piecewise linear manner.

In another aspect, as also shown in Fig. 1, the lighting unit 100 optionally may include one or more user interfaces 118 that are provided to facilitate any of a number of user-selectable settings or functions (e.g., generally controlling the light output of the

lighting unit 100, changing and/or selecting various pre-programmed lighting effects to be generated by the lighting unit, changing and/or selecting various parameters of selected lighting effects, setting particular identifiers such as addresses or serial numbers for the lighting unit, etc.). In various embodiments, the communication between the user interface 118 and the lighting unit may be accomplished through wire or cable, or wireless transmission.

In one implementation, the processor 103 of the lighting unit monitors the user interface 118 and controls one or more of the light sources 104A, 104B, and 104C based at least in part on a user's operation of the interface. For example, the processor 103 may be configured to respond to operation of the user interface by originating one or more control signals for controlling one or more of the light sources. Alternatively, the processor 103 may be configured to respond by selecting one or more pre-programmed control signals stored in memory, modifying control signals generated by executing a lighting program, selecting and executing a new lighting program from memory, or otherwise affecting the radiation generated by one or more of the light sources.

In particular, in one implementation, the user interface 118 may constitute one or more switches (e.g., a standard wall switch) that interrupt power to the processor 103. In one aspect of this implementation, the processor 103 is configured to monitor the power as controlled by the user interface, and in turn control one or more of the light sources 104A, 104B, and 104C based at least in part on a duration of a power interruption caused by operation of the user interface. As discussed above, the processor may be particularly configured to respond to a predetermined duration of a power interruption by, for example, selecting one or more pre-programmed control signals stored in memory, modifying control signals generated by executing a lighting program, selecting and executing a new lighting program from memory, or otherwise affecting the radiation generated by one or more of the light sources.

Fig. 1 also illustrates that the lighting unit 100 may be configured to receive one or more signals 122 from one or more other signal sources 124. In one implementation,

the processor 103 of the lighting unit may use the signal(s) 122, either alone or in combination with other control signals (e.g., signals generated by executing a lighting program, one or more outputs from a user interface, etc.), so as to control one or more of the light sources 104A, 104B and 104C in a manner similar to that discussed above in connection with the user interface.

Examples of the signal(s) 122 that may be received and processed by the processor 103 include, but are not limited to, one or more audio signals, video signals, power signals, various types of data signals, signals representing information obtained from a network (e.g., the Internet), signals representing one or more detectable/sensed conditions, signals from lighting units, signals consisting of modulated light, etc. In various implementations, the signal source(s) 124 may be located remotely from the lighting unit 100, or included as a component of the lighting unit. For example, in one embodiment, a signal from one lighting unit 100 could be sent over a network to another lighting unit 100.

Some examples of a signal source 124 that may be employed in, or used in connection with, the lighting unit 100 of Fig. 1 include any of a variety of sensors or transducers that generate one or more signals 122 in response to some stimulus. Examples of such sensors include, but are not limited to, various types of environmental condition sensors, such as thermally sensitive (e.g., temperature, infrared) sensors, humidity sensors, motion sensors, photosensors/light sensors (e.g., sensors that are sensitive to one or more particular spectra of electromagnetic radiation), various types of cameras, sound or vibration sensors or other pressure/force transducers (e.g., microphones, piezoelectric devices), and the like.

Additional examples of a signal source 124 include various metering/detection devices that monitor electrical signals or characteristics (e.g., voltage, current, power, resistance, capacitance, inductance, etc.) or chemical/biological characteristics (e.g., acidity, a presence of one or more particular chemical or biological agents, bacteria, etc.) and provide one or more signals 122 based on measured values of the signals or

characteristics. Yet other examples of a signal source 124 include various types of scanners, image recognition systems, voice or other sound recognition systems, artificial intelligence and robotics systems, and the like. A signal source 124 could also be a lighting unit 100, a processor 103, or any one of many available signal generating devices, such as media players, MP3 players, computers, DVD players, CD players, television signal sources, camera signal sources, microphones, speakers, telephones, cellular phones, instant messenger devices, SMS devices, wireless devices, personal organizer devices, and many others.

In one embodiment, the lighting unit 100 shown in Fig. 1 also may include one or more optical elements 130 to optically process the radiation generated by the light sources 104A, 104B, and 104C. For example, one or more optical elements may be configured so as to change one or both of a spatial distribution and a propagation direction of the generated radiation. In particular, one or more optical elements may be configured to change a diffusion angle of the generated radiation. In one aspect of this embodiment, one or more optical elements 130 may be particularly configured to variably change one or both of a spatial distribution and a propagation direction of the generated radiation (e.g., in response to some electrical and/or mechanical stimulus). Examples of optical elements that may be included in the lighting unit 100 include, but are not limited to, reflective materials, refractive materials, translucent materials, filters, lenses, mirrors, and fiber optics. The optical element 130 also may include a phosphorescent material, luminescent material, or other material capable of responding to or interacting with the generated radiation.

As also shown in Fig. 1, the lighting unit 100 may include one or more communication ports 120 to facilitate coupling of the lighting unit 100 to any of a variety of other devices. For example, one or more communication ports 120 may facilitate coupling multiple lighting units together as a networked lighting system, in which at least some of the lighting units are addressable (e.g., have particular identifiers or addresses) and are responsive to particular data transported across the network.

In particular, in a networked lighting system environment, as discussed in greater detail further below (e.g., in connection with Fig. 2), as data is communicated via the network, the processor 103 of each lighting unit coupled to the network may be configured to be responsive to particular data (e.g., lighting control commands) that pertain to it (e.g., in some cases, as dictated by the respective identifiers of the networked lighting units). Once a given processor identifies particular data intended for it, it may read the data and, for example, change the lighting conditions produced by its light sources according to the received data (e.g., by generating appropriate control signals to the light sources). In one aspect, the memory 114 of each lighting unit coupled to the network may be loaded, for example, with a table of lighting control signals that correspond with data the processor 103 receives. Once the processor 103 receives data from the network, the processor may consult the table to select the control signals that correspond to the received data, and control the light sources of the lighting unit accordingly.

In one aspect of this embodiment, the processor 103 of a given lighting unit, whether or not coupled to a network, may be configured to interpret lighting instructions/data that are received in a DMX protocol (as discussed, for example, in U.S. Patents 6,016,038 and 6,211,626), which is a lighting command protocol conventionally employed in the lighting industry for some programmable lighting applications. However, it should be appreciated that lighting units suitable for purposes of the present invention are not limited in this respect, as lighting units according to various embodiments may be configured to be responsive to other types of communication protocols so as to control their respective light sources.

In one embodiment, the lighting unit 100 of Fig. 1 may include and/or be coupled to one or more power sources 108. In various aspects, examples of power source(s) 108 include, but are not limited to, AC power sources, DC power sources, batteries, solar-based power sources, thermoelectric or mechanical-based power sources and the like. Additionally, in one aspect, the power source(s) 108 may include or be associated with

one or more power conversion devices that convert power received by an external power source to a form suitable for operation of the lighting unit 100.

While not shown explicitly in Fig. 1, the lighting unit 100 may be implemented in any one of several different structural configurations according to various embodiments of the present invention. Examples of such configurations include, but are not limited to, an essentially linear or curvilinear configuration, a circular configuration, an oval configuration, a rectangular configuration, combinations of the foregoing, various other geometrically shaped configurations, various two or three dimensional configurations, and the like.

A given lighting unit also may have any one of a variety of mounting arrangements for the light source(s), enclosure/housing arrangements and shapes to partially or fully enclose the light sources, and/or electrical and mechanical connection configurations. In particular, a lighting unit may be configured as a replacement or "retrofit" to engage electrically and mechanically in a conventional socket or fixture arrangement (e.g., an Edison-type screw socket, a halogen fixture arrangement, a fluorescent fixture arrangement, etc.).

Additionally, one or more optical elements as discussed above may be partially or fully integrated with an enclosure/housing arrangement for the lighting unit. Furthermore, a given lighting unit optionally may be associated with (e.g., include, be coupled to and/or packaged together with) various other components (e.g., control circuitry such as the processor and/or memory, one or more sensors/transducers/signal sources, user interfaces, displays, power sources, power conversion devices, etc.) relating to the operation of the light source(s).

Fig. 2 illustrates an example of a networked lighting system 200 according to one embodiment of the present invention. In the embodiment of Fig. 2, a number of lighting units 100, similar to those discussed above in connection with Fig. 1, are coupled together to form the networked lighting system. It should be appreciated, however, that

the particular configuration and arrangement of lighting units shown in Fig. 2 is for purposes of illustration only, and that the invention is not limited to the particular system topology shown in Fig. 2.

Additionally, while not shown explicitly in Fig. 2, it should be appreciated that the networked lighting system 200 may be configured flexibly to include one or more user interfaces, as well as one or more signal sources such as sensors/transducers. For example, one or more user interfaces and/or one or more signal sources such as sensors/transducers (as discussed above in connection with Fig. 1) may be associated with any one or more of the lighting units of the networked lighting system 200. Alternatively (or in addition to the foregoing), one or more user interfaces and/or one or more signal sources may be implemented as "stand alone" components in the networked lighting system 200. Whether stand alone components or particularly associated with one or more lighting units 100, these devices may be "shared" by the lighting units of the networked lighting system. Stated differently, one or more user interfaces and/or one or more signal sources such as sensors/transducers may constitute "shared resources" in the networked lighting system that may be used in connection with controlling any one or more of the lighting units of the system.

As shown in the embodiment of Fig. 2, the lighting system 200 may include one or more lighting unit controllers (hereinafter "LUCs") 208A, 208B, 208C, and 208D, wherein each LUC is responsible for communicating with and generally controlling one or more lighting units 100 coupled to it. Although Fig. 2 illustrates one lighting unit 100 coupled to each LUC, it should be appreciated that the invention is not limited in this respect, as different numbers of lighting units 100 may be coupled to a given LUC in a variety of different configurations (serially connections, parallel connections, combinations of serial and parallel connections, etc.) using a variety of different communication media and protocols.

In the system of Fig. 2, each LUC in turn may be coupled to a central controller 202 that is configured to communicate with one or more LUCs. Although Fig. 2 shows

four LUCs coupled to the central controller 202 via a generic connection 204 (which may include any number of a variety of conventional coupling, switching and/or networking devices), it should be appreciated that according to various embodiments, different numbers of LUCs may be coupled to the central controller 202. Additionally, according to various embodiments of the present invention, the LUCs and the central controller may be coupled together in a variety of configurations using a variety of different communication media and protocols to form the networked lighting system 200. Moreover, it should be appreciated that the interconnection of LUCs and the central controller, and the interconnection of lighting units to respective LUCs, may be accomplished in different manners (e.g., using different configurations, communication media, and protocols).

For example, according to one embodiment of the present invention, the central controller 202 shown in Fig. 2 may by configured to implement Ethernet-based communications with the LUCs, and in turn the LUCs may be configured to implement DMX-based communications with the lighting units 100. In particular, in one aspect of this embodiment, each LUC may be configured as an addressable Ethernet-based controller and accordingly may be identifiable to the central controller 202 via a particular unique address (or a unique group of addresses) using an Ethernet-based protocol. In this manner, the central controller 202 may be configured to support Ethernet communications throughout the network of coupled LUCs, and each LUC may respond to those communications intended for it. In turn, each LUC may communicate lighting control information to one or more lighting units coupled to it, for example, via a DMX protocol, based on the Ethernet communications with the central controller 202.

More specifically, according to one embodiment, the LUCs 208A, 208B, and 208C shown in Fig. 2 may be configured to be "intelligent" in that the central controller 202 may be configured to communicate higher level commands to the LUCs that need to be interpreted by the LUCs before lighting control information can be forwarded to the lighting units 100. For example, a lighting system operator may want to generate a color changing effect that varies colors from lighting unit to lighting unit in such a way as to

generate the appearance of a propagating rainbow of colors ("rainbow chase"), given a particular placement of lighting units with respect to one another. In this example, the operator may provide a simple instruction to the central controller 202 to accomplish this, and in turn the central controller may communicate to one or more LUCs using an Ethernet-based protocol high level command to generate a "rainbow chase." The command may contain timing, intensity, hue, saturation or other relevant information, for example. When a given LUC receives such a command, it may then interpret the command so as to generate the appropriate lighting control signals which it then communicates using a DMX protocol via any of a variety of signaling techniques (e.g., PWM) to one or more lighting units that it controls.

It should again be appreciated that the foregoing example of using multiple different communication implementations (e.g., Ethernet/DMX) in a lighting system according to one embodiment of the present invention is for purposes of illustration only, and that the invention is not limited to this particular example.

An embodiment of the present invention describes a method 300 for generating control signals as illustrated in the block diagram in Fig. 3. The method may involve providing or generating an image or representation of an image, i.e., a graphical representation 302. The graphical representation may be a static image such as a drawing, photograph, generated image, or image that is or appears to be static. The static image may include images displayed on a computer screen or other screen even though the image is continually being refreshed on the screen. The static image may also be a hard copy of an image.

Providing a graphical representation 302 may also involve generating an image or representation of an image. For example, a processor may be used to execute software to generate the graphical representation 302. Again, the image that is generated may be or appear to be static or the image may be dynamic. An example of software used to

generate a dynamic image is Flash 5 computer software offered by Macromedia, Incorporated. Flash 5 is a widely used computer program to generate graphics, images and animations. Other useful products used to generate images include, for example, Adobe Illustrator, Adobe Photoshop, and Adobe LiveMotion. There are many other programs that can be used to generate both static and dynamic images. For example, Microsoft Corporation makes a computer program Paint. This software is used to generate images on a screen in a bit map format. Other software programs may be used to generate images in bitmaps, vector coordinates, or other techniques. There are also many programs that render graphics in three dimensions or more. Direct X libraries, from Microsoft Corporation, for example generate images in three-dimensional space. The output of any of the foregoing software programs or similar programs can serve as the graphical representation 302.

In embodiments the graphical representation 302 may be generated using software executed on a processor but the graphical representation 302 may never be displayed on a screen. In an embodiment, an algorithm may generate an image or representation thereof, such as an explosion in a room for example. The explosion function may generate an image and this image may be used to generate control signals as described herein with or without actually displaying the image on a screen. The image may be displayed through a lighting network for example without ever being displayed on a screen.

In an embodiment, generating or representing an image may be accomplished through a program that is executed on a processor. In an embodiment, the purpose of generating the image or representation of the image may be to provide information defined in a space. For example, the generation of an image may define how a lighting effect travels through a room. The lighting effect may represent an explosion, for example. The representation may initiate bright white light in the corner of a room and the light may travel away from this corner of the room at a velocity (with speed and direction) and the color of the light may change as the propagation of the effect continues. An illustration of an environment 100 showing vectors 104 demonstrating the

velocity of certain lighting effects is illustrated in Fig. 1. In an embodiment, an image generator may generate a function or algorithm. The function or algorithm may represent an event such as an explosion, lighting strike, headlights, train passing through a room, bullet shot through a room, light moving through a room, sunrise across a room, or other event. The function or algorithm may represent an image such as lights swirling in a room, balls of light bouncing in a room, sounds bouncing in a room, or other images. The function or algorithm may also represent randomly generated effects or other effects.

Referring again to Fig. 3, a light system configuration facility 304 may accomplish further steps for the methods and systems described herein. The light system configuration facility may generate a system configuration file, configuration data or other configuration information for a lighting system, such as the one depicted in connection with Fig. 1.

The light system configuration facility can represent or correlate a system, such as a light system 102, sound system or other system as described herein with a position or positions in the environment 100. For example, an LED light system 102 may be correlated with a position within a room. In an embodiment, the location of a lighted surface 107 may also be determined for inclusion into the configuration file. The position of the lighted surface may also be associated with a light system 102. In embodiments, the lighted surface 107 may be the desired parameter while the light system 102 that generates the light to illuminate the surface is also important. Lighting control signals may be communicated to a light system 102 when a surface is scheduled to be lit by the light system 102. For example, control signals may be communicated to a lighting system when a generated image calls for a particular section of a room to change in hue, saturation or brightness. In this situation, the control signals may be used to control the lighting system such that the lighted surface 107 is illuminated at the proper time. The lighted surface 107 may be located on a wall but the light system 102 designed to project light onto the surface 107 may be located on the ceiling. The configuration information could be arranged to initiate the light system 102 to activate or change when the surface 107 is to be lit.

