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(74) Agent: WRAIGE, David; IPULSE, 9-10 Savile Road, London W1S 3PF (GB).

(71) Applicant (for all designated States except US): LITE-LOGIC LIMITED [GB/GB]; 1a Station Road, Hampton Wick, Surrey KT1 4HG (GB).

(72) Inventors; and

(75) Inventors/Applicants (for US only): SIRMON, James [GB/GB]; 113 Rosecroft Gardens, Twickenham, Middlesex TW2 7PU (GB). COLE, Anthony [GB/GB]; 91 Ratcliffe Drive, Stoke Gifford, Bristol, BS34 8TY (GB).

(54) Title: CALIBRATION METHOD AND APPARATUS

(57) Abstract: A method for calibrating an array of light sources is disclosed. The method comprises: a) supplying a preset signal to a first light source in the array, the preset signal being associated with a desired value of the wavelength and/or intensity of light emitted by the first light source; b) monitoring the wavelength and/or intensity of the light emitted by the first light source; c) determining a compensation factor to be applied to the preset signal such that the monitored wavelength and/or intensity has the desired value; d) storing the compensation factor; and e) carrying out steps (a) to (d) for each other light source in the array. A corresponding apparatus is disclosed.
CALIBRATION METHOD AND APPARATUS

This invention relates to calibration of an array of light sources for use in a display device. The display device may be a static display device made up of a plurality of panels of arrays of lights sources, or it may be of the type in which the intensity of light emitted by each light source in the array is modulated as it rotates around an axis so that the light sources in combination cause a desired image to be visible to an observer by virtue of persistence of vision.

Such types of display device are well known and several examples are described in our co-pending PCT patent application, published as WO2006/021 788. The arrays of lights sources used in such display devices typically comprise a set of light emitting diodes (LEDs) mounted on a printed circuit board (PCB).

There is a problem with this type of display device however. This problem is caused by the fact that LEDs tend to have slightly different characteristics in terms of brightness and hue from each other as a result of the manufacturing process. In the type of rotating display mentioned above, a slight variance in the colour or brightness characteristics of just one LED can lead to a very noticeable streaking effect because each LED effectively draws a horizontal line, or part thereof, of the image being displayed. The streaks will appear either brighter, darker or a different colour to adjacent parts of the image depending on the difference in characteristics between adjacent LEDs on the same array and corresponding LEDs on other arrays spinning around the same axis. Indeed, variation in colour and/or brightness between an LED on one array and the corresponding LED on another array can lead to a flickering of the streak if these two LEDs are both used to refresh the same line on the image. Needless to say, the streaking and flickering effects can be extremely annoying and in extreme cases can disrupt the image almost entirely.

A similar problem occurs with static displays made up from a plurality of panels. The variance in colour or brightness characteristics of the LEDs can affect the quality of the display dramatically.
One way of dealing with these problems is to purchase matched LEDs from the
manufacturer. However, this is extremely costly and whilst it leads to adequate
matching within an array, this cannot be guaranteed for different arrays.

In accordance with one aspect of the invention, there is provided a method for
calibrating an array of light sources for use in a display device in which the intensity
of light emitted by each light source in the array is modulated as it rotates around
an axis so that the light sources in combination cause a desired image to be visible
to an observer by virtue of persistence of vision, the method comprising:

a) supplying a preset signal to a first light source in the array, the preset signal
being associated with a desired value of the wavelength and/or intensity of light
emitted by the first light source;
b) monitoring the wavelength and/or intensity of the light emitted by the first light
source;
c) determining a compensation factor to be applied to the preset signal such that
the monitored wavelength and/or intensity has the desired value;
d) storing the compensation factor; and
e) carrying out steps (a) to (d) for each other light source in the array.

In accordance with a second aspect of the invention, there is provided apparatus
for calibrating an array of light sources, the apparatus comprising a monitoring
device for monitoring the wavelength and/or intensity of the light emitted by the light
sources in the array and a controller adapted to:
a) supply a preset signal to a first light source in the array, the preset signal being
associated with a desired value of the wavelength and/or intensity of light emitted
by the first light source;
b)determine a compensation factor to be applied to the preset signal such that the
monitored wavelength and/or intensity of the light emitted by the first light source
has the desired value;
c) store the compensation factor; and
d) carry out steps (a) to (c) for each other light source in the array.