Referring still to Fig. 3, the graphical representation 302 and the configuration information from the light system configuration facility 304 can be delivered to a conversion module 308, which associates position information from the configuration facility with information from the graphical representation and converts the information into a control signal, such as a control signal 310 for a light system 102. Then the conversion module can communicate the control signal, such as to the light system 102. In embodiments the conversion module maps positions in the graphical representation to positions of light systems 102 in the environment, as stored in a configuration file for the environment (as described below). The mapping might be a one-to-one mapping of pixels or groups of pixels in the graphical representation to light systems 102 or groups of light systems 102 in the environment 100. It could be a mapping of pixels in the graphical representation to surfaces 107, polygons, or objects in the environment that are lit by light systems 102. It could be a mapping of vector coordinate information, a wave function, or algorithm to positions of light systems 102. Many different mapping relations can be envisioned and are encompassed herein.

Referring to Fig. 4, another embodiment of a block diagram for a method and system for generating a control signal is depicted. A light management facility 402 is used to generate a map file 404 that maps light systems 102 to positions in an environment, to surfaces that are lit by the light systems, and the like. An animation facility 408 generates a sequence of graphics files 410 for an animation effect. A conversion module 412 relates the information in the map file 404 for the light systems 102 to the graphical information in the graphics files. For example, color information in the graphics file may be used to convert to a color control signal for a light system to generate a similar color. Pixel information for the graphics file may be converted to address information for light systems which will correspond to the pixels in question. In embodiments, the conversion module 412 includes a lookup table for converting particular graphics file information into particular lighting control signals, based on the content of a configuration file for the lighting system and conversion algorithms appropriate for the animation facility in question. The converted information can be sent

to a playback tool 414, which may in turn play the animation and deliver control signals 418 to light systems 102 in an environment.

Referring to Fig. 5, an embodiment of a configuration file 500 is depicted, showing certain elements of configuration information that can be stored for a light system 102 or other system. Thus, the configuration file 500 can store an identifier 502 for each light system 102, as well as the position 508 of that light system in a desired coordinate or mapping system for the environment 100 (which may be (x,y,z) coordinates, polar coordinates, (x,y) coordinates, or the like). The position 508 and other information may be time-dependent, so the configuration file 500 can include an element of time 504. The configuration file 500 can also store information about the position 510 that is lit by the light system 102. That information can consist of a set of coordinates, or it may be an identified surface, polygon, object, or other item in the environment. The configuration file 500 can also store information about the available degrees of freedom for use of the light system 102, such as available colors in a color range 512, available intensities in an intensity range 514, or the like. The configuration file 500 can also include information about other systems 518 in the environment that are controlled by the control systems disclosed herein, information about the characteristics of surfaces 107 in the environment, and the like. Thus, the configuration file 500 can map a set of light systems 102 to the conditions that they are capable of generating in an environment 100.

In an embodiment, configuration information such as the configuration file 500 may be generated using a program executed on a processor. Referring to Fig. 6, the program may run on a computer 600 with a graphical user interface 612 where a representation of an environment 602 can be displayed, showing light systems 102, lit surfaces 107 or other elements in a graphical format. The interface may include a representation 602 of a room for example. Representations of lights, lighted surfaces or other systems may then be presented in the interface 612 and locations can be assigned to the system. In an embodiment, position coordinates or a position map may represent a system, such as a light system. A position map may also be generated for the

representation of a lighted surface for example. Figure 6 illustrates a room with light systems 102.

The representation 602 can also be used to simplify generation of effects. For example, a set of stored effects can be represented by icons 610 on the screen 612. An explosion icon can be selected with a cursor or mouse, which may prompt the user to click on a starting and ending point for the explosion in the coordinate system. By locating a vector in the representation, the user can cause an explosion to be initiated in the upper corner of the room 602 and a wave of light and or sound may propagate through the environment. With all of the light systems 102 in predetermined positions, as identified in the configuration file 500, the representation of the explosion can be played in the room by the light system and or another system such as a sound system.

In use, a control system such as used herein can be used to provide information to a user or programmer from the light systems 102 in response to or in coordination with the information being provided to the user of the computer 600. One example of how this can be provided is in conjunction with the user generating a computer animation on the computer 600. The light system 102 may be used to create one or more light effects in response to displays 612 on the computer 600. The lighting effects, or illumination effects, can produce a vast variety of effects including color-changing effects; stroboscopic effects; flashing effects; coordinated lighting effects; lighting effects coordinated with other media such as video or audio; color wash where the color changes in hue, saturation or intensity over a period of time; creating an ambient color; color fading; effects that simulate movement such as a color chasing rainbow, a flare streaking across a room, a sun rising, a plume from an explosion, other moving effects; and many other effects. The effects that can be generated are nearly limitless. Light and color continually surround the user, and controlling or changing the illumination or color in a space can change emotions, create atmosphere, provide enhancement of a material or object, or create other pleasing and or useful effects. The user of the computer 600 can observe the effects while modifying them on the display 612, thus enabling a feedback loop that allows the user to conveniently modify effects.

Fig. 7 illustrates how the light from a given light system 102 may be displayed on a surface. A light system 102, sound system, or other system may project onto a surface. In the case of a light system 102, this may be an area 702 that is illuminated by the light system 102. The light system 102, or other system, may also move, so the area 702 may move as well. In the case of a sound system, this may be the area where the user desires the sound to emanate from.

In an embodiment, the information generated to form the image or representation may be communicated to a light system 102 or plurality of light systems 102. The information may be sent to lighting systems as generated in a configuration file. For example, the image may represent an explosion that begins in the upper right hand comer of a room and the explosion may propagate through the room. As the image propagates through its calculated space, control signals can be communicated to lighting systems in the corresponding space. The communication signal may cause the lighting system to generate light of a given hue, saturation and intensity when the image is passing through the lighted space the lighting systems projects onto. An embodiment of the invention projects the image through a lighting system. The image may also be projected through a computer screen or other screen or projection device. In an embodiment, a screen may be used to visualize the image prior or during the playback of the image on a lighting system. In an embodiment, sound or other effects may be correlated with the lighting effects. For example, the peak intensity of a light wave propagating through a space may be just ahead of a sound wave. As a result, the light wave may pass through a room followed by a sound wave. The light wave may be played back on a lighting system and the sound wave may be played back on a sound system. This coordination can create effects that appear to be passing through a room or they can create various other effects.

Referring to Fig. 6, an effect can propagate through a virtual environment that is represented in 3D on the display screen 612 of the computer 600. In embodiments, the effect can be modeled as a vector or plane moving through space over time. Thus, all light systems 102 that are located on the plane of the effect in the real world environment

can be controlled to generate a certain type of illumination when the effect plane propagates through the light system plane. This can be modeled in the virtual environment of the display screen, so that a developer can drag a plane through a series of positions that vary over time. For example, an effect plane 618 can move with the vector 608 through the virtual environment. When the effect plan 618 reaches a polygon 614, the polygon can be highlighted in a color selected from the color palette 604. A light system 102 positioned on a real world object that corresponds to the polygon can then illuminate in the same color in the real world environment. Of course, the polygon could be any configuration of light systems on any object, plane, surface, wall, or the like, so the range of 3D effects that can be created is unlimited.

In an embodiment, the image information may be communicated from a central controller. The information may be altered before a lighting system responds to the information. For example, the image information may be directed to a position within a position map. All of the information directed at a position map may be collected prior to sending the information to a lighting system. This may be accomplished every time the image is refreshed or every time this section of the image is refreshed or at other times. In an embodiment, an algorithm may be performed on information that is collected. The algorithm may average the information, calculate and select the maximum information, calculate and select the minimum information, calculate and select the first quartile of the information, calculate and select the third quartile of the information, calculate and select the most used information calculate and select the integral of the information or perform another calculation on the information. This step may be completed to level the effect of the lighting system in response to information received. For example, the information in one refresh cycle may change the information in the map several times and the effect may be viewed best when the projected light takes on one value in a given refresh cycle.

In an embodiment, the information communicated to a lighting system may be altered before a lighting system responds to the information. The information format may change prior to the communication for example. The information may be communicated from a computer through a USB port or other communication port and the

format of the information may be changed to a lighting protocol such as DMX when the information is communicated to the lighting system. In an embodiment, the information or control signals may be communicated to a lighting system or other system through a communications port of a computer, portable computer, notebook computer, personal digital assistant or other system. The information or control signals may also be stored in memory, electronic or otherwise, to be retrieved at a later time. Systems such the iPlayer and SmartJack systems manufactured and sold by Color Kinetics Incorporated can be used to communicate and or store lighting control signals.

In an embodiment, several systems may be associated with position maps and the several systems may a share position map or the systems may reside in independent position areas. For example, the position of a lighted surface from a first lighting system may intersect with a lighted surface from a second lighting system. The two systems may still respond to information communicated to the either of the lighting systems. In an embodiment, the interaction of two lighting systems may also be controlled. An algorithm, function or other technique may be used to change the lighting effects of one or more of the lighting systems in a interactive space. For example, if the interactive space is greater than half of the non-interactive space from a lighting system, the lighting system's hue, saturation or brightness may be modified to compensate the interactive area. This may be used to adjust the overall appearance of the interactive area or an adjacent area for example.

Control signals generated using methods and or systems according to the principles of the present invention can be used to produce a vast variety of effects. Imagine a fire or explosion effect that one wishes to have move across a wall or room. It starts at one end of the room as a white flash that quickly moves out followed by a high brightness yellow wave whose intensity varies as it moves through the room. When generating a control signal according to the principles of the present invention, a lighting designer does not have to be concerned with the lights in the room and the timing and generation of each light system's lighting effects. Rather the designer only needs to be concerned with the relative position or actual position of those lights in the room. The

designer can lay out the lighting in a room and then associate the lights in the room with graphical information, such as pixel information, as described above. The designer can program the fire or explosion effect on a computer, using Flash 5 for example, and the information can be communicated to the light systems 102 in an environment. The position of the lights in the environment may be considered as well as the surfaces 107 or areas 702 that are going to be lit.

In an embodiment, the lighting effects could also be coupled to sound that will add to and reinforce the lighting effects. An example is a 'red alert' sequence where a ' whoop whoop' siren-like effect is coupled with the entire room pulsing red in concert with the sound. One stimulus reinforces the other. Sounds and movement of an earthquake using low frequency sound and flickering lights is another example of coordinating these effects. Movement of light and sound can be used to indicate direction.

In an embodiment the lights are represented in a two-dimensional or plan view. This allows representation of the lights in a plane where the lights can be associated with various pixels. Standard computer graphics techniques can then be used for effects. Animation tweening and even standard tools may be used to create lighting effects. Macromedia Flash works with relatively low-resolution graphics for creating animations on the web. Flash uses simple vector graphics to easily create animations. The vector representation is efficient for streaming applications such as on the World Wide Web for sending animations over the net. The same technology can be used to create animations that can be used to derive lighting commands by mapping the pixel information or vector information to vectors or pixels that correspond to positions of light systems 102 within a coordinate system for an environment 100.

For example, an animation window of a computer 600 can represent a room or other environment of the lights. Pixels in that window can correspond to lights within the room or a low-resolution averaged image can be created from the higher resolution image. In this way lights in the room can be activated when a corresponding pixel or

neighborhood of pixels turn on. Because LED-based lighting technology can create any color on demand using digital control information, see U.S. Patents 6,016,038, 6,150,774, and 6,166,496, the lights can faithfully recreate the colors in the original image.

Some examples of effects that could be generated using systems and methods according to the principles of the invention include, but are not limited to, explosions, colors, underwater effects, turbulence, color variation, fire, missiles, chases, rotation of a room, shape motion, tinkerbell-like shapes, lights moving in a room, and many others. Any of the effects can be specified with parameters, such as frequencies, wavelengths, wave widths, peak-to-peak measurements, velocities, inertia, friction, speed, width, spin, vectors, and the like. Any of these can be coupled with other effects, such as sound.

In computer graphics, anti-aliasing is a technique for removing staircase effects in imagery where edges are drawn and resolution is limited. This effect can be seen on television when a narrow striped pattern is shown. The edges appear to crawl like ants as the lines approach the horizontal. In a similar fashion, the lighting can be controlled in such a way as to provide a smoother transition during effect motion. The effect parameters such as wave width, amplitude, phase or frequency can be modified to provide better effects.

For example, referring to Fig. 8, a schematic diagram 800 has circles that represent a single light 804 over time. For an effect to 'traverse' this light, it might simply have a step function that causes the light to pulse as the wave passes through the light. However, without the notion of width, the effect might be indiscernible. The effect preferably has width. If however, the effect on the light was simply a step function that turned on for a period of time, then might appear to be a harsh transition, which may be desirable in some cases but for effects that move over time (i.e. have some velocity associated with them) then this would not normally be the case.

The wave 802 shown in Fig. 8 has a shape that corresponds to the change. In essence it is a visual convolution of the wave 802 as it propagates through a space. So as a wave, such as from an explosion, moves past points in space, those points rise in intensity from zero, and can even have associated changes in hue or saturation, which gives a much more realistic effect of the motion of the effect. At some point, as the number and density of lights increases, the room then becomes an extension of the screen and provides large sparse pixels. Even with a relatively small number of light systems 102 the effect eventually can serve as a display similar to a large screen display.

Effects can have associated motion and direction, i.e. a velocity. Even other physical parameters can be described to give physical parameters such as friction, inertia, and momentum. Even more than that, the effect can have a specific trajectory. In an embodiment, each light may have a representation that gives attributes of the light. This can take the form of 2D position, for example. A light system 102 can have all various degrees of freedom assigned (e.g., xyz-rpy), or any combination.

The techniques listed here are not limited to lighting. Control signals can be propagated through other devices based on their positions, such as special effects devices such as pyrotechnics, smell-generating devices, fog machines, bubble machines, moving mechanisms, acoustic devices, acoustic effects that move in space, or other systems.

An embodiment of the present invention is a method of automatically capturing the position of the light systems 102 within an environment. An imaging device may be used as a means of capturing the position of the light. A camera, connected to a computing device, can capture the image for analysis can calculation of the position of the light. Fig. 9 depicts a flow diagram 900 that depicts a series of steps that may be used to accomplish this method. First, at a step 902, the environment to be mapped may be darkened by reducing ambient light. Next, at a step 904, control signals can be sent to each light system 102, commanding the light system 102 to turn on and off in turn. Simultaneously, the camera can capture an image during each "on" time at a step 906. Next, at a step 908, the image is analyzed to locate the position of the "on" light system

102. At a step 910 a centroid can be extracted. Because no other light is present when the particular light system 102 is on, there is little issue with other artifacts to filter and remove from the image. Next, at a step 912, the centroid position of the light system 102 is stored and the system generates a table of light systems 102 and centroid positions. This data can be used to populate a configuration file, such as that depicted in connection with Fig. 5. In sum, each light system 102, in turn, is activated, and the centroid measurement determined. This is done for all of the light systems 102. An image thus gives a position of the light system in a plane, such as with (x,y) coordinates.

Where a 3D position is desired a second image may be captured to triangulate the position of the light in another coordinate dimension. This is the stereo problem. In the same way human eyes determine depth through the correspondence and disparity between the images provided by each eye, a second set of images may be taken to provide the correspondence. The camera is either duplicated at a known position relative to the first camera or the first camera is moved a fixed distance and direction. This movement or difference in position establishes the baseline for the two images and allows derivation of a third coordinate (e.g., (x,y,z)) for the light system 102.