Hence, this invention provides a method and apparatus for calibrating the light
sources in an array so that they all produce the same brightness and/or colour of
light when provided with the same current. The compensation factor that is
determined effectively forms an adjustment which will be made to signals applied
to the light sources in use such that it can be ensured that they always emit light of
the expected wavelength and/or intensity.

The process can be performed quickly and is therefore cheap in a production
scenario. Furthermore, an array calibrated with this method will match any other
array calibrated at the same time to the same desired value of wavelength and/or
intensity.

It should be understood that the preset signal will depend on the nature of the light
sources in the array. For example, if the light source is a simple single-colour LED
for a monochromatic display then the preset signal may simply be a preset current
or voltage. It may alternatively be a pulse width modulated signal.

However, in the case where the light source is, for example, a full-colour LED which
can produce any desired colour by mixing red, green and blue light in appropriate
proportions then the preset signal will typically be a composite signal. In this
composite signal, there will be three components, each one of which controls the
quantity of a respective red, green or blue component of the light emitted by the
light source. Again, each component of the composite signal may be a preset
current or voltage, or a pulse width modulated signal.

In this regard, it is important to appreciate that the compensation factor may affect
the colour balance (i.e. wavelength) of light emitted by the light source by causing
each of the components of the preset signal to vary relative to each other. It may
also, or instead, affect intensity (i.e. brightness) of light emitted by the light source
by causing each of the components of the preset signal to vary in unison with each
other.

Typically, each light source in the array is a light emitting diode (LED).

In one embodiment, each light source is a tricolour LED.
Each light source in the array may be a triad of red, green and blue light sources. In this case, each of the red, green and blue light sources in the triad may be a discrete LED.

In one embodiment, the wavelength and/or intensity of the light emitted by the first light source is monitored by visual inspection allowing for a manual calibration process.

In this embodiment, the monitoring device may comprise an optical viewer for visual inspection of the wavelength and/or intensity of the light emitted by the light sources in the array.

The optical viewer may comprise a frustoconical element having an aperture at each end, the aperture at the smaller end lying adjacent to the array of light sources. The inside surface of the frustoconical element may be polished. The frustoconical element may be made from a metal.

The controller may be further adapted to adjust the preset signal in accordance with user input until the monitored wavelength and/or intensity equals the desired value of wavelength and/or intensity, and to set the compensation factor depending on the degree of adjustment required to the preset signal so that the monitored wavelength and/or intensity equals the desired value of wavelength and/or intensity.

In this case, the user input is typically generated by a joystick. The joystick is preferably a three-axis joystick, each axis representing a degree of adjustment required to a respective one of the red, green and blue components of the monitored wavelength and/or intensity so that it equals the desired value of wavelength and/or intensity.

The controller may be further adapted to set the compensation factor to be the ratio between the adjusted preset signal and the preset signal.
In another embodiment, the wavelength and/or intensity of the light emitted by the first light source are monitored electronically allowing an automatic or semi-automatic process of calibration.

In this embodiment, the monitoring device comprises a photometer, which generates output signals indicating the monitored wavelength and/or intensity.

The controller may be further adapted to receive the output signals from the photometer, to adjust the preset signal so that the output signals from the photometer indicate that the monitored wavelength and/or intensity equals the desired values of wavelength and/or intensity, and to set the compensation factor depending on the degree of adjustment required to the preset signal so that the monitored wavelength and/or intensity equals the desired values of wavelength and/or intensity.

In this case, the controller may be further adapted to adjust the preset signal in accordance with user input. This allows a semi-automatic process in which, for example, a user can observe the output signals from the photometer to obtain an indication of the monitored wavelength and/or intensity and then refer to a table of correction values to input to the controller to allow it to adjust the preset signal accordingly. It also allows the user to override an automatic process.

Typically, however, the user input is generated by a joystick. The joystick is preferably a three-axis joystick, each axis representing a degree of adjustment required to a respective one of the red, green and blue components of the monitored wavelength and/or intensity so that it equals the desired value of wavelength and/or intensity.

Alternatively, the controller may be further adapted to adjust the preset signal in accordance with a predetermined algorithm.

The controller may be further adapted to set the compensation factor to be the ratio between the adjusted preset signal and the preset signal.
The monitoring device may be movable relative to the array so that each of the light sources in the array may be brought into alignment with the monitoring device. Typically, the apparatus further comprises a motor operable by the controller for moving the monitoring device relative to the array.