Another embodiment of the invention is depicted in Fig. 10, which contains a flow diagram 1000 with steps for generating a control signal. First, at a step 1002 a user can access a graphical user interface, such as the display 612 depicted in Fig. 6. Next, at a step 1003, the user can generate an image on the display, such as using a graphics program or similar facility. The image can be a representation of an environment, such as a room, wall, building, surface, object, or the like, in which light systems 102 are disposed. It is assumed in connection with Fig. 10 that the configuration of the light systems 102 in the environment is known and stored, such as in a table or configuration file 500. Next, at a step 1004, a user can select an effect, such as from a menu of effects. In an embodiment, the effect may be a color selected from a color palette. The color might be a color temperature of white. The effect might be another effect, such as described herein. In an embodiment, generating the image 1003 may be accomplished through a program executed on a processor. The image may then be displayed on a

computer screen. Once a color is selected from the palette at the step 1004, a user may select a portion of the image at a step 1008. This may be accomplished by using a cursor on the screen in a graphical user interface where the cursor is positioned over the desired portion of the image and then the portion is selected with a mouse. Following the selection of a portion of the image, the information from that portion can be converted to lighting control signals at a step 1010. This may involve changing the format of the bit stream or converting the information into other information. The information that made the image may be segmented into several colors such as red, green, and blue. The information may also be communicated to a lighting system in, for example, segmented red, green, and blue signals. The signal may also be communicated to the lighting system as a composite signal at a step 1012. This technique can be useful for changing the color of a lighting system. For example, a color palette may be presented in a graphical user interface and the palette may represent millions of different colors. A user may want to change the lighting in a room or other area to a deep blue. To accomplish her task, the user can select the color from the screen using a mouse and the lighting in the room changes to match the color of the portion of the screen she selected. Generally, the information on a computer screen is presented in small pixels of red, green and blue. LED systems, such as those found in U.S. Patent Nos. 6,016,038, 6,150,774 and 6,166,496, may include red, green and blue lighting elements as well. The conversion process from the information on the screen to control signals may be a format change such that the lighting system understands the commands. However, in an embodiment, the information or the level of the separate lighting elements may be the same as the information used to generate the pixel information. This provides for an accurate duplication of the pixel information in the lighting system.

Using the techniques described herein, including techniques for determining positions of light systems in environments, techniques for modeling effects in environments (including time- and geometry-based effects), and techniques for mapping light system environments to virtual environments, it is possible to model an unlimited range of effects in an unlimited range of environments. Effects need not be limited to those that can be created on a square or rectangular display. Instead, light systems can be

disposed in a wide range of lines, strings, curves, polygons, cones, cylinders, cubes, spheres, hemispheres, non-linear configurations, clouds, and arbitrary shapes and configurations, then modeled in a virtual environment that captures their positions in selected coordinate dimensions. Thus, light systems can be disposed in or on the interior or exterior of any environment, such as a room, building, home, wall, object, product, retail store, vehicle, ship, airplane, pool, spa, hospital, operating room, or other location.

In embodiments, the light system may be associated with code for the computer application, so that the computer application code is modified or created to control the light system. For example, object-oriented programming techniques can be used to attach attributes to objects in the computer code, and the attributes can be used to govern behavior of the light system. Object oriented techniques are known in the field, and can be found in texts such as "Introduction to Object-Oriented Programming" by Timothy Budd, the entire disclosure of which is herein incorporated by reference. It should be understood that other programming techniques may also be used to direct lighting systems to illuminate in coordination with computer applications, object oriented programming being one of a variety of programming techniques that would be understood by one of ordinary skill in the art to facilitate the methods and systems described herein.

In an embodiment, a developer can attach the light system inputs to objects in the computer application. For example, the developer may have an abstraction of a light system 102 that is added to the code construction, or object, of an application object. An object may consist of various attributes, such as position, velocity, color, intensity, or other values. A developer can add light as an instance in the object in the code of a computer application. For example, the object could be vector in an object-oriented computer animation program or solid modeling program, with attributes, such as direction and velocity. A light system 102 can be added as an instance of the object of the computer application, and the light system can have attributes, such as intensity, color, and various effects. Thus, when events occur in the computer application that call on the object of the vector, a thread running through the program can draw code to serve

as an input to the processor of the light system. The light can accurately represent geometry, placement, spatial location, represent a value of the attribute or trait, or provide indication of other elements or objects.

Referring to Fig. 12, a flow chart 1200 provides steps for a method of providing for coordinated illumination. At the step 1202, the programmer codes an object for a computer application, using, for example, object-oriented programming techniques. At a step 1204, the programming creates instances for each of the objects in the application. At a step 1208, the programmer adds light as an instance to one or more objects of the application. At a step 1210, the programmer provides for a thread, running through the application code. At a step 1212, the programmer provides for the thread to draw lighting system input code from the objects that have light as an instance. At a step 1214, the input signal drawn from the thread at the step 1212 is provided to the light system, so that the lighting system responds to code drawn from the computer application.

Using such object-oriented light input to the light system 102 from code for a computer application, various lighting effects can be associated in the real world environment with the virtual world objects of a computer application. For example, in animation of an effect such as explosion of a polygon, a light effect can be attached with the explosion of the polygon, such as sound, flashing, motion, vibration and other temporal effects. Further, the light system 102 could include other effects devices including sound producing devices, motion producing devices, fog machines, rain machines or other devices which could also produce indications related to that object.

Referring to Fig. 13, a flow diagram 1300 depicts steps for coordinated illumination between a representation on virtual environment of a computer screen and a light system 102 or set of light systems 102 in a real environment. In embodiments, program code for control of the light system 102 has a separate thread running on the machine that provides its control signals. At a step 1302 the program initiates the thread. At a step 1304 the thread as often as possible runs through a list of virtual lights, namely,

objects in the program code that represent lights in the virtual environment. At a step 1308 the thread does three-dimensional math to determine which real-world light systems 102 in the environment are in proximity to a reference point in the real world (e.g., a selected surface 107) that is projected as the reference point of the coordinate system of objects in the virtual environment of the computer representation. Thus, the (0,0,0) position can be a location in a real environment and a point on the screen in the display of the computer application (for instance the center of the display. At a step 1310, the code maps the virtual environment to the real world environment, including the light systems 102, so that events happening outside the computer screen are similar in relation to the reference point as are virtual objects and events to a reference point on the computer screen.

At a step 1312, the host of the method may provide an interface for mapping. The mapping function may be done with a function, e.g., "project-all-lights," as described in Directlight API described below and in Appendix A, that maps real world lights using a simple user interface, such as drag and drop interface. The placement of the lights may not be as important as the surface the lights are directed towards. It may be this surface that reflects the illumination or lights back to the environment and as a result it may be this surface that is the most important for the mapping program. The mapping program may map these surfaces rather than the light system locations or it may also map both the locations of the light systems and the light on the surface.

A system for providing the code for coordinated illumination may be any suitable computer capable of allowing programming, including a processor, an operating system, and memory, such as a database, for storing files for execution.

Each real light 102 may have attributes that are stored in a configuration file. An example of a structure for a configuration file is depicted in Fig. 5. In embodiments, the configuration file may include various data, such as a light number, a position of each light, the position or direction of light output, the gamma (brightness) of the light, an indicator number for one or more attributes, and various other attributes. By changing

the coordinates in the configuration file, the real world lights can be mapped to the virtual world represented on the screen in a way that allows them to reflect what is happening in the virtual environment. The developer can thus create time-based effects, such as an explosion. There can then be a library of effects in the code that can be attached to various application attributes. Examples include explosions, rainbows, color chases, fades in and out, etc. The developer attaches the effects to virtual objects in the application. For example, when an explosion is done, the light goes off in the display, reflecting the destruction of the object that is associated with the light in the configuration file.

To simplify the configuration file, various techniques can be used. In embodiments, hemispherical cameras, sequenced in turn, can be used as a baseline with scaling factors to triangulate the lights and automatically generate a configuration file without ever having to measure where the lights are. In embodiments, the configuration file can be typed in, or can be put into a graphical user interface that can be used to drag and drop light sources onto a representation of an environment. The developer can create a configuration file that matches the fixtures with true placement in a real environment. For example, once the lighting elements are dragged and dropped in the environment, the program can associate the virtual lights in the program with the real lights in the environment. An example of a light authoring program to aid in the configuration of lighting is included in U.S. Patent Application No. 09/616,214 "Systems and Methods for Authoring Lighting Sequences." Color Kinetics Inc. also offers a suitable authoring and configuration program called "ColorPlay."

Further details as to the implementation of the code can be found in the Directlight API document attached hereto as Appendix A. Directlight API is a programmer's interface that allows a programmer to incorporate lighting effects into a program. Directlight API is attached in Appendix A and the disclosure incorporated by reference herein. Object oriented programming is just one example of a programming technique used to incorporate lighting effects. Lighting effects could be incorporated

into any programming language or method of programming. In object oriented programming, the programmer is often simulating a 3D space.

In the above examples, lights were used to indicate the position of objects which produce the expected light or have light attached to them. There are many other ways in which light can be used. The lights in the light system can be used for a variety of purposes, such as to indicate events in a computer application (such as a game), or to indicate levels or attributes of objects.

Simulation types of computer applications are often 3D rendered and have objects with attributes as well as events. A programmer can code events into the application for a simulation, such as a simulation of a real world environment. A programmer can also code attributes or objects in the simulation. Thus, a program can track events and attributes, such as explosions, bullets, prices, product features, health, other people, patterns of light, and the like. The code can then map from the virtual world to the real world. In embodiments, at an optional step, the system can add to the virtual world with real world data, such as from sensors or input devices. Then the system can control real and virtual world objects in coordination with each other. Also, by using the light system as an indicator, it is possible to give information through the light system that aids a person in the real world environment.

Architectural visualization, mechanical engineering models, and other solid modeling environments are encompassed herein as embodiments. In these virtual environments lighting is often relevant both in a virtual environment and in a solid model real world visualization environment. The user can thus position and control a light system 102 the illuminates a real world sold model to illuminate the real world solid model in correspondence to illumination conditions that are created in the virtual world modeling environment. Scale physical models in a room of lights can be modeled for lighting during the course of a day or year or during different seasons for example, possibly to detect previously unknown interaction with the light and various building surfaces. Another example would be to construct a replica of a city or portion of a city in

a room with a lighting system such as those discussed above. The model could then be analyzed for color changes over a period of time, shadowing, or other lighting effects. In an embodiment, this technique could be used for landscape design. In an embodiment, the lighting system is used to model the interior space of a room, building, or other piece of architecture. For example, an interior designer may want to project the colors of the room, or fabric or objects in the room with colors representing various times of the day, year, or season. In an embodiment, a lighting system is used in a store near a paint section to allow for simulation of lighting conditions on paint chips for visualization of paint colors under various conditions. These types of real world modeling applications can enable detection of potential design flaws, such as reflective buildings reflecting sunlight in the eyes of drivers during certain times of the year. Further, the three-dimensional visualization may allow for more rapid recognition of the aesthetics of the design by human beings, than by more complex computer modeling.

Solid modeling programs can have virtual lights. One can light a model in the virtual environment while simultaneously lighting a real world model the same way. For example, one can model environmental conditions of the model and recreate them in the real world modeling environment outside the virtual environment. For example, one can model a house or other building and show how it would appear in any daylight environment. A hobbyist could also model lighting for a model train set (for instance based on pictures of an actual train) and translate that lighting into the illumination for the room wherein the model train exists. Therefore the model train may not only be a physical representation of an actual train, but may even appear as that train appeared at a particular time. A civil engineering project could also be assembled as a model and then a lighting system according to the principles of the invention could be used to simulate the lighting conditions over the period of the day. This simulation could be used to generate lighting conditions, shadows, color effects or other effects. This technique could also be used in Film/Theatrical modeling or could be used to generate special effects in filmmaking. Such a system could also be used by a homeowner, for instance by selecting what they want their dwelling to look like from the outside and having lights be selected to produce that look. This is a possibility for safety when the owner is away.

Alternatively, the system could work in reverse where the owner turns on the lights in their house and a computer provides the appearance of the house from various different directions and distances.

Although the above examples discuss modeling for architecture, one of skill in the art would understand that any device, object, or structure where the effect of light on that device, object, or structure can be treated similarly.

Medical or other job simulation could also be performed. A lighting system according to the principles of the present invention may be used to simulate the lighting conditions during a medical procedure. This may involve creating an operating room setting or other environment such as an auto accident at night, with specific lighting conditions. For example, the lighting on highways is generally high-pressure sodium lamps which produce nearly monochromatic yellow light and as a result objects and fluids may appear to be a non-normal color. Parking lots generally use metal halide lighting systems and produce a broad spectrum light that has spectral gaps. Any of these environments could be simulated using a system according to the principles of the invention. These simulators could be used to train emergency personnel how to react in situations lit in different ways. They could also be used to simulate conditions under which any job would need to be performed. For instance, the light that will be experienced by an astronaut repairing an orbiting satellite can be simulated on earth in a simulation chamber.

Lights can also be used to simulate travel in otherwise inaccessible areas such as the light that would be received traveling through space or viewing astronomical phenomena, or lights could be used as a three dimensional projection of an otherwise unviewable object. For instance, a lighting system attached to a computing device could provide a three dimensional view from the inside of a molecular model. Temporal Function or other mathematical concepts could also be visualized.

Referring to Fig. 14, in embodiments of the invention, the lighting system may be used to illuminate an environment. On such environment 1400 is shown in Fig. 14. The environment has at least one lighting unit 100 mounted therein, and in a preferred embodiment may have multiple lighting units 100 therein. The lighting unit 100 may be a controllable lighting unit 100, such as described above in connection with Fig. 2, with lights 208 that illuminate portions of the environment 100.

Referring still to Fig. 14, the environment 1400 may include a surface 1407 that is lit by one or more lighting units 100. In the depicted embodiment the surface 1407 comprises a wall or other surface upon which light could be reflected. In another embodiment, the surface could be designed to absorb and retransmit light, possibly at a different frequency. For instance the surface 1407 could be a screen coated with a phosphor where illumination of a particular color could be projected on the screen and the screen could convert the color of the illumination and provide a different color of illumination to a viewer in the environment 1400. For instance the projected illumination could primarily be in the blue, violet or ultraviolet range while the transmitted light is more of a white. In embodiments, the surface 1407 may also include one or more colors, figures, lines, designs, figures, pictures, photographs, textures, shapes or other visual or graphical elements that can be illuminated by the lighting system. The elements on the surface can be created by textures, materials, coatings, painting, dyes, pigments, coverings, fabrics, or other methods or mechanisms for rendering graphical or visual effects. In embodiments, changing the illumination from the lighting system may create visual effects. For example, a picture on the surface 1407 may fade or disappear, or become more apparent or reappear, based on the color of the light from the lighting system that is rendered on the surface 1407. Thus, effects can be created on the surface 1407 not only by shining light on a plain surface, but also through the interaction of light with the visual or graphical elements on the surface.

In certain preferred embodiments, the lighting units 1400 are networked lighting systems where the lighting control signals are packaged into packets of addressed information. The addressed information may then be communicated to the lighting

systems in the lighting network. Each of the lighting systems may then respond to the control signals that are addressed to the particular lighting system. This is an extremely useful arrangement for generating and coordinating lighting effects in across several lighting systems. Embodiments of U.S. Patent Application No. 09/616,214 "Systems and Methods for Authoring Lighting Sequences" describe systems and methods for generating system control signals and is hereby incorporated by reference herein.

A lighting system, or other system according to the principles of the present invention, may be associated with an addressable controller. The addressable controller may be arranged to "listen" to network information until it "hears" its address. Once the systems address is identified, the system may read and respond to the information in a data packet that is assigned to the address. For example, a lighting system may include an addressable controller. The addressable controller may also include an alterable address and a user may set the address of the system. The lighting system may be connected to a network where network information is communicated. The network may be used to communicate information to many controlled systems such as a plurality of lighting systems for example. In such an arrangement, each of the plurality of lighting systems may be receiving information pertaining to more than one lighting system. The information may be in the form of a bit stream where information for a first addressed lighting system is followed by information directed at a second addressed lighting system. An example of such a lighting system can be found in U.S. Patent No. 6,016,038, which is hereby incorporated by reference herein.

In an embodiment, the lighting unit 100 is placed in a real world environment 1400. The real world environment 1400 could be a room. The lighting system could be arranged, for example, to light the walls, ceiling, floor or other sections or objects in a room, or particular surfaces 1407 of the room. The lighting system may include several addressable lighting units 100 with individual addresses. The illumination can be projected so as to be visible to a viewer in the room either directly or indirectly. That is a light of a lighting unit 100 could shine so that the light is projected to the viewer

without reflection, or could be reflected, refracted, absorbed and reemitted, or in any other manner indirectly presented to the viewer.

Referring to Fig. 15, it is desirable to provide a light system manager 1650 to manage a plurality of lighting units 100 or other light systems.

Referring to Fig. 16, a light system manager 1650 is provided, which may consist of a combination of hardware and software components. Included is a mapping facility 1658 for mapping the locations of a plurality of light systems. The mapping facility 1658 may use various techniques for discovering and mapping lights, such as described herein or as known to those of skill in the art. Also provided is a light system composer 1652 for composing one or more lighting shows that can be displayed on a light system. The authoring of the shows may be based on geometry and an object-oriented programming approach, such as the geometry of the light systems that are discovered and mapped using the mapping facility 1658, according to various methods and systems disclosed herein or known in the art. Also provided is a light system engine 1654, for playing lighting shows by executing code for lighting shows and delivering lighting control signals, such as to one or more lighting systems, or to related systems, such as power/data systems, that govern lighting systems. Further details of the light system manager 1650, mapping facility 1658, light system composer 1652 and light system engine 1654 are provided herein.

The light system manager 1650, mapping facility 1658, light system composer 1652 and light system engine 1654 may be provided through a combination of computer hardware, telecommunications hardware and computer software components. The different components may be provided on a single computer system or distributed among separate computer systems.

Referring to Fig. 17, in an embodiment, the mapping facility 1658 and the light system composer 1652 are provided on an authoring computer 1750. The authoring

computer 1750 may be a conventional computer, such as a personal computer. In embodiments the authoring computer 1750 includes conventional personal computer components, such as a graphical user interface, keyboard, operating system, memory, and communications capability. In embodiments the authoring computer 1750 operates with a development environment with a graphical user interface, such as a Windows environment. The authoring computer 1750 may be connected to a network, such as by any conventional communications connection, such as a wire, data connection, wireless connection, network card, bus, Ethernet connection, Firewire, 802.11 facility, Bluetooth, or other connection. In embodiments, such as in Fig. 17, the authoring computer 1750 is provided with an Ethernet connection, such as via an Ethernet switch 1754, so that it can communicate with other Ethernet-based devices, optionally including the light system engine 1654, a light system itself (enabled for receiving instructions from the authoring computer 1750), or a power/data supply (PDS) 1758 that supplies power and/or data to a light system. The mapping facility 1650 and the light system composer 1652 may comprise software applications running on the authoring computer 1750.

Referring still to Fig. 17, in an architecture for delivering control systems for complex shows to one or more light systems, shows that are composed using the authoring computer 1750 are delivered via an Ethernet connection through one or more Ethernet switches1754 to the light system engine 1654. The light system engine 1654 downloads the shows composed by the light system composer 1652 and plays them, generating lighting control signals for light systems. In embodiments, the lighting control signals are relayed by an Ethernet switch 1754 to one or more power/data supplies 1758 and are in turn relayed to light systems that are equipped to execute the instructions, such as by turning LEDs on or off, controlling their color or color temperature, changing their hue, intensity, or saturation, or the like. In embodiments the power/data supply may be programmed to receive lighting shows directly from the light system composer 1652. In embodiments a bridge 1752 may be programmed to convert signals from the format of the light system engine 1654 to a conventional format, such as DMX or DALI signals used for entertainment lighting.

Referring to Fig. 18, in embodiments the lighting shows composed using the light system composer 1652 are compiled into simple scripts that are embodied as XML documents. The XML documents can be transmitted rapidly over Ethernet connections. In embodiments, the XML documents are read by an XML parser 1802 of the light system engine 1654. Using XML documents to transmit lighting shows allows the combination of lighting shows with other types of programming instructions. For example, an XML document type definition may include not only XML instructions for a lighting show to be executed through the light system engine 1654, but also XML with instructions for another computer system, such as a sound system, and entertainment system, a multimedia system, a video system, an audio system, a sound-effect system, a smoke effect system, a vapor effect system, a dry-ice effect system, another lighting system, a security system, an information system, a sensor-feedback system, a sensor system, a browser, a network, a server, a wireless computer system, a building information technology system, or a communication system.

Thus, methods and systems provided herein include providing a light system engine for relaying control signals to a plurality of light systems, wherein the light system engine plays back shows. The light system engine 1654 may include a processor, a data facility, an operating system and a communication facility. The light system engine 1654 may be configured to communicate with a DALI or DMX lighting control facility. In embodiments, the light system engine communicates with a lighting control facility that operates with a serial communication protocol. In embodiments the lighting control facility is a power/data supply for a lighting unit 100.

In embodiments, the light system engine 1654 executes lighting shows downloaded from the light system composer 1652. In embodiments the shows are delivered as XML files from the light show composer 1652 to the light system engine 1654. In embodiment the shows are delivered to the light system engine over a network. In embodiments the shows are delivered over an Ethernet facility. In embodiments the shows are delivered over a wireless facility. In embodiments the shows are delivered over a Firewire facility. In embodiments shows are delivered over the Internet.

In embodiments lighting shows composed by the lighting show composer 1652 can be combined with other files from another computer system, such as one that includes an XML parser that parses an XML document output by the light show composer 1652 along with XML elements relevant to the other computer. In embodiments lighting shows are combined by adding additional elements to an XML file that contains a lighting show. In embodiments the other computer system comprises a browser and the user of the browser can edit the XML file using the browser to edit the lighting show generated by the lighting show composer. In embodiments the light system engine 1654 includes a server, wherein the server is capable of receiving data over the Internet. In embodiments the light system engine 1654 is capable of handling multiple zones of light systems, wherein each zone of light systems has a distinct mapping. In embodiments the multiple zones are synchronized using the internal clock of the light system engine 1654.

The methods and systems included herein include methods and systems for providing a mapping facility 1658 of the light system manager 1650 for mapping locations of a plurality of light systems. In embodiments, the mapping system discovers lighting systems in an environment, using techniques described above. In embodiments, the mapping facility then maps light systems in a two-dimensional space, such as using a graphical user interface.

In embodiments of the invention, the light system engine 1654 comprises a personal computer with a Linux operating system. In embodiments the light system engine is associated with a bridge to a DMX or DALI system.

Referring to Fig. 19, the graphical user interface of the mapping facility 1652 of the authoring computer 1650 can display a two-dimensional map, or it may represent a two-dimensional space in another way, such as with a coordinate system, such as Cartesian, polar or spherical coordinates. In embodiments, lights in an array, such as a rectangular array, can be represented as elements in a matrix, such as with the lower left

corner being represented as the origin (0, 0) and each other light being represented as a coordinate pair (x, y), with x being the number of positions away from the origin in the horizontal direction and y being the number of positions away from the origin in the vertical direction. Thus, the coordinate (3, 4) can indicate a light system three positions away from the origin in the horizontal direction and four positions away from the origin in the vertical direction. Using such a coordinate mapping, it is possible to map addresses of real world lighting systems into a virtual environment, where control signals can be generated and associated geometrically with the lighting systems. With conventional addressable lighting systems, a Cartesian coordinate system may allow for mapping of light system locations to authoring systems for light shows.

Referring to Fig. 20, it may be convenient to map lighting systems in other ways. For example, a rectangular array 2050 can be formed by suitably arranging a curvilinear string 2052 of lighting units. The string of lighting units may use a serial addressing protocol, such as described in the applications incorporated by reference herein, wherein each lighting unit in the string reads, for example, the last unaltered byte of data in a data stream and alters that byte so that the next lighting unit will read the next byte of data. If the number of lighting units N in a rectangular array of lighting units is known, along with the number of rows in which the lighting units are disposed, then, using a table or similar facility, a conversion can be made from a serial arrangement of lighting units 1 to N to another coordinate system, such as a Cartesian coordinate system. Thus, control signals can be mapped from one system to the other system. Similarly, effects and shows generated for particular configurations can be mapped to new configurations, such as any configurations that can be created by arranging a string of lighting units, whether the share is rectangular, square, circular, triangular, or has some other geometry. In embodiments, once a coordinate transformation is known for setting out a particular geometry of lights, such as building a two-dimensional geometry with a curvilinear string of lighting units, the transformation can be stored as a table or similar facility in connection with the light management system 1650, so that shows authored using one authoring facility can be converted into shows suitable for that particular geometric arrangement of lighting units using the light management system 1650. The light system

composer 1652 can store pre-arranged effects that are suitable for known geometries, such as a color chasing rainbow moving across a tile light with sixteen lighting units in a four-by-four array, a burst effect moving outward from the center of an eight-by-eight array of lighting units, or many others.

Various other geometrical configurations of lighting units are so widely used as to benefit from the storing of pre-authored coordinate transformations, shows and effects. For example, referring to Fig. 21, a rectangular configuration 2150 is widely employed in architectural lighting environments, such as to light the perimeter of a rectangular item, such as a space, a room, a hallway, a stage, a table, an elevator, an aisle, a ceiling, a wall, an exterior wall, a sign, a billboard, a machine, a vending machine, a gaming machine, a display, a video screen, a swimming pool, a spa, a walkway, a sidewalk, a track, a roadway, a door, a tile, an item of furniture, a box, a housing, a fence, a railing, a deck, or any other rectangular item.

Referring to Fig. 22, a triangular configuration 2250 can be created, using a curvilinear string of lighting units, or by placing individual addressable lighting units in the configuration. Again, once the locations of lighting units and the dimensions of the triangle are known, a transformation can be made from one coordinate system to another, and pre-arranged effects and shows can be stored for triangular configurations of any selected number of lighting units. Triangular configurations 2250 can be used in many environments, such as for lighting triangular faces or items, such as architectural features, alcoves, tiles, ceilings, floors, doors, appliances, boxes, works of art, or any other triangular items.

Referring to Fig. 23, lighting units can be placed in the form of a character, number, symbol, logo, design mark, trademark, icon, or other configuration designed to convey information or meaning. The lighting units can be strung in a curvilinear string to achieve any configuration in any dimension, such as the formation of the number "80" in the configuration 2350 of Fig. 23. Again, once the locations of the lighting units are known, a conversion can be made between Cartesian (x, y) coordinates and the positions

of the lighting units in the string, so that an effect generated using a one coordinate system can be transformed into an effect for the other. Characters such as those mentioned above can be used in signs, on vending machines, on gaming machines, on billboards, on transportation platforms, on buses, on airplanes, on ships, on boats, on automobiles, in theatres, in restaurants, or in any other environment where a user wishes to convey information.

Referring to Fig. 24, lighting units can be configured in any arbitrary geometry, not limited to two-dimensional configurations. For example, a string of lighting units can cover two sides of a building, such as in the configuration 2450 of Fig. 24. The three-dimensional coordinates (x, y, z) can be converted based on the positions of the individual lighting units in the string 2452. Once a conversion is known between the (x, y, z) coordinates and the string positions of the lighting units, shows authored in Cartesian coordinates, such as for individually addressable lighting units, can be converted to shows for a string of lighting units, or vice versa. Pre-stored shows and effects can be authored for any geometry, whether it is a string or a two- or three-dimensional shape. These include rectangles, squares, triangles, geometric solids, spheres, pyramids, tetrahedrons, polyhedrons, cylinders, boxes and many others, including shapes found in nature, such as those of trees, bushes, hills, or other features.

Referring to Fig. 25, the light system manager 1650 may operate in part on the authoring computer 1750, which may include a mapping facility 1658. The mapping facility 1658 may include a graphical user interface 2550, or management tool, which may assist a user in mapping lighting units to locations. The management tool 2550 may include various panes, graphs or tables, each displayed in a window of the management tool. A lights/interfaces pane 2552 lists lighting units or lighting unit interfaces that are capable of being managed by the management tool. Interfaces may include power/data supplies (PDS) 1758 for one or more lighting systems, DMX interfaces, DALI interfaces, interfaces for individual lighting units, interfaces for a tile lighting unit, or other suitable interfaces. The interface 2550 also includes a groups pane 2554, which lists groups of lighting units that are associated with the management tool 2550, including groups that

can be associated with the interfaces selected in the lights/interfaces pane 2552. As described in more detail below, the user can group lighting units into a wide variety of different types of groups, and each group formed by the user can be stored and listed in the groups pane 2554. The interface 2550 also includes the layout pane 2558, which includes a layout of individual lighting units for a light system or interface that is selected in the lights/interfaces pane 2552. The layout pane 2558 shows a representative geometry of the lighting units associated with the selected interface, such as a rectangular array if the interface is an interface for a rectangular tile light, as depicted in Fig. 25. The layout can be any other configuration, as described in connection with the other figures above. Using the interface 2550, a user can discover lighting systems or interfaces for lighting systems, map the layout of lighting units associated with the lighting system, and create groups of lighting units within the mapping, to facilitate authoring of shows or effects across groups of lights, rather than just individual lights. The grouping of lighting units dramatically simplifies the authoring of complex shows for certain configurations of lighting units.

Referring to Fig. 26, further details of the lights/interfaces pane 2552 are provided. Here, by clicking the "+" sign, the user can display a list 2650 of all of the individual lighting units that are associated with a particular interface that is presented in the lights/interfaces pane 2552. The pane 2650 of Fig. 26 lists each of the nodes of a tile light, but other lighting units could be listed, depending on the configuration of lighting units associated with a particular interface.

Referring to Fig. 27, the interface 2550 includes a series of menus 2750 that can be initiated by placing the mouse over the appropriate menu at the top of the display 2550. The "light view" menu 2752 opens up a menu that includes various options for the user, including discover interfaces 2754, discover lights 2758, add interfaces 2760, add string 2762, add tile 2764 and add lights 2768. Clicking on any one of those menus allows the user to initiate the associated action. The discover interfaces 2754 option initiates a wizard through which the user can discover interfaces that can be managed using the light management system 1650, such as PDS interfaces 1758 that supply power

and data to various lighting units, as well as tile light interfaces for tile lights and other interfaces. The discover lights menu 2758 allows the user to discover lights that are associated with particular interfaces or that can be managed directly through the light management system 1658. The add interfaces menu 2760 allows the user to add a new interface to the lights/interfaces pane 2752. The add string menu 2762 allows the user to add a number of lighting units in a string configuration to the lights/interfaces pane 2752. The add tile menu 2764 allows the user to add a tile light interface to the lights/interfaces pane 2752. The add lights menu 2768 allows the user to add a lighting unit to the lights/interfaces pane 2752. Once the interface, light, tile, string, or other item is added to the lights/interfaces pane 2752, it can be manipulated by the interface 2550 to provide an appropriate mapping for the light management tool 1650.

Referring to Fig. 28, when the discover interfaces button 2754 is selected in the interface 2550, after selecting the light view menu button 2752, a discover interfaces wizard 2850 appears, through which a user can add an interface to be managed by the light management system 1650. The user can click a query button 2852 to query the surrounding network neighborhood for connected devices that employ lighting system network protocols. Discovered devices appear in a discovered interfaces pane 2854. The user can click the arrow 2860 to add a discovered device (such as a PDS 1758, tile light interface, light string, or the like) to the add to map pane 2858, in which case the discovered device or interface will then appear in the lights/interfaces pane 2552 of the interface 2550, and the user will be able to initiate other actions to manage the newly discovered interface.

Referring to Fig. 29, when the discover lights button 2758 is selected in the interface 2550, after selecting the light view menu button 2752, a discover lights wizard 2950 appears, through which a user can discover lights that are under the control of the interfaces that appear in the lights/interfaces pane 2552. A pane 2952 allows the user to select the particular interface for which the user wishes to discover lights.

Referring to Fig. 30, when the add string button 2762 is selected from the menu that results from clicking the light view menu button 2752 in the interface 2550, a create string wizard 3050 appears that assists the user in adding a string of lights as one of the interfaces in the lights/interfaces pane 2552. In the create string wizard 3050, the user can elect to add a string to an existing interface or to a new interface. The user then indicates the number of lighting units in the string at the tab 3052. The user then sets the base DMX address for the string at the tab 3054 and sets the base light number of the string at the tab 3058. The user can then name the base light in the string with a character or string that serves as an identifier in the tab 3060. Using a button 3062, the user can elect to layout the string vertically or horizontally (or, in embodiments, in other configurations). The user can elect to create a synchronized group by placing an "x" in the button 3064. The user can elect to create a chasing group by placing an "x" in the button 3068. Thus, using the create string wizard 3050, the user names a string, assigns it to an interface, such as a PDS 1758, determines its basic layout, determines its base DMX address and base light number, and determines whether it should consist of a synchronized group, a chasing group, or neither. Similar menus can optionally be provided to add other known lighting configurations, such as a new tile, a new circle of lights, a new array of lights, a new rectangle of lights, or the like, in any desired configuration.

Referring to Fig. 31, by clicking the file menu 3150 of the interface 2550 the user is offered options to create a new map 3152, open an existing map 3154 or save a map 3158 (including to save the map in a different file location). Thus, maps of a given set of interfaces, lights, groups and layouts can be stored as files. A given set of light interfaces can, for example, be mapped in different ways. For example, in a stage lighting environment, the lights on two different sides of the stage could be made part of the same map, or they could be mapped as separate maps, or zones, so that the user can author shows for the two zones together, separately, or both, depending on the situation.