The controller may be further adapted to store the compensation factor along with the desired values of wavelength and/or intensity of light associated with the preset signal.

The controller may be further adapted to repeat steps (a) to (c) with two or more different preset signals.

Typically, the array further comprises a memory device for storing the compensation factor for each light source, and the compensation factor is stored in a memory device associated with the array.

The method and apparatus of the first and second aspects of the invention may also be used to calibrate PCBs which are to be used as replacements in a display system which has already been commissioned, for example because a PCB has developed a fault. In such a case, it is vital that the light sources on the replacement PCB match the intensity and/or wavelength of the light sources on the other PCBs making up the display. The light sources on the replacement need to be artificially aged to match the light sources on the other PCBs in the display because the light sources on the other PCBs are likely to have deteriorated somewhat during the passage of time, which it is known causes the output of light sources such as LEDs to decrease.

In this case, the desired value may be determined by monitoring the wavelength and/or intensity of light emitted by a corresponding light source on a reference array of light sources and setting the desired value to be equal to the monitored wavelength and/or intensity. This determination of the desired value of wavelength and/or intensity will of course typically be repeated for each light source in the array so that there is correspondence between each light source in the array and each
corresponding light source in the reference array. This provides a natural-looking effect when the replacement array is installed.

To achieve this, the controller may be further adapted to determine the desired value by causing the photometer to monitor the wavelength and/or intensity of light emitted by a corresponding light source on a reference array of light sources and receiving the generated output signals from the photometer, setting the desired value to be equal to the monitored wavelength and/or intensity based on the output signals from the photometer, and storing the desired value in a memory.

Alternatively, the desired value may be determined by monitoring the wavelength and/or intensity of light emitted by all of the light sources on a reference array of light sources and setting the desired value to be equal to the average of the monitored wavelengths and/or intensities.

In this case, the controller may be further adapted to determine the desired value by causing the photometer to monitor the wavelength and/or intensity of light emitted by each light source on a reference array of light sources and receiving the generated output signals from the photometer, setting the desired value to be equal to the average of the monitored wavelengths and/or intensities based on the output signals from the photometer, and storing the desired value in a memory.

The method according to the first aspect and the apparatus according to the second aspect may be used to calibrate an array of light sources for use in a display device in which the intensity of light emitted by each light source in the array is modulated as it rotates around an axis so that the light sources in combination cause a desired image to be visible to an observer by virtue of persistence of vision.

The method according to the first aspect and the apparatus according to the second aspect may be used to calibrate an array of light sources for use in a display device comprising a plurality of arrays of static light sources.

In a third aspect of the invention, there is provided an array of light sources calibrated by the method of the first aspect.
In a fourth aspect, there is provided an array of light sources calibrated using the apparatus of the second aspect.

Two embodiments of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 shows a system for manual calibration of an array of LEDs; and

Figure 2 shows an enhancement of this system to allow automatic calibration of an array of LEDs.

Figure 1 shows a PCB 1 on which are mounted an array of LEDs 2 set out in a line at one edge of the PCB 1. The PCB 1 is suitable for use in a rotating-type display device in which the intensity of light emitted by each LED in the array 2 is modulated as it rotates around an axis so that the light sources in combination cause a desired image to be visible to an observer by virtue of persistence of vision. Typically, such a display device will comprise more than one array of LEDs.

The PCB 1 also carries a solid-state memory device 3. This memory device 3 can be used to store a respective compensation factor for each of the LEDs in the array 2. The compensation factor will then be applied to drive signals supplied to that LED in future so that it can be ensured that the desired wavelength and/or intensity of light are emitted by the LED. By selecting each compensation factor so that the associated LED emits the same wavelength and/or intensity of light for a given drive signal the array can be calibrated.

The array of LEDs 2 is shown located in a calibration jig in Figure 1, and is held fast between two end walls 4a and 4b of the jig. Extending between these two end walls 4a and 4b is a rail 6 on which is mounted a carriage 5. The carriage 5 carries an optical viewer 7. The carriage 5 is slidable along the rail 6 so that the optical viewer 7 can be brought into alignment with any one of the LEDs in the array 2.