Referring to Fig. 32, by clicking the group view menu 3250 on the interface 2550, the user is offered a menu button 3252 by which the user can choose to add a

group. An added group will be displayed in the group pane 2554. The ability to group lights offers powerful benefits in the composing of lighting shows using the lighting show composer 1652. Rather than having to specify color, hue, saturation or intensity values for a every specific lighting unit in a complex configuration, a user can group the lighting units, and all units in the group can respond in kind to a control signal. For example, a synchronized group of lights can all light in the same color and intensity at the same time. A chasing group of lights can illuminate in a predetermined sequence of colors, so that, for example, a rainbow chases down a string of lights in a particular order.

Referring to Fig. 33, groups can take various configurations. For example, a group may consist of a single line or column 3350 of lighting units, such as disposed in an array. A group can consist of a subsection of an array, such as the array 3352 or the dual column 3354. Many other groupings can be envisioned. In embodiments, a group can be formed in the layout pane 2558 by creating a "rubber band" 3358 around lights in a group by clicking the mouse at the point 3360 and moving it to the point 3362 before clicking again, so that all groups that are included in the rectangle of the rubber band 3358 are made into members of the same group.

Fig. 34 shows the creation of a group 3452 by dragging a rubber band 3450 around the group in the layout pane 2558 of the interface 2550. Referring to Fig. 35, by right-clicking the mouse after forming the group with the rubber band 3450, the user can create a new group with the option 3550, in which case the group appears in the groups pane 2554.

Referring to Fig. 36, groups can be created in various ways in the layout pane 2558. For example, an arrow 3650 can be dragged across a graphic depicting a layout of lighting units. Individual lighting units can be added to a group in the sequence that the lighting units are crossed by the arrow 3650, so that effects that use the group can initiate in the same sequence as the crossing of lighting units by the arrow 3650. Other shapes can be used to move across groups in the layout pane 2558, putting the lighting units in

the order that the shapes cross the lighting units. Moving the arrow 3650 allows the creation of complex patterns, such as spirals, bursts, scalloped shapes, and the like, as chasing groups are created by moving lines or other shapes across a layout of lights in a desired order. The group ordering can be combined with various effects to generate lighting shows in the light show composer.

Referring to Fig. 37, by double clicking on a group in the groups pane 2554, a user can bring up a groups editor 3750, in which the user can edit characteristics of members of a group that appear in the group members pane 3752, such as by adding or deleting lighting units from the available lights pane 3754 or adding other groups from the available groups pane 3758.

Referring to Fig. 38, various options are available to the user if the user clicks the layout view menu item 3850. Through a pull-down menu, the user can snap the layout to a grid with a button 3852. The user can zoom in with a button 3854 or zoom out with a button 3858. The user can enable live playing with a button 3860. The user can create an animation template in the layout pane 2558 with a button 3862. In embodiments, a user may be offered various other editing options for the view of the layout of lighting units in the layout pane 2558. For example, in embodiments the layout pane 2558 may be enabled with a three-dimensional visualization capability, so that the user can layout lights in a three-dimensional rendering that corresponds to a three-dimensional mapping in the real world.

Referring to Fig. 39, a flow diagram 3900 shows various steps that are optionally accomplished using the mapping facility 1658, such as the interface 2550, to map lighting units and interfaces for an environment into maps and layouts on the authoring computer 1750. At a step 3902, the mapping facility 1658 can discover interfaces for lighting systems, such as power/data supplies 1758, tile light interfaces, DMX or DALI interfaces, or other lighting system interfaces, such as those connected by an Ethernet switch. At a step 3904 a user determines whether to add more interfaces, returning to the step 3902 until all interfaces are discovered. At a step 3908 the user can discover a

lighting unit, such as one connected by Ethernet, or one connected to an interface discovered at the step 3902. The lights can be added to the map of lighting units associated with each mapped interface, such as in the lights/interfaces pane 2552 of the interface 2550. At a step 3910 the user can determine whether to add more lights, returning to the step 3908 until all lights are discovered. When all interfaces and lights are discovered, in step 3912 the user can map the interfaces and lights, such as using the layout pane 2558 of the interface 2550. Standard maps can appear for tiles, strings, arrays, or similar configurations. Once all lights are mapped to locations in the layout pane 2558, a user can create groups of lights at a step 3918, returning from the decision point 3920 to the step 3918 until the user has created all desired groups. The groups appear in the groups pane 2554 as they are created. The order of the steps in the flow diagram 3900 can be changed; that is, interfaces and lights can be discovered, maps created, or groups formed, in various orders. Once all interfaces and lights are discovered, maps created and groups formed, the mapping is complete at a step 3922. Many embodiments of a graphical user interface for mapping lights in a software program may be envisioned by one of skill in the art in accordance with this invention.

Wherein the lighting systems are selected from the group consisting of an architectural lighting system, an entertainment lighting system, a restaurant lighting system, a stage lighting system, a theatrical lighting system, a concert lighting system, an arena lighting system, a signage system, a building exterior lighting system, a landscape lighting system, a pool lighting system, a spa lighting system, a transportation lighting system, a marine lighting system, a military lighting system, a stadium lighting system, a motion picture lighting system, photography lighting system, a medical lighting system, a residential lighting system, a studio lighting system, and a television lighting system.

Using a mapping facility, light systems can optionally be mapped into separate zones, such as DMX zones. The zones can be separate DMX zones, including zones located in different rooms of a building. The zones can be located in the same location within an environment. In embodiments the environment can be a stage lighting environment.

Thus, in various embodiments, the mapping facility allows a user to provide a grouping facility for grouping light systems, wherein grouped light systems respond as a group to control signals. In embodiments the grouping facility comprises a directed graph. In embodiments, the grouping facility comprises a drag and drop user interface. In embodiments, the grouping facility comprises a dragging line interface. The grouping facility can permit grouping of any selected geometry, such as a two-dimensional representation of a three-dimensional space. In embodiments, the grouping facility can permit grouping as a two-dimensional representation that is mapped to light systems in a three-dimensional space. In embodiments, the grouping facility groups lights into groups of a predetermined conventional configuration, such as a rectangular, two-dimensional array, a square, a curvilinear configuration, a line, an oval, an oval-shaped array, a circle, a circular array, a square, a triangle, a triangular array, a serial configuration, a helix, or a double helix.

Referring to Fig. 40, a light system composer 1652 can be provided, running on the authoring computer 1750, for authoring lighting shows comprised of various lighting effects. The lighting shows can be downloaded to the light system engine 1654, to be executed on lighting units 100. The light system composer 1652 is preferably provided with a graphical user interface 4050, with which a lighting show developer interacts to develop a lighting show for a plurality of lighting units 100 that are mapped to locations through the mapping facility 1658. The user interface 4050 supports the convenient generation of lighting effects, embodying the object-oriented programming approaches described above. In the user interface 4050, the user can select an existing effect by initiating a tab 4052 to highlight that effect. In embodiments, certain standard attributes are associated with all or most effects. Each of those attributes can be represented by a field in the user interface 4050. For example, a name field 4054 can hold the name of the effect, which can be selected by the user. A type field 4058 allows the user to enter a type of effect, which may be a custom type of effect programmed by the user, or may be selected from a set of preprogrammed effect types, such as by clicking on a pull-down menu to choose among effects. For example, in Fig. 40, the type field 4058 for the

second listed effect indicates that the selected effect is a color-chasing rainbow. A group field 4060 indicates the group to which a given effect is assigned, such as a group created through the light system manager interface 2550 described above. For example, the group might be the first row of a tile light, or it might be a string of lights disposed in an environment. A priority field 4062 indicate the priority of the effect, so that different effects can be ranked in their priority. For example, an effect can be given a lower priority, so that if there are conflicting effects for a given group during a given show, the a higher priority effect takes precedence. A start field 4064 allows the user to indicate the starting time for an effect, such as in relation to the starting point of a lighting show. An end field 4068 allows the user to indicate the ending time for the effect, either in relation to the timing of the lighting show or in relation to the timing of the start of the effect. A fade in field 4070 allows the user to create a period during which an effect fades in, rather than changes abruptly. A fade out field 4072 allows the user to fade the effect out, rather than ending it abruptly. For a given selected type of effect, the parameters of the effect can be set in an effects pane 4074. The effects pane 4074 automatically changes, prompting the user to enter data that sets the appropriate parameters for the particular type of effect. A timing pane 4078 allows the user to set timing of an effect, such as relative to the start of a show or relative to the start or end of another effect.

Referring to Fig. 41, a schematic 4150 indicates standard parameters that can exist for all or most effects. These include the name 4152, the type 4154, the group 4158, the priority 4160, the start time 4162, the end time 4164, the fade in parameter 4168 and the fade out parameter 4170.

Referring to Fig. 42, a set of effects 4250 can be linked temporally, rather than being set at fixed times relative to the beginning of a show. For example, a second effect can be linked to the ending of a first effect at a point 4252. Similarly, a third effect might be set to begin at a time that is offset by a fixed amount 4254 relative to the beginning of the second effect. With linked timing of effects, a particular effect can be changed, without requiring extensive editing of all of the related effects in a lighting

show. Once a series of effects is created, each of them can be linked, and the group can be saved together as a meta effect, which can be executed across one or more groups of lights.

Referring to the schematic diagram 4350 of Fig. 43, once a user has created meta effects, the user can link them, such as by linking a first meta effect 4352 and a second meta effect 4354 in time relative to each other. Linking effects and meta effects, a user can script entire shows, or portions of shows. The creation of reusable meta effects can greatly simplify the coding of shows across groups.

Referring to Fig. 44, the user interface 4050 allows the user to set parameters and timing for various effects. First, a user can select a particular type of effect in the type field 4058, such as by pulling down the pull-down menu 4430. Once the user has selected a particular type of effect, the parameters for that effect appear in the parameters pane 4074. For example, where the effect is a color-chasing rainbow, as selected in the type field 4058 of Fig. 44, certain parameters appear in the parameters pane 4074, but if other types are selected, then other parameters appear. When the color-chasing rainbow is selected, a timing field 4450 appears, where the user can enter a cycle time in a field 4452 and light-to-light offset in a field 4454. In a field 4458, the user can elect to reverse the direction of a particular effect. The user can also elect to reverse the color cycle at a field 4460. At a field 4462, the user can select to choose a particular starting color for the rainbow, completing the setting of the parameters for the color-chasing rainbow effect.

Referring still to the interface 4050 of Fig. 44, the user sets the starting time for the particular effect. The user can elect a fixed time by selecting the button 4482, in which case the effect will start at the time entered at the field 4480, relative to the start of the show. If the user wishes to start an effect at a relative time, linked to another effect, then the user can indicated a linked timing with a button 4483, in which case the user chooses to link either to the start or end of another effect, using the buttons 4488 and 4484, and the user enters the name of the other effect to which the timing of the effect

will be linked at the field 4490. The user can enter an offset in the timing of the effects at a field 4492.

Referring still to Fig. 44, the user also sets the ending time for a particular effect. The user can choose a fixed ending time by selecting the button 4494 and entering the time (relative to the start of the lighting show, for example) at the field 4499. If the user wishes to use timing linked to other effects, rather than relative to the start of the show, the user indicates so by indicating that the effect will be linked at the button 4498. As with the start of effects, the user elects either the start or the end of the other effect as the timing and enters the name of the other effect at the field 4425. The user indicates the duration of any desired offset at a field 4427. Rather than linking to a fixed time relative to the beginning of the show or linking to another effect, the user can also set a fixed duration for the effect by selecting the button 4433 and entering the duration at the field 4429.

The user interface 4050 of Figs. 40 and 44 is representative of a wide range of potential user interfaces that allow a user to create effects and to assign parameters to those effects, including timing parameters, including ones that link particular effects to other effects. Many different effects can be generated, in each case consisting of a set of control instructions that govern the intensity, saturation, color, hue, color temperature, or other characteristic of each lighting unit 100 in a group of lighting units 100 along a timeline. Thus, effects consist of sets of control instructions, groups allow a user to apply control instructions across more than one lighting unit 100 at a time, and parameters allow the user to modify attributes of the effects. Meta effects allow users to build larger effects, and eventually shows, from lower level effects. Once a user has created an effect, meta effect, or show, it can be stored, so that it can be accessed for later purposes, such as to build other effects, meta effects, or shows, or it can be edited, such as by changing parameters or timing in the user interface 4050.

Referring to Fig. 45, a user can select a group to which the user wishes to apply an effect, such as by selecting a pull-down menu 4550 in the user interface 4050. The

group can be, for example, any group that is mapped according to the mapping facility 1658 of the authoring computer 1750. The group might be a group of a tile light, a string light, a set of addressable lighting units, a column of an array, a group created by dragging a rubber band in the user interface 2550, a group created by dragging a line or arrow across the group in a particular order, a synchronized group, a chasing group, or another form of group. Selecting a group automatically loads the attributes of the group that were stored using the user interface 2550 of the mapping facility 1658 of the light system manager 1650.

Referring to Fig. 46, when the user selects the choose color button 4462 in the user interface 4050, a palette 4650 appears, from which the user can select the first color of a color chasing effect, such as a color-chasing rainbow. Similarly, the palette 4650 may appear to select a color for a fixed color effect, or for a starting color for any other effect identified above. If the effect is a custom rainbow, then the user can be prompted, such as through a wizard, to select a series of colors for a color chasing rainbow. Thus, the palette 4650 is a simple mechanism for the user to visualize and select colors for lighting effects, where the palette colors correspond to real-world colors of the lighting units 100 of a lighting system that is managed by the light system manager 1650. Using fields of the palette 4650, a user can create custom colors and otherwise specify values for the lighting unit 100. For example, using a field 4652, the user can set the hue numerically within a known color space. Using a field 4654, the user can select the red value of a color, corresponding to the intensity, for example, of a red LED in a triad of red, green and blue LEDs. Using a field 4658 the user can select a green value, and using a field 4660 the user can select a blue value. Thus, the user can select the exact intensities of the three LEDs in the triad, to produce an exactly specified mixed color of light from a lighting unit 100. Using a field 4662, the user can set the saturation of the color, and using a field 4664, the user can set the value of the color. Thus, through the palette 4650, a user can exactly specify the lighting attributes of a particular color for a lighting unit 100 as the color appears in a specified effect. While red, green and blue LEDs appear in the palette 4650, in other embodiments the LEDs might be amber, orange, ultraviolet, different color temperatures of white, yellow, infrared, or other

colors. The LED fields might include multiple fields with different wavelength LEDs of a similar color, such as three different wavelengths of white LED.

Referring to Fig. 47, a user can select an animation effect 4750, in which case the effect parameters pane 4074 presents parameters that are relevant to animation effects. An animation effect might be generated using software. An example of software used to generate a dynamic image is Flash 5 computer software offered by Macromedia, Incorporated. Flash 5 is a widely used computer program to generate graphics, images and animations. Other useful products used to generate images include, for example, Adobe Illustrator, Adobe Photoshop, and Adobe LiveMotion. In the parameters pane 4074, the user can set parameters for the animation effect. As described above, the pixels of the animation can drive colors for a lighting show, such as a show that is prepared for display on an array or tile light, with the lighting units 100 that make up the tile or array being addressed in a way that corresponds to pixels of the animation, as described above. In the parameters pane 4074, an animation pane 4752 appears, in which a user can enter an animation director in a field 4754 and load the animation by selecting the load button 4758, in which case the particular animation loads for further processing. In addition to the usual timing parameters in the timing pane 4078, the user can set timing parameters that relate to the animation, such as the number of frames, in a field 4758, and the number of frames per second in a field 4760. The user can also determine a geometry for the animation, using a geometry pane 4762. The user can set the image size 4768 and the output size 4764. The user can also offset the image in the X direction using an offset field 4772 and in the Y direction using another offset field 4770. The user can also set a scaling factor for the animation, using a field 4774. By setting these parameters, a user can connect an animation to a lighting show, so that lighting units conduct displays that correspond to an animation that appears on the user's computer screen (or runs on the light system engine 1654). The animation effect thus embodies many of the geometric authoring techniques described above.