The optical viewer could take many forms. For instance, it could simply be a hole drilled in the carriage 5 lying directly above the array of LEDs 2. However, in this
instance a frustoconical metal or plastic element is provided having an aperture at each end. The interior surface may be polished. The larger aperture is coincident with a similarly-sized aperture in the carriage 5 whilst the smaller aperture lies directly above the array of LEDs 2. This type of optical viewer allows an operator to view the light emitted by a particular LED in the array 2 without being distracted by other sources of light.

In order to calibrate the array of LEDs 2, the carriage is aligned with the first LED in the array 2. This is supplied a preset signal by a controller 8. The preset signal is associated with a desired wavelength and/or intensity of light. Typically, the preset signal will be associated with full brightness, white light (i.e. the red, green and blue components of the preset signal are all at a maximum value), or simply full brightness, red, green or blue light. It should be noted that before calibration there will be no compensation factor stored in memory 3 for the first (or any other) LED and so no adjustment to the preset signal will initially be made.

The first LED will emit light as a result of the application of the preset signal. However, this light is unlikely to actually be at the desired wavelength and/or intensity. A skilled operator is able to detect this by viewing the first LED through the optical viewer 7.

If the wavelength and/or intensity of light is not what is desired then the operator can adjust the red, green and blue components of the light until the wavelength and/or intensity of light emitted equal the desired values. This adjustment is made by a three-axis joystick 9. Each axis is used to adjust preset signal so as to control a respective one of the red, green and blue components of the emitted light. The controller 8 detects the movement of the joystick 9 and adjusts the preset signal accordingly, thereby affecting the wavelength and/or intensity of the light emitted by the first LED in the array 2. When the light is at the desired wavelength and/or intensity then this is indicated to the controller 8 by the user by pressing button 10.

For example, if the light emitted as a result of applying the preset signal appears to have too high a red content then the joystick may be used to decrease the red content alone (i.e. leaving the green and blue content unaffected). If, on the other
hand it is relatively too bright then the joystick may be used to reduce the red, green and blue contents in unison. Of course, adjustment of both wavelength and intensity could be made.

When the desired wavelength and/or intensity have been achieved and button 10 has been pressed to indicate this then the controller 8 writes an appropriate compensation factor to memory 3 for the first LED. This compensation factor is typically calculated to be the ratio between the preset signal after it has been adjusted by the operator and the initial preset signal. This means that if the preset signal has red, green and blue components then the compensation factor will have a component for each of the red, green and blue components of the preset signal, each component of the compensation factor effectively acting as a scaling factor for future signals to be applied to the LED. The different components of the compensation factor may have different values to allow relative variation of the red, green and blue components.

The carriage 5 is then moved along rail 6 to align the optical viewer 7 with the next LED in the array 2 and the calibration process is repeated. This is done for each of the other LEDs in the array 2.

The controller 8 may calibrate each LED with more than one preset signal, for example at full brightness, half brightness and possibly other levels of brightness, and/or with white, red, green and blue light. This ensures the calibration is uniform across the entire output range of the LED. The calibration process is effectively the same, simply being repeated for the second and any subsequent preset signals. However, it is necessary for the controller 8 to write the compensation factor along with the desired wavelength and/or intensity to memory 3 for each of the preset signals so that the correct compensation factor can be applied for a given wavelength in future.

This is especially useful when the display is to be used in daylight and at night time when a lower intensity of emitted light is required. By calibrating with two different preset signals, the colour and brightness balance of the display is ensured in both situations. It is possible to interpolate between these two calibration points to derive
appropriate compensation factors for signals lying between the two preset signals used for calibration.

Figure 2 shows an enhancement to the embodiment of Figure 1 to allow for an automatic process of calibration more suited to high-volume manufacturing. Where the same reference numerals are used in Figure 2 as in Figure 1 these refer to the same parts and the description of these will not be repeated.

In addition to the parts making up the Figure 1 embodiment, the system shown in Figure 2 comprises a colorimetric photometer 11 attached to the optical viewer 7. This detects the light produced by an LED in the array 2 and produces output signals indicating the wavelength and/or intensity of the light. These output signals are supplied to the controller 8.

Also provided are a stepper motor 12, mounted on the carriage 5, and a stepper motor controller 13 attached to the controller 8. The motor 12 is coupled to a pinion gear 14 which meshes with a rack gear 15 mounted on the rail 6 through a hole in the carriage 5. The stepper motor controller 13 causes the stepper motor 12 to be actuated in response to commands from the controller 8. Actuation of the stepper motor 12 causes the carriage 5, and hence the photometer 11, to move along the rail 6. By driving the stepper motor 12 through an appropriate number of pulses, the photometer 11 can be brought into alignment with any of the LEDs in the array 2.