Referring to Fig. 48, a fractal effect 4850 can be selected, in which case the parameters pane 4074 presents parameters related to a fractal function 4852. The fractal

function allows the user to generate an effect where the illumination of lighting units depends on a complex function that has real and complex components. Various fractal types can be selected, such as a Julia type, using a button 4854, or a Mandelbrot type, using a button 4858. The user can then set the cycle timing of the fractal effect 4850, using a field 4860. The user can also determine the coefficients 4862 of the fractal function, including a real coefficient in a field 4864 and a complex coefficient in a field 4868, as well as a radius in a field 4870. Parameters related to the view of the fractal can be set as well, including a real minimum parameter in a field 4874, a complex minimum parameter in a field 4880, a real span parameter in a field 4872, and a complex span parameter in a field 4878. Uses of fractal functions can produce very striking and unexpected lighting effects, particularly when presented on an array, such as in a tile light, where the lighting units 100 are positioned in an array behind a diffusing panel.

Referring to Fig. 49, a random color effect 4950 can be selected from the menu of the type field 4058, in which case the parameters pane 4074 presents parameters for a random color effect. The user can set various parameters, including those related to timing, such as the time per color in a field 4952, the fade time in a field 4954, the number of colors that appear randomly before a cycle is created in a field 4758, and the light-to-light offset in a field 4760. Using the button 4462, the user can select the initial color, such as by selecting it from the palette 4650 of Fig. 46.

Referring still to Fig. 49, a simulation window 4970 can be generated for any effect, which simulates the appearance of an effect on the selected group of lights. The simulation includes the map of light locations created using the mapping facility 1658 and user interface 2550, and the lighting units 100 represented on the map display colors that correspond to the light that will emit from particular lighting units 100 represented by the map. The simulation window 4970 is an animation window, so that the effect runs through time, representing the timing parameters selected by the user. The simulation window 4970 can be used to display a simulation of any effect selected by the user, simply by selecting the simulation arrow 4972 in the menu of the user interface 4050.

Referring to Fig. 50, a user can select a sparkle effect 5050 from the pull-down menu of the type field 4058, in which case the parameters pane 4074 shows parameters appropriate for a sparkle effect. The parameters include timing parameters, such as the rate of decay, set in a field 5052. The parameters also include appearance parameters 5054, including the density, which can be set in a field 5058, and a time constant, set in a field 5056. The user can also set colors, including a primary sparkle color 5060, which can be selected using a button 5062, which can pull up the palette 4650. Using a button 5062, the user can elect to make the sparkle color transparent, so that other effects show through. The user can also select a background color using a button 5070, which again pulls up a palette 4650. The user can use a button 5068 to make the background color transparent.

Referring to Fig. 51, the user can select a streak effect 5150 using the pull-down menu of the type field 4058, in which case the parameters pane 4074 shows parameters that govern the attributes of a streak effect 5150. The parameters including the conventional timing and linking parameters that apply to all or most all effects, plus additional parameters, such as a cycle time parameter, set in a field 5152. The user can also set various pulse parameters for the streak effect 5150, such as the pulse width 5154, the forward tail width 5158, and the reverse tail width 5160. The user can use a button 5162 to cause the effect to reverse directions back and forth or a button 5164 to cause the effect to wrap in a cycle. The user can select a color for the streak using the button 4462, in which case the palette 4650 presents color options for the user. The user can make the effect transparent using the button 5168.

Referring to Fig. 52, the user can select a sweep effect 5150 using the pull-down menu of the type field 4058, in which case the parameters pane 4074 shows parameters that govern the attributes of a sweep effect 5150. The user can set the timing, using the cycle time field 5152. The user can select to have the sweep operate in a reversing fashion by selecting the button 5254. The user can select a sweep color using the color button 5258, which pulls up the palette 4650, and make the sweep color transparent

using the button 5260. The user can select a background color using the button 5264, which also pulls up the palette 4650, and the user can make the background color transparent using the button 5262.

Referring to Fig. 53, the user can select a white fade effect 5350 using the pull-down menu of the type field 4058, in which case the parameters pane 4074 shows parameters that govern the attributes of a white fade effect 5350. The user can enter the cycle time in the field 5352, and the user can determine fade values 5354 by using a slide bar 5358 to set the start intensity and a slide bar 5360 to set the end intensity.

Referring to Fig. 54, the user can select an XY burst effect 5450 using the pull-down menu of the type field 4058, in which case the parameters pane 4074 shows parameters that govern the attributes of an XY burst effect 5450. The user can set the cycle time in a field 5452, and the user can set the ring width of the burst using a field 5454.

Referring to Fig. 55, the user can select an XY spiral effect 5550 using the pull-down menu of the type field 4058, in which case the parameters pane 4074 shows parameters that govern the attributes of an XY spiral effect 5550. The user can set the cycle time in a field 5552, and the user can set effect that relate to the geometry effect in the other fields of the parameters pane 4074. For example, the user can set a twist parameter in the field 5554, and the user can set the number of arms in the spiral in a field 5558. The user can also determine the direction of rotation of the spiral, by selecting a counterclockwise button 5560 or a clockwise button 5562.

Referring to Fig. 56, the user can select a text effect 5650 using the pull-down menu of the type field 4058, in which case the parameters pane 4074 shows parameters that govern the attributes of a text effect 5650. The user can enter a text string in a field 5652, which will appear as a text item on the lighting units 100, such as an array, where the lighting units 100 in the array appears as pixels that build the text effect that appears in the field 5652. The attributes of the text string can be set, such as whether the text is

bold in a field 5654, whether it is in italics in a field 5658, and whether it is underlined in a field 5662. A field 5660 allows the user to select a font for the text, such as "times new roman" or "courier." A button 5664 allows the user to smooth the text on the display. The user can select the size or pitch of the font using a field 5666. The user can set the cycle time for the text string using a field 5668. The user can choose the foreground color using a button 4462, pulling up the palette 4650 for color selection. The user can make the foreground color transparent using the button 5670. The text effect allows a user to conveniently display text, messages, brands, logos, information or other content over lighting systems, such as arrays, tile lights, or other lighting displays of any geometry that are mapped into the mapping facility 1658.

Referring to Fig. 57, a new effect button 5750 allows a user to add a new effect to the interface 4050. The selection of the button 5750 pulls up a menu 5752 listing types of effects. When the user highlights and clicks a particular type of effect, the parameters pane 4074 then shows parameters of the appropriate type for the new effect type that the user selected from the window 5752.

Referring to Fig. 58, the user may elect various file options in the interface 4050 by selecting the file menu 5850. From the file menu 5850, the user has an option 5852 to load a map, such as one created using the mapping facility 1658. The user can create a new show with the option 5854, in which case the user begins scripting new effects as described herein. The use can also open an existing show with the option 5858, in which case the user can browse files to find existing shows. The user can save a show with the option 5860, including edited versions of the show. The user can save an existing show in another location with the option 5862. The user also has the option to write DMX control instructions that correspond to the show 5864 that the user creates using the interface 4050.

Referring to Fig. 59, a user can elect various editing options by selecting an edit menu 5950. The user can cut an effect with an option 5952. The user can copy an effect

with the option 5954. The user can paste an effect with an option 5958. The user can delete an effect with the option 5960. The user can select all effects with an option 5962.

Referring to Fig. 60, a user can select a simulation menu 6050 and elect to show a simulation, in which case the simulation window 4970 appears. The user can keep the simulation always on top, using an option 6052. The user can enable live playing of effect using an option 6054. The user can pause updating of the simulation using an option 6058. The user can zoom in using an option 6060, and the user can zoom out using an option 6062.

Fig. 61 shows a simulation window 4970 with an X burst effect 6150, using a chasing group.

Fig. 62 shows a simulation window 4970 with a sweep effect 6250.

As seen in connection with the various embodiments of the user interface 4050 and related figures, methods and systems are included herein for providing a light system composer for allowing a user to author a lighting show using a graphical user interface. The light system composer includes an effect authoring system for allowing a user to generate a graphical representation of a lighting effect. In embodiments the user can set parameters for a plurality of predefined types of lighting effects, create user-defined effects, link effects to other effects, set timing parameters for effects, generate meta effects, and generate shows comprised of more than one meta effect, including shows that link meta effects.

In embodiments, a user may assign an effect to a group of light systems. Many effects can be generated, such as a color chasing rainbow, a cross fade effect, a custom rainbow, a fixed color effect, an animation effect, a fractal effect, a random color effect, a sparkle effect, a streak effect, an X burst effect, an XY spiral effect, and a sweep effect.

In embodiments an effect can be an animation effect. In embodiments the animation effect corresponds to an animation generated by an animation facility. In embodiments the effect is loaded from an animation file. The animation facility can be a flash facility, a multimedia facility, a graphics generator, or a three-dimensional animation facility.

In embodiments the lighting show composer facilitates the creation of meta effects that comprise a plurality of linked effects. In embodiments the lighting show composer generates an XML file containing a lighting show according to a document type definition for an XML parser for a light engine. In embodiments the lighting show composer includes stored effects that are designed to run on a predetermined configuration of lighting systems. In embodiments the user can apply a stored effect to a configuration of lighting systems. In embodiments the light system composer includes a graphical simulation of a lighting effect on a lighting configuration. In embodiments the simulation reflects a parameter set by a user for an effect. In embodiments the light show composer allows synchronization of effects between different groups of lighting systems that are grouped using the grouping facility. In embodiments the lighting show composer includes a wizard for adding a predetermined configuration of light systems to a group and for generating effects that are suitable for the predetermined configuration. In embodiments the configuration is a rectangular array, a string, or another predetermined configuration.

Referring to Fig. 63, once a show is downloaded to the light system engine 1654, the light system engine 1654 can execute one or more shows in response to a wide variety of user input. For example, a stored show can be triggered for a lighting unit 100 that is mapped to a particular PDS 1758 associated with a light system engine 1654. There can be a user interface for triggering shows downloaded on the light system engine 1654. For example, the user interface may be a keypad 6350, with one or more buttons 6352 for triggering shows. Each button 6352 might trigger a different show, or a given sequence of buttons might trigger a particular show, so that a simple push-button interface can trigger many different shows, depending on the sequence. In embodiments,

the light system engine 1654 might be associated with a stage lighting system, so that a lighting operator can trigger pre-scripted lighting shows during a concert or other performance by pushing the button at a predetermined point in the performance.

In embodiments, other user interfaces can trigger shows stored on a light system engine 1654, such as a knob, a dial, a button, a touch screen, a serial keypad, a slide mechanism, a switch, a sliding switch, a switch/slide combination, a sensor, a decibel meter, an inclinometer, a thermometer, a anemometer, a barometer, or any other input capable of providing a signal to the light system engine 1654. In embodiments the user interface is the serial keypad 6350, wherein initiating a button on the keypad 6350 initiates a show in at least one zone of a lighting system governed by a light system engine connected to the keypad.

Referring to Fig. 64, a configuration interface 6450 can be provided for a lighting system, to enable the configuration of lighting systems to play lighting shows, such as those authored by the light system composer 1652 for the light system engine 1654. The configuration interface 6450, in embodiments, can be provided in connection with the light system composer 1652, in connection with the light system engine 1654, in connection with a user interface for the light system engine 1654, or in connection with a separate light system controller, such as for a concert or building lighting system. The configuration interface 6450 allows the user to handle different lighting zones 6454, to configure keypads 6458 for triggering light shows, and to configure events 6460 that are comprised of lighting shows and other effects. A user can configure an event 6462, including naming the event. The user can add events with a button 6464 and delete events with a button 6468. The user can name the event in the event name field 6469. The user can set a start time for the event with the field 6470. The user can set timing parameters, such as how frequently the event will repeat, with the tabs 6472, whether it is one time, each second, each minute, each hour, each day, each week, each month, or each year. With the button 6474 the user can have an event triggered after a selected number of days. The user can also set the time for recurrence to terminate with the parameters in the field 6478. Using the configuration interface 6450, a user can take

shows that are generated by the light system composer 1652 and turn them into events that are scheduled to run on particular lighting systems in particular zones that are associated with a light system engine 1654 or other controller.

Referring to Fig. 65, a playback interface 6554 can be provided that facilitates the playback of lighting effects and shows created by the light system composer 1652, such as by the light system engine 1654 or by another controller. The playback interface 6554 allows a user to select shows with an option 6550, to select scrolling text files using an option 6558, to select animation shows or effects using an option 6560, to pull up information, or to select scheduled events using an option 6562. A user can apply playback to one or more selected zones with the field 6552. A user can select a show for playback using the field 6564. The user can set transition parameters for playback using the transition fields 6566. For example, the user can snap between shows using a snap button 6568, provide a cross-fade using a cross-fade button 6570, or fade to black between shows using a button 6572. A user can set transition timing using a field 6573 and set brightness using a bar 6574.

Many different forms of playback control can be provided. Since the light shows composed by the light show composer 1652 can be exported as XML files, any form of playback or download mechanism suitable for other markup language files can be used, analogous to playback facilities used for MP3 files and the like.

Referring to Fig. 66, a download tool 6650 can be provided, by which a show can be downloaded to a light system engine 1654. The user can select and enter the name or address of a particular controller in the field 6652. The user can add or delete shows in the field 6654 for downloading to a particular controller, similar to the downloading of MP3 files to an MP3 player.

Referring to Fig. 67, one form of download of a light show is through a network 6752, such as the Internet. A light system engine 1654 can be supplied with a browser 6750 or similar facility for downloading a lighting show, such as one composed by the

light system composer 1652. Because the lighting shows can be transmitted as XML files, it is convenient and fast to pass the files to the light system engine 1654 through a web facility. In embodiments, a user may use an XML parser to edit XML files after they are created by the light show composer 1652, such as to make last minute, on-site changes to a lighting show, such as for a concert or other event.

Referring to Fig. 68, in embodiments of the invention input to the light system manager 5000 may take the form of video from a video source 6850. The video source 6850 may be any type of video source, analog or digital, such as Firewire video, broadcast video, streaming video, DV, NTSC video, PAL video, SECAM video, RS-170 format video, MPEG format video, HD or high-definition video, RGB video, component video, or other video signals. The video source 6850 may be a broadcast source, cable, wire, satellite video transmitter, tape, videotape, video camera, television camera, motion picture camera, DVD, flash memory, hard drive, jump drive, or other video source 6850. The video source 6850 can serve as an input to the light system manager 5000. In embodiments the video source 6850 may be fed into the light system composer 1750 or a similar facility for converting the video signal into lighting control signals. In embodiments the light system composer 1750 may include an authoring facility, such as for manipulating video signals and/or lighting control signals to generate effects or to modify effects that respond to video signals. In other embodiments the light system composer 1750 may pass through video signals into lighting control signals without offering a separate user interface or authoring facility.

The light system manager 1650 and/or light system composer 1652 may include a capture facility 6852 for capturing incoming video signals from a video source 6850. The capture facility may take a wide range of forms, depending on the nature of the video source 6850. For example, the capture facility may be a satellite antenna and associated receiver electronics, a cable set-top box, a video card for a PC, a Firewire video facility, a receiver, a video codec, or other video capture facility. The video capture facility 6852 may capture successive frames of video input. In embodiments the video capture facility 6852 may either capture digitized video signals or convert analog

video signals into digitized video signals. The digitized video signals may include pixel values for each pixel in the row-column format of a standard video frame, where the pixel values correspond to the brightness of red, green and blue primary colors of a given pixel in the array. The combined red, green and blue values (RGB values) for a given pixel determine the color of the pixel in the video frame according to conventional color-mixing principles.

Once digitized RGB values are obtained for each frame through the capture facility 6852, the values can be handed to a mapping facility 1658, which can map the RGB values of the digitized video to RGB control signals for lighting units 100. For example, an array of video pixels can be mapped to a similar array of lighting units 100 in a one-to-one mapping. In embodiments a subset of the video pixels can be mapped to a lighting unit array, such as to produce a sparse-array video display. In other embodiments the video signals may be mapped to a non-rectangular arrangement of lighting units, such as a lighting display that is wrapped around a non-rectangular object, such as a tree, or the corner of a building or room. Thus, the mapping facility may map pixels of video to real-world lighting arrays in a manner similar to that described in connection with animation effects described above. In embodiments the mapping facility 1658 may include a frame manipulation facility 6854, such as a buffer, such as a ring buffer, for storing and manipulating video frames, to assist in the processing of incoming video signals into lighting control signals.