The joystick 9 and button 10 are still provided in case it is required to manually override the automatic process. This ensures that if the software is unable to calibrate an LED correctly, a human operator can intervene. If the operator is able to successfully calibrate the LED then this prevents the PCB having to be reworked, which is a costly process.

In the automatic process the controller 8 causes the stepper motor controller 13 to actuate the stepper motor 12 so that the photometer 11 is brought into alignment with the first LED in the array 2. The preset signal is then applied to the first LED causing it to emit light. The wavelength and/or intensity are measured by the photometer 11, the output signals of which are supplied to the controller 8.
The controller 8 then adjusts the preset signal appropriately to cause the light emitted by the first LED to be at the desired wavelength and/or intensity. When the desired wavelength and/or intensity are detected by the photometer 11, controller 8 writes an appropriate compensation factor to memory 3 for the first LED. This compensation factor is typically calculated to be the ratio between the preset signal after it has been adjusted by the controller 8 and the initial preset signal.

The controller 8 then issues a command to the stepper motor controller 13 to cause it to actuate the motor 12 such that the photometer is brought into alignment with the next LED in the array 2 which is then calibrated. This is repeated for all the LEDs in the array 2.

As in the Figure 1 embodiment, the controller 8 may calibrate each LED with more than one preset signal, for example at full brightness and half brightness.

Using this embodiment, the desired value of wavelength and/or intensity may be set by first inserting a reference PCB into the apparatus. This reference PCB will typically be taken from a previously commissioned display in which one of the PCBs has developed a fault. The use of a reference PCB from the display allows the LEDs on the replacement PCB to be matched to the other PCBs in the display which will have aged since original commissioning so that the replacement looks natural and is not glaringly apparent.

The stepper motor controller 13 will then cause the stepper motor 12 to move the carriage 5 so that the optical viewer 7 and photometer 11 are brought into alignment with each of the LEDs in the reference PCB in turn. At each turn, the controller 8 causes the preset signal is applied to the respective LED and the output signals from the photometer 11 are measured and stored in a memory in controller 8.

The PCB 1 to be calibrated is then inserted and the calibration procedure described above is carried out. However, in this case the desired value is set based on the measured values of wavelength and/or intensity taken from the reference PCB. The desired value of the wavelength and/or intensity for each LED in the PCB 1 to be calibrated may be set to be equal to the average of the measured wavelength
and/or intensity values of all the LEDs on the reference PCB. However, it is more desirable to set the desired value for each LED in the PCB 1 to be calibrated to be the same as the measured value of wavelength and/or intensity for the corresponding LED on the reference PCB.

Either of the embodiments described may be simply adapted for use with arrays of LEDs on the PCBs extend in two directions (i.e. they form a dot matrix). To do this, the carriage 5 can be modified to be movable in each of the two directions so that it can be positioned over any one of the LEDs (or other types of light source) forming the dot matrix.
1. A method for calibrating an array of light sources, the method comprising:
   a) supplying a preset signal to a first light source in the array, the preset signal
      being associated with a desired value of the wavelength and/or intensity of light
      emitted by the first light source;
   b) monitoring the wavelength and/or intensity of the light emitted by the first light
      source;
   c) determining a compensation factor to be applied to the preset signal such that
      the monitored wavelength and/or intensity has the desired value;
   d) storing the compensation factor; and
   e) carrying out steps (a) to (d) for each other light source in the array.

2. A method according to claim 1, wherein each light source in the array is a light
   emitting diode (LED).

3. A method according to claim 2, wherein each light source is a tricolour LED.

4. A method according to claim 1, wherein each light source in the array is a triad
   of red, green and blue light sources.

5. A method according to claim 4, wherein each of the red, green and blue light
   sources in the triad is a discrete LED.

6. A method according to any of the preceding claims, wherein the wavelength
   and/or intensity of the light emitted by the first light source is monitored by visual
   inspection.

7. A method according to claim 6, wherein step (c) comprises adjusting the preset
   signal in accordance with user input until the monitored wavelength and/or intensity
   equals the desired value of wavelength and/or intensity, the compensation factor
   depending on the degree of adjustment required to the preset signal so that the
   monitored wavelength and/or intensity equals the desired value of wavelength
   and/or intensity.
8. A method according to claim 7, wherein the compensation factor is set to be the ratio between the adjusted preset signal and the preset signal.

9. A method according to any of claims 1 to 5, wherein the wavelength and/or intensity of the light emitted by the first light source is monitored by a photometer, which generates output signals indicating the monitored wavelength and/or intensity.

10. A method according to claim 9, wherein step (c) comprises receiving the output signals from the photometer, and adjusting the preset signal so that the output signals from the photometer indicate that the monitored wavelength and/or intensity equals the desired values of wavelength and/or intensity, the compensation factor depending on the degree of adjustment required to the preset signal so that the monitored wavelength and/or intensity equals the desired values of wavelength and/or intensity.

11. A method according to claim 10, wherein the preset signal is adjusted in accordance with user input.

12. A method according to claim 10, wherein the preset signal is adjusted by a controller in accordance with a predetermined algorithm.

13. A method according to any of claims 10 to 12, wherein the compensation factor is set to be the ratio between the adjusted preset signal and the preset signal.

14. A method according to any of the preceding claims, wherein in step (d) the compensation factor is stored along with the desired values of wavelength and/or intensity of light associated with the preset signal.

15. A method according to claim 14, wherein steps (a) to (d) are repeated with two or more different preset signals.

16. A method according to any of the preceding claims, wherein the compensation factor is stored in a memory device associated with the array.
17. A method according to any of the preceding claims, wherein the desired value is determined by monitoring the wavelength and/or intensity of light emitted by a corresponding light source on a reference array of light sources and setting the desired value to be equal to the monitored wavelength and/or intensity.

18. A method according to any of claims 1 to 17, wherein the desired value is determined by monitoring the wavelength and/or intensity of light emitted by all of the light sources on a reference array of light sources and setting the desired value to be equal to the average of the monitored wavelengths and/or intensities.

19. Use of the method according to any of claims 1 to 18 to calibrate an array of light sources for use in a display device in which the intensity of light emitted by each light source in the array is modulated as it rotates around an axis so that the light sources in combination cause a desired image to be visible to an observer by virtue of persistence of vision.

20. Use of the method according to any of claims 1 to 18 to calibrate an array of light sources for use in a display device comprising a plurality of arrays of static light sources.

21. Apparatus for calibrating an array of light sources, the apparatus comprising a monitoring device for monitoring the wavelength and/or intensity of the light emitted by the light sources in the array and a controller adapted to:
   a) supply a preset signal to a first light source in the array, the preset signal being associated with a desired value of the wavelength and/or intensity of light emitted by the first light source;
   b) determine a compensation factor to be applied to the preset signal such that the monitored wavelength and/or intensity of the light emitted by the first light source has the desired value;
   c) store the compensation factor; and
   d) carry out steps (a) to (c) for each other light source in the array.

22. Apparatus according to claim 21, wherein each light source in the array is a light emitting diode (LED).
23. Apparatus according to claim 22, wherein each light source is a tricolour LED.

24. Apparatus according to claim 21, wherein each light source in the array is a triad of red, green and blue light sources.

25. Apparatus according to claim 24, wherein each of the red, green and blue light sources in the triad is a discrete LED.

26. Apparatus according to any of claims 21 to 25, wherein the monitoring device comprises an optical viewer for visual inspection of the wavelength and/or intensity of the light emitted by the light sources in the array.

27. Apparatus according to claim 26, wherein the optical viewer comprises a frustoconical element having an aperture at each end, the aperture at the smaller end lying adjacent to the array of light sources.

28. Apparatus according to claim 27, wherein the inside surface of the frustoconical element is polished.

29. Apparatus according to claim 27 or claim 28, wherein the frustoconical element is made from a metal.

30. Apparatus according to any of claims 26 to 29, wherein the controller is further adapted to adjust the preset signal in accordance with user input until the monitored wavelength and/or intensity equals the desired value of wavelength and/or intensity, and to set the compensation factor depending on the degree of adjustment required to the preset signal so that the monitored wavelength and/or intensity equals the desired value of wavelength and/or intensity.

31. Apparatus according to claim 30, wherein the user input is generated by a joystick.

32. Apparatus according to claim 31, wherein the joystick is a three-axis joystick, each axis representing a degree of adjustment required to a respective one of the
red, green and blue components of the monitored wavelength and/or intensity so that it equals the desired value of wavelength and/or intensity.