Once the RGB values of a digitized video frame are mapped to lighting control signals, the control signals can be fed into one or more output buffers 6858, which may hold a stream of such signals to be displayed in turn on lighting units 100 according to the timing of the input video signals (or other timing if the mapping facility 1658 is used to manipulate the video signal, such as to produce slow-motion or fast-motion effects). Each output buffer 6858 can feed a lighting unit 100, such as a red, green or blue lighting unit 100 in an array of lighting units 100. In embodiments the system may include a precalculation facility 6860 for performing any necessary calculations, such as preprocessing or optimizing the stream of bytes of lighting control signals that are fed

into the buffers 6858. The precalculation facility 6860 can, for example, precompute the math needed to generate RGB lighting control signals from RGB pixel values, so that the sequence of lighting control signals can be fed into the output buffers 6858. In embodiments once a buffer 6858 has been built, it can be reused for each frame, rather than being built on the fly. Thus, the precalculation facility 6860 can, for example, precalculate that a particular byte from a digital RGB pixel array should be stored in a particular location in memory, namely, the location from which a lighting control signal in a lighting array will be retrieved. In embodiments the precalculation facility 6860 can be used to manipulate video, such as through time-based effects, such as by sending bytes from the incoming video signal to different locations or buffers at different times, rather than sending the data for the same pixel to the same storage location every time.

Various embodiments can be provided that accept video input and produce corresponding lighting control signals. Referring to Fig. 69, in one embodiment, the light system manager 1650 may comprise a personal computer 6952 configured to receive a high-speed serial data stream, such as the stream from the video source 6850. The personal computer 6952 may be equipped, for example, with a Firewire facility 6950, such as a card. The Firewire facility 6950 (which may be any kind of high-speed serial data facility), may output lighting control signals as a series of outgoing signals to a network, such as to output buffers 6858 or to other network facilities, such as Ethernet facilities, as described above. In such an embodiment, data storage is optional and may be absent. In embodiments the personal computer 6952 may be a Unix-type personal computer, such as using the Unix or Linux operating systems.

Referring to Fig. 70, in another embodiment the video source 6850 may comprise a storage medium 7050, such as a disk, cassette, hard disk, DVD, or the like, encoded in a video format, such as Quicktime, MPEG standard, or the like. In such an embodiment, the light system composer 1652 may include real-time video manipulation software 7052, with features such as a scheduling module and one or more triggering modules, such as to schedule and play video segments, such as AppleScript software from Apple Computer of Cupertino, California. The scheduling module may be used to schedule and

sequence video inputs. Examples of features of the video manipulation software 7052 include timing diagrams, ladder diagrams, Boolean logic, and other features used to play given effects at given times. As in other embodiments, the video input can be mapped, such as by a mapping facility, to lighting control signals, such as to be stored in output buffers 6858. Thus, the user can use conventional video editing software to schedule and manipulate video, edit video, create effects, and the like, and the mapping facility of the light system composer 1652 can map the video output into lighting control signals, such as RGB signals, that are fed to lighting units 100, such as through a series of output buffers 6858. The user can select among multiple video streams, combine streams, create transitions among streams, create cross-fade effects, create dissolving effects, create flyaway effects and use any other effects, such as from stored libraries of effects, all with conventional video manipulation software.

Referring to Fig. 71, in embodiments the video manipulation software 7052 may be configured to receive input from any type of video source 6850, such as a stream of video, such as QuickTime-format video. The system can then output video-over-Ethernet signals 7150, such as to one or more power-data systems or other systems that convert the video into lighting control signals. The lighting control signals in various video embodiment can be stored, manipulated and transmitted according to the various embodiments described herein.

While the invention has been described in connection with certain preferred embodiments, other embodiments would be recognized by one of ordinary skill in the art and all such embodiments are encompassed by this disclosure.

CLAIMS

1. A method for managing control instructions for a plurality of light systems, comprising:

providing a light system manager for mapping locations of a plurality of light systems;

providing a light system composer for composing a lighting show; and

providing a light system engine for playing a lighting show on a plurality of light systems.

2. A method of claim 1, wherein the light system engine is connected to a network.

3. A method of claim 2, wherein shows composed using the light system composer are delivered via the network to the light system engine.

4. A method for managing control of a plurality of light systems, comprising:

providing a light system manager for mapping locations of a plurality of light systems; and

providing a graphical user interface of the light system manager for displaying a representation of the locations of lighting units in an environment.

5. A method of controlling a plurality of light systems, comprising:

providing a mapping facility of the light system manager for mapping locations of a plurality of light systems.

6. A method of claim 5, wherein the mapping facility discovers lighting systems in an environment.

7. A method of claim 5, wherein the mapping facility maps lights in a two-dimensional space.

8. A method of claim 7, wherein the space represents lighting units for lighting a rectangular item selected from the group consisting of a space, a room, a hallway, a stage, a table, an elevator, an aisle, a ceiling, a wall, an exterior wall, a sign, a billboard, a machine, a vending machine, a gaming machine, a display, a video screen, a swimming pool, a spa, a walkway, a sidewalk, a track, a tile a roadway, a door, an item of furniture, a box, a housing, a fence, a railing, and a deck.

9. A method of claim 5, wherein the lighting systems are selected from the group consisting of an architectural lighting system, an entertainment lighting system, a restaurant lighting system, a stage lighting system, a theatrical lighting system, a concert lighting system, an arena lighting system, a signage system, a building exterior lighting system, a landscape lighting system, a pool lighting system, a spa lighting system, a transportation lighting system, a marine lighting system, a military lighting system, a stadium lighting system, a motion picture lighting system, photography lighting system, a medical lighting system, a residential lighting system, a studio lighting system, and a television lighting system.

10. A method of claim 5, wherein light systems can be mapped into separate zones.

11. A method of claim 10, wherein the zones are separate DMX zones.

12. A method of claim 10, wherein the zones are located in different rooms of a building.

13. A method of claim 10, wherein the zones are located in the same location within an environment.

14. A method of claim 10, wherein the environment is a stage lighting environment.

15. A method of claim 5, further comprising:

automatically discovering interfaces that are capable of being managed by the light system manager and adding them to a graphical user interface for mapping locations of lighting units associated with the interfaces.

16. A method of managing lighting control, comprising:

providing a grouping facility for grouping a plurality of light systems, wherein grouped light systems respond as a group to control signals.

17. A method of claim 16, wherein the grouping facility comprises a directed graph.

18. A method of claim 16, wherein the grouping facility comprises a drag and drop user interface.

19. A method of claim 16, wherein the grouping facility comprises a dragging line interface.

20. A method of claim 16, wherein the grouping facility permits grouping of any selected geometry.

21. A method of claim 16, wherein the grouping facility permits grouping in a two-dimensional representation of a three-dimensional space.

22. A method of claim 21, wherein the two-dimensional representation is mapped to light systems in a three-dimensional space.

23. A method of claim 16, wherein the grouping facility groups lights into groups of a predetermined conventional configuration.

24. A method of claim 23, wherein the known configuration is a rectangular, two-dimensional array.

25. A method of claim 24, wherein the known configuration is a square.

26. A method of claim 23, wherein the configuration is curvilinear.

27. A method of claim 23, wherein the configuration is a line.

28. A method of claim 23, wherein the configuration is an oval.

29. A method of claim 23, wherein the configuration is an oval-shaped array.

30. A method of claim 23, wherein the configuration is a circle.

31. A method of claim 23, wherein the configuration is a circular array.

32. A method of claim 23, wherein the configuration is triangle.

33. A method of claim 23, wherein the configuration is a triangular array.

34. A method of claim 23, wherein the configuration is a serial configuration.

35. A method of claim 23, wherein the configuration is a helix.

36. A method of claim 23, wherein the configuration is a double helix.

37. A method of providing lighting control, comprising:

providing a light system composer for allowing a user to author a lighting show using a graphical user interface.

38. A method of claim 37, wherein the light system composer further comprises an effect authoring system for allowing a user to generate a graphical representation of a lighting effect.

39. A method of claim 38, wherein the effect authoring system allows a user to set parameters for a plurality of predefined types of lighting effects.

40. A method of claim 37, wherein the effect authoring system allows a user to create user-defined effects.

41. A method of claim 37, wherein the effect authoring system allows a user to link effects to other effects.

42. A method of claim 37, wherein the effect authoring system allows a user to set a timing parameter for a lighting effect.

43. A method of claim 37, wherein the effect authoring system allows a user to generate meta effects comprised of more than one lighting effect.

44. A method of claim 43, wherein the light system composer allows the user to generate shows comprised of more than one meta effect.

45. A method of claim 43, wherein the user can link meta effects.

46. A method of claim 37, wherein effects can be linked to each other in timing.

47. A method of claim 37, wherein the user may assign an effect to a group of light systems.

48. A method of claim 37, wherein the effect is selected from the group consisting of a color chasing rainbow, a cross fade effect, a custom rainbow, a fixed color effect, an animation effect, a fractal effect, a random color effect, a sparkle effect, a streak effect, a burst effect, an XY spiral effect, and a sweep effect.

49. A method of claim 37, wherein the effect is an animation effect and wherein the animation effect corresponds to an animation generated by an animation facility.

50. A method of claim 49, wherein the animation effect is loaded from an animation file.

51. A method of claim 50, wherein the animation facility is a flash animation facility.

52. A method of claim 50, wherein the animation facility is a multimedia animation facility.

53. A method of claim 50, wherein the animation facility is a video animation facility.

54. A method of claim 50, wherein the animation facility is a three-dimensional simulation animation facility.

55. A method of claim 50, wherein the lighting show composer facilitates the creation of meta effects that comprise a plurality of linked effects.

56. A method of claim 37, wherein the lighting show composer generates an XML file containing a lighting show.

57. A method of claim 37, wherein the lighting show composer includes stored effects that are designed to run on a predetermined configuration of lighting systems.

58. A method of claim 37, wherein the user can apply a stored effect to a configuration of lighting systems.

59. A method of claim 37, wherein the lighting system composer includes a graphical simulation of a lighting effect on a lighting configuration.

60. A method of claim 59, wherein the simulation reflects a parameter set by a user for an effect.

61. A method of claim 59, wherein the simulation is an animation window of a graphical user interface.

62. A method of claim 37, wherein the lighting show composer allows synchronization of effects between different groups of lighting systems that are grouped using a grouping facility.

63. A method of claim 62, wherein the lighting show composer further comprises a wizard for adding a predetermined configuration of light systems to a group and for generating effects that are suitable for the predetermined configuration.

64. A method of claim 63, wherein the predetermined configuration is a rectangular array.

65. A method of claim 63, wherein the predetermined configuration is a string.

66. A method of providing lighting control, comprising:

providing a light system engine for relaying control signals to a plurality of light systems, wherein the light system engine plays back lighting shows.

67. A method of claim 66, wherein the light system engine includes a processor, a data facility, an operating system and a communication facility.

68. A method of claim 66, wherein the light system engine is configured to communicate with a lighting control facility.

69. A method of claim 68, wherein the lighting control facility is a DALI facility.

70. A method of claim 68, wherein the lighting control facility is a DMX facility.

71. A method of claim 68, wherein the lighting control facility operates with a serial communication protocol.

72. A method of claim 68, wherein the lighting control facility is a power/data supply.

73. A method of claim 66, wherein the light system engine executes lighting shows downloaded from the light system composer.

74. A method of claim 73, wherein shows are delivered as XML files from the lighting show composer to the light system engine.

75. A method of claim 73, wherein shows are delivered to the light system engine over a network.

76. A method of claim 73, wherein shows are delivered over an Ethernet facility.

77. A method of claim 73, wherein shows are delivered over a wireless facility.

78. A method of claim 73, wherein shows are delivered over a Firewire facility.

79. A method of claim 73, wherein shows are delivered over the Internet.

80. A method of claim 73, wherein the lighting shows composed by the lighting show composer are combined with other files from another computer system.

81. A method of claim 80, wherein the lighting shows are combined by adding additional elements to an XML file that contains a lighting show.

82. A method of claim 81, wherein the other computer system includes an XML parser for handling XML files.

83. A method of claim 80, wherein the other computer system is selected from the group consisting of a sound system, and entertainment system, a multimedia system, a video system, an audio system, a sound-effect system, a smoke effect system, a vapor effect system, a dry-ice effect system, another lighting system, a security system, an information system, a sensor-feedback system, a sensor system, a browser, a network, a server, a wireless computer system, a building information technology system, and a communication system.

84. A method of claim 80, wherein the other computer system comprises a browser and wherein the user of the browser can edit the XML file using the browser to edit the lighting show generated by the lighting show composer.

85. A method of claim 73, wherein the light system engine includes a server, wherein the server is capable of receiving data over the Internet.

86. A method of claim 66, wherein the light system engine is capable of handling multiple zones of light systems, wherein each zone of light systems has a distinct mapping.

87. A method of claim 86, wherein the multiple zones are synchronized using the internal clock of the light system engine.

88. A method of claim 66, wherein the light system engine comprises a personal computer with a Linux operating system.

89. A method of claim 66, wherein the light system engine is associated with a bridge to a DMX system.

90. A method of claim 66, wherein the light system engine is associated with a bridge to a DALI system.

91. A method of providing lighting control, comprising:

providing a user interface for triggering shows downloaded on a light system engine.

92. A method of claim 91, wherein the user interface is selected from the group consisting of a knob, a dial, a button, a touch screen, a serial keypad, a slide mechanism, a switch, a sliding switch, a switch/slide combination, a sensor, a decibel meter, an inclinometer, a thermometer, a anemometer, and a barometer.

93. A method of claim 91, wherein the user interface is a serial keypad and wherein initiating a button on the keypad initiates a show in at least one zone of a lighting system governed by a light system engine connected to the keypad.

94. A system for managing control instructions for a plurality of light systems, comprising:

a light system manager for mapping locations of a plurality of light systems;

a light system composer for composing a lighting show; and

a light system engine for playing a lighting show on a plurality of light systems.

95. A system of claim 94, wherein the light system engine is connected to a network.

96. A system of claim 95, wherein shows composed using the light system composer are delivered via the network to the light system engine.

97. A system for managing control of a plurality of light systems, comprising:

a light system manager for mapping locations of a plurality of light systems; and

a graphical user interface of the light system manager for displaying a representation of the locations of lighting units in an environment.

98. A system for controlling a plurality of light systems, comprising:

a mapping facility of the light system manager for mapping locations of a plurality of light systems.

99. A system of claim 98, wherein the mapping facility discovers lighting systems in an environment.

100. A system of claim 98, wherein the mapping facility maps lights in a two-dimensional space.

101. A system of claim 100, wherein the space represents lighting units for lighting a rectangular item selected from the group consisting of a space, a room, a hallway, a stage, a table, an elevator, an aisle, a ceiling, a wall, an exterior wall, a sign, a billboard, a machine, a vending machine, a gaming machine, a display, a video screen, a swimming pool, a spa, a walkway, a sidewalk, a track, a tile a roadway, a door, an item of furniture, a box, a housing, a fence, a railing, and a deck.

102. A system of claim 98, wherein the lighting systems are selected from the group consisting of an architectural lighting system, an entertainment lighting system, a restaurant lighting system, a stage lighting system, a theatrical lighting system, a concert lighting system, an arena lighting system, a signage system, a building exterior lighting system, a landscape lighting system, a pool lighting system, a spa lighting system, a transportation lighting system, a marine lighting system, a military lighting system, a stadium lighting system, a motion picture lighting system, photography lighting system, a medical lighting system, a residential lighting system, a studio lighting system, and a television lighting system.

103. A system of claim 98, wherein light systems can be mapped into separate zones.

104. A system of claim 103, wherein the zones are separate DMX zones.

105. A system of claim 103, wherein the zones are located in different rooms of a building.

106. A system of claim 103, wherein the zones are located in the same location within an environment.

107. A system of claim 103, wherein the environment is a stage lighting environment.

108. A system of claim 98 further comprising:

a discovery module for automatically discovering interfaces that are capable of being managed by the light system manager and adding them to a graphical user interface for mapping locations of lighting units associated with the interfaces.

109. A system of managing lighting control, comprising:

a grouping facility for grouping a plurality of light systems, wherein grouped light systems respond as a group to control signals.

110. A system of claim 109, wherein the grouping facility comprises a directed graph.

111. A system of claim 109, wherein the grouping facility comprises a drag and drop user interface.

112. A system of claim 109, wherein the grouping facility comprises a dragging line interface.

113. A system of claim 109, wherein the grouping facility permits grouping of any selected geometry.

114. A system of claim 109, wherein the grouping facility permits grouping in a two-dimensional representation of a three-dimensional space.