33. Apparatus according to any of claims 30 to 32, wherein the controller is further adapted to set the compensation factor to be the ratio between the adjusted preset signal and the preset signal.

34. Apparatus according to any of claims 21 to 33, wherein the monitoring device comprises a photometer, which generates output signals indicating the monitored wavelength and/or intensity.

35. Apparatus according to claim 34, wherein the controller is further adapted to receive the output signals from the photometer, to adjust the preset signal so that the output signals from the photometer indicate that the monitored wavelength and/or intensity equals the desired values of wavelength and/or intensity, and to set the compensation factor depending on the degree of adjustment required to the preset signal so that the monitored wavelength and/or intensity equals the desired values of wavelength and/or intensity.

36. Apparatus according to claim 35, wherein the controller is further adapted to adjust the preset signal in accordance with user input.

37. Apparatus according to claim 36, wherein the user input is generated by a joystick.

38. Apparatus according to claim 37, wherein the joystick is a three-axis joystick, each axis representing a degree of adjustment required to a respective one of the red, green and blue components of the monitored wavelength and/or intensity so that it equals the desired value of wavelength and/or intensity.

39. Apparatus according to claim 35, wherein the controller is further adapted to adjust the preset signal in accordance with a predetermined algorithm.
40. Apparatus according to any of claims 34, 35 or 39, wherein the controller is further adapted to determine the desired value by causing the photometer to monitor the wavelength and/or intensity of light emitted by a corresponding light source on a reference array of light sources and receiving the generated output signals from the photometer, setting the desired value to be equal to the monitored wavelength and/or intensity based on the output signals from the photometer, and storing the desired value in a memory.

41. Apparatus according to any of claims 34, 35 or 39, wherein the controller is further adapted to determine the desired value by causing the photometer to monitor the wavelength and/or intensity of light emitted by each light source on a reference array of light sources and receiving the generated output signals from the photometer, setting the desired value to be equal to the average of the monitored wavelengths and/or intensities based on the output signals from the photometer, and storing the desired value in a memory.

42. Apparatus according to any of claims 35 to 41, wherein the controller is further adapted to set the compensation factor to be the ratio between the adjusted preset signal and the preset signal.

43. Apparatus according to any of claims 21 to 42, wherein the monitoring device is movable relative to the array so that each of the light sources in the array may be brought into alignment with the monitoring device.

44. Apparatus according to claim 43, further comprising a motor operable by the controller for moving the monitoring device relative to the array.

45. Apparatus according to any of claims 21 to 44, wherein the controller is further adapted to store the compensation factor along with the desired values of wavelength and/or intensity of light associated with the preset signal.

46. Apparatus according to claim 45, wherein the controller is further adapted to repeat steps (a) to (c) with two or more different preset signals.
47. Apparatus according to any of claims 21 to 46, wherein the array further comprises a memory device for storing the compensation factor for each light source.

48. Use of the apparatus according to any of claims 21 to 47 to calibrate an array of light sources for use in a display device in which the intensity of light emitted by each light source in the array is modulated as it rotates around an axis so that the light sources in combination cause a desired image to be visible to an observer by virtue of persistence of vision.

49. Use of the apparatus according to any of claims 21 to 47 to calibrate an array of light sources for use in a display device comprising a plurality of arrays of static light sources.

50. An array of light sources calibrated by the method of any of claims 1 to 20.

51. An array of light sources calibrated using the apparatus of any of claims 21 to 47.

52. A method substantially as hereinbefore described with reference to the accompanying drawings.

53. Apparatus substantially as hereinbefore described with reference to the accompanying drawings.
INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2008/0P1635

A. CLASSIFICATION OF SUBJECT MATTER
INV: H05B33/08

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)
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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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IA1 document defining the general state of the art which is not considered to be of particular relevance
IE2 earlier document but published on or after the international filing date
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IO4 document referring to an oral disclosure, use, exhibition or other means
IP5 document published prior to the international filing date but later than the priority date claimed

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Date of the actual completion of the international search
14 July 2008

Date of mailing of the international search report
29/07/2008

Name and mailing address of the ISA
European Patent Office, P B 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel (+31-70) 340-2040 Tx 31 651 epo nl Fax (+31-70) 340-3016

Authorized officer
Hunckler, Jose

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**C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT**

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**International application No**
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