115. A system of claim 114, wherein the two-dimensional representation is mapped to light systems in a three-dimensional space.

116. A system of claim 109, wherein the grouping facility groups lights into groups of a predetermined conventional configuration.

117. A system of claim 116, wherein the known configuration is a rectangular, two-dimensional array.

118. A system of claim 117, wherein the known configuration is a square.

119. A system of claim 116, wherein the configuration is curvilinear.

120. A system of claim 116, wherein the configuration is a line.

121. A system of claim 116, wherein the configuration is an oval.

122. A system of claim 116, wherein the configuration is an oval-shaped array.

123. A system of claim 116, wherein the configuration is a circle.

124. A system of claim 116, wherein the configuration is a circular array.

125. A system of claim 116, wherein the configuration is triangle.

126. A system of claim 116, wherein the configuration is a triangular array.

127. A system of claim 116, wherein the configuration is a serial configuration.

128. A system of claim 116, wherein the configuration is a helix.

129. A system of claim 116, wherein the configuration is a double helix.

130. A system of providing lighting control, comprising:

a light system composer for allowing a user to author a lighting show using a graphical user interface.

131. A system of claim 130, wherein the light system composer further comprises an effect authoring system for allowing a user to generate a graphical representation of a lighting effect.

132. A system of claim 131, wherein the effect authoring system allows a user to set parameters for a plurality of predefined types of lighting effects.

133. A system of claim 130, wherein the effect authoring system allows a user to create user-defined effects.

134. A system of claim 130, wherein the effect authoring system allows a user to link effects to other effects.

135. A system of claim 130, wherein the effect authoring system allows a user to set a timing parameter for a lighting effect.

136. A system of claim 130, wherein the effect authoring system allows a user to generate meta effects comprised of more than one lighting effect.

137. A system of claim 136, wherein the light system composer allows the user to generate shows comprised of more than one meta effect.

138. A system of claim 136, wherein the user can link meta effects.

139. A system of claim 130, wherein effects can be linked to each other in timing.

140. A system of claim 130, wherein the user may assign an effect to a group of light systems.

141. A system of claim 130, wherein the effect is selected from the group consisting of a color chasing rainbow, a cross fade effect, a custom rainbow, a fixed color effect, an animation effect, a fractal effect, a random color effect, a sparkle effect, a streak effect, a burst effect, an XY spiral effect, and a sweep effect.

142. A system of claim 130, wherein the effect is an animation effect and wherein the animation effect corresponds to an animation generated by an animation facility.

143. A system of claim 142, wherein the animation effect is loaded from an animation file.

144. A system of claim 143, wherein the animation facility is a flash animation facility.

145. A system of claim 143, wherein the animation facility is a multimedia animation facility.

146. A system of claim 143, wherein the animation facility is a video animation facility.

147. A system of claim 143, wherein the animation facility is a three-dimensional simulation animation facility.

148. A system of claim 143, wherein the lighting show composer facilitates the creation of meta effects that comprise a plurality of linked effects.

149. A system of claim 130, wherein the lighting show composer generates an XML file containing a lighting show.

150. A system of claim 130, wherein the lighting show composer includes stored effects that are designed to run on a predetermined configuration of lighting systems.

151. A system of claim 130, wherein the user can apply a stored effect to a configuration of lighting systems.

152. A system of claim 130, wherein the lighting system composer includes a graphical simulation of a lighting effect on a lighting configuration.

153. A system of claim 152, wherein the simulation reflects a parameter set by a user for an effect.

154. A system of claim 152, wherein the simulation is an animation window of a graphical user interface.

155. A system of claim 130, wherein the lighting show composer allows synchronization of effects between different groups of lighting systems that are grouped using a grouping facility.

156. A system of claim 155, wherein the lighting show composer further comprises a wizard for adding a predetermined configuration of light systems to a group and for generating effects that are suitable for the predetermined configuration.

157. A system of claim 156, wherein the predetermined configuration is a rectangular array.

158. A system of claim 156, wherein the predetermined configuration is a string.

159. A system of providing lighting control, comprising:

a light system engine for relaying control signals to a plurality of light systems, wherein the light system engine plays back lighting shows.

160. A system of claim 159, wherein the light system engine includes a processor, a data facility, an operating system and a communication facility.

161. A system of claim 159, wherein the light system engine is configured to communicate with a lighting control facility.

162. A system of claim 161, wherein the lighting control facility is a DALI facility.

163. A system of claim 161, wherein the lighting control facility is a DMX facility.

164. A system of claim 161, wherein the lighting control facility operates with a serial communication protocol.

165. A system of claim 161, wherein the lighting control facility is a power/data supply.

166. A system of claim 159, wherein the light system engine executes lighting shows downloaded from the light system composer.

167. A system of claim 166, wherein shows are delivered as XML files from the lighting show composer to the light system engine.

168. A system of claim 166, wherein shows are delivered to the light system engine over a network.

169. A system of claim 166, wherein shows are delivered over an Ethernet facility.

170. A system of claim 166, wherein shows are delivered over a wireless facility.

171. A system of claim 166, wherein shows are delivered over a Firewire facility.

172. A system of claim 166, wherein shows are delivered over the Internet.

173. A system of claim 166, wherein the lighting shows composed by the lighting show composer are combined with other files from another computer system.

174. A system of claim 173, wherein the lighting shows are combined by adding additional elements to an XML file that contains a lighting show.

175. A system of claim 174, wherein the other computer system includes an XML parser for handling XML files.

176. A system of claim 173, wherein the other computer system is selected from the group consisting of a sound system, and entertainment system, a multimedia system, a video system, an audio system, a sound-effect system, a smoke effect system, a vapor effect system, a dry-ice effect system, another lighting system, a security system, an information system, a sensor-feedback system, a sensor system, a browser, a network, a server, a wireless computer system, a building information technology system, and a communication system.

177. A system of claim 173, wherein the other computer system comprises a browser and wherein the user of the browser can edit the XML file using the browser to edit the lighting show generated by the lighting show composer.

178. A system of claim 166, wherein the light system engine includes a server, wherein the server is capable of receiving data over the Internet.

179. A system of claim 159, wherein the light system engine is capable of handling multiple zones of light systems, wherein each zone of light systems has a distinct mapping.

180. A system of claim 179, wherein the multiple zones are synchronized using the internal clock of the light system engine.

181. A system of claim 159, wherein the light system engine comprises a personal computer with a Linux operating system.

182. A system of claim 159, wherein the light system engine is associated with a bridge to a DMX system.

183. A system of claim 159, wherein the light system engine is associated with a bridge to a DALI system.

184. A system of providing lighting control, comprising:
a user interface for triggering shows downloaded on a light system engine.

185. A system of claim 184, wherein the user interface is selected from the group consisting of a knob, a dial, a button, a touch screen, a serial keypad, a slide mechanism, a switch, a sliding switch, a switch/slide combination, a sensor, a decibel meter, an inclinometer, a thermometer, a anemometer, and a barometer.

186. A system of claim 185, wherein the user interface is a serial keypad and wherein initiating a button on the keypad initiates a show in at least one zone of a lighting system governed by a light system engine connected to the keypad.

187. A method of providing lighting control signals, comprising:
capturing an incoming video signal;

determining pixel values from the video signal; and

converting the pixel values to corresponding lighting control signals for a lighting system.

188. A method of claim 187, wherein the video signal is a streaming video signal.

189. A method of claim 187, wherein the video signal comes from a video storage medium.

190. A method of claim 189, wherein the video storage medium is selected from the group consisting of a disk, a tape, and a DVD.

191. A method of claim 187, wherein the video signal is a data stream.

192. A method of claim 187, wherein capturing the video signal uses a Firewire facility.

193. A method of claim 187, wherein converting the pixel values includes precalculating a storage location for a lighting control signal based on a pixel location in a video signal.

194. A method of claim 187, further comprising manipulating the video signal before converting the video signal into a lighting control signal.

195. A system for providing lighting control signals, comprising:

a capture facility for capturing an incoming video signal and determining pixel values from the video signal; and

a mapping facility for converting the pixel values to corresponding lighting control signals for a lighting system.

196. A system of claim 195, wherein the video signal is a streaming video signal.

197. A system of claim 195, wherein the video signal comes from a video storage medium.

198. A method of claim 197, wherein the video storage medium is selected from the group consisting of a disk, a tape, and a DVD.

199. A system of claim 195, wherein the video signal is a data stream.

200. A system of claim 195, further comprising a Firewire facility.

201. A system of claim 195, wherein the mapping facility includes a precalculation facility for precalculating a storage location for a lighting control signal based on a pixel location in a video signal.

202. A system of claim 195, further comprising a manipulation facility for manipulating the video signal before converting the video signal into a lighting control signal.

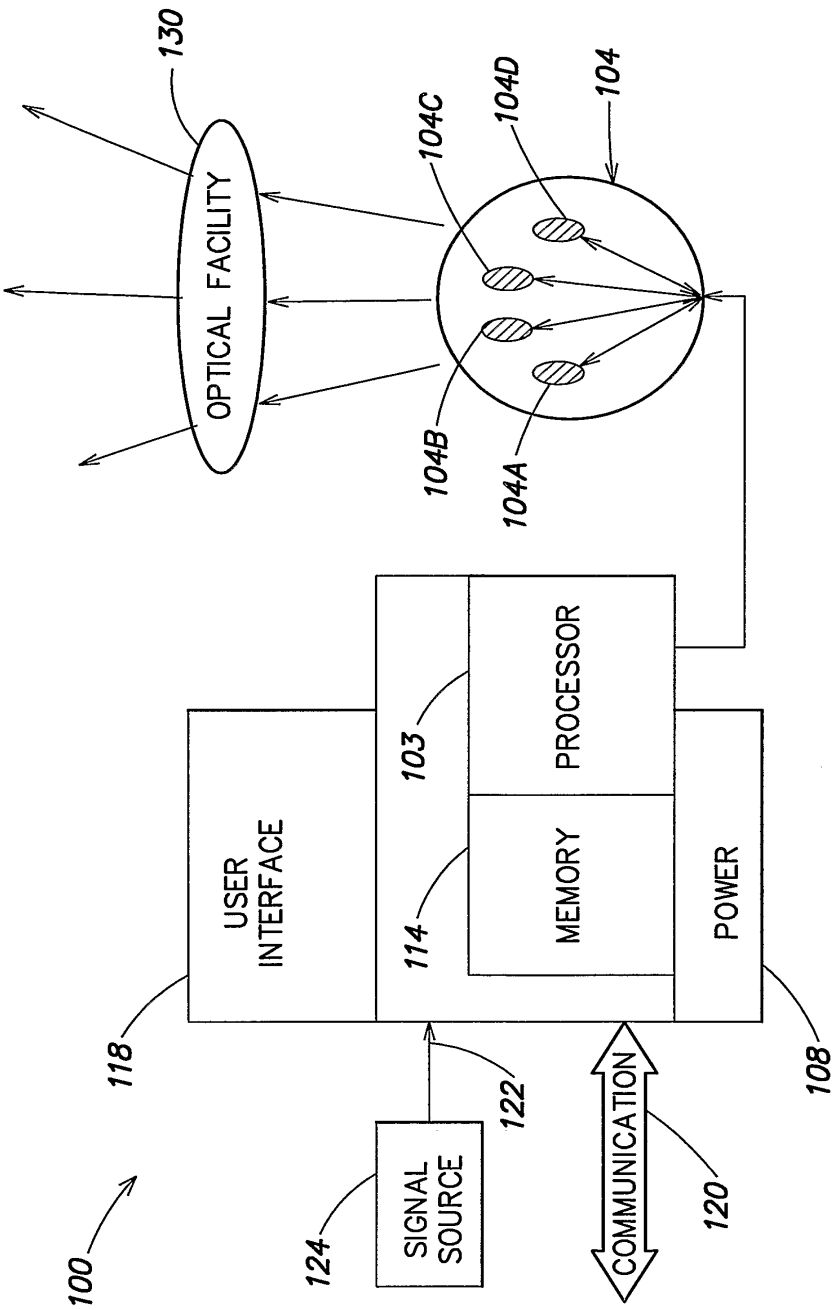

130
OPTICAL FACILITY
104C
104D
104
104B
104A
PROCESSOR
103
USER INTERFACE
MEMORY
114
POWER
118
122
108
COMMUNICATION
120
SIGNAL SOURCE
124
100

FIG. 1

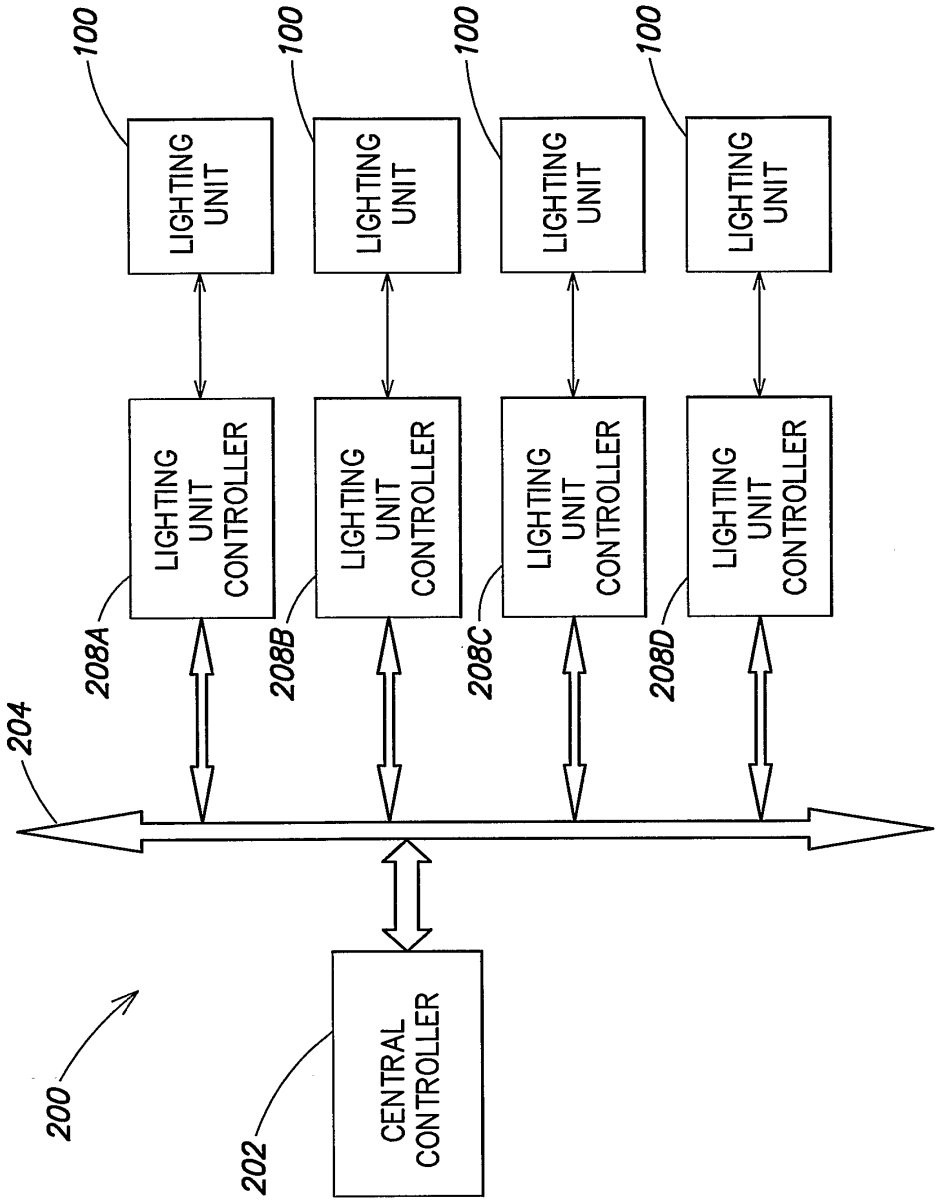

100
100
100
100
LIGHTING UNIT
LIGHTING UNIT
LIGHTING UNIT
LIGHTING UNIT
LIGHTING UNIT CONTROLLER
LIGHTING UNIT CONTROLLER
LIGHTING UNIT CONTROLLER
LIGHTING UNIT CONTROLLER
208A
208B
208C
208D
204
200
202
CENTRAL CONTROLLER

FIG. 2