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(54) Traffic signal light

(57) Traffic control signal comprising an array of light emitting diodes. Light emitted from one light emitting diode passes through a first optical filter (36) and is sensed by a light detector (18). An electro-optic feedback system uses the detected light to control the light emitting diodes.

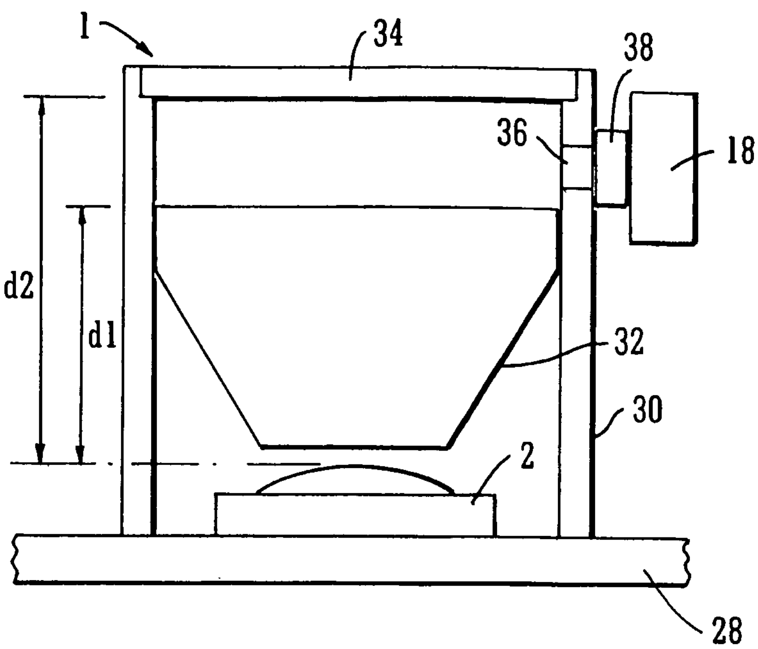

FIG. 4

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Description

[0001] The present invention relates to improvements in light emitting diode (LED) based traffic control signal lights.

[0002] Signal lights are commonly used to control rail, road and airborne traffic. It is important that different colour signal lights can be discriminated between by the vehicle operators who use the signal lights, and who may have variations in their eyesight in terms of colour perception. Also, variations in the angle and intensity of sunlight incident on the traffic control signal light, over a day and/or a year, can alter the perceived colour of the signal light. Accordingly, for different colour signal lights to be recognised safely, it is necessary to ensure that each signal light generates a narrow band of light, which band is centred on the dominant wavelength for the colour of signal. The dominant wavelength for any colour is that wavelength which an average person most easily perceives as being of that colour. If these tight specifications are not adhered to then different colour signal lights can be confused. Accordingly, high colour integrity for a traffic control signal light, that is the signal light consistently transmits light of the desired colour, is an important factor.

[0003] In addition, these traffic control signal lights must generate a high intensity, highly collimated light beam, the colour of which can be perceived as far away as 800m.

[0004] A known LED based traffic control signal light is disclosed in International patent application PCT/GB98/01242. This LED based traffic signal light comprises an array of around 100 to 200 low power LEDs which results in a relatively complicated electronic system for monitoring the LEDs and for generating feedback for regulating the output of the LEDs. To minimise this complication only a sample of the LEDs in the array are monitored, which means that irregularities in the performance of unmonitored LEDs may not be detected. A further disadvantage with the traffic signal light described in PCT/GB89/01242 is that the range of wavelengths generated by the array of LEDs is too high, to meet the tight specifications required for, in particular, railway traffic control signal lights.

[0005] W02006/067267 discloses an LED light for traffic control signalling comprising high power LEDs. The operation of the light is adjusted using an electro-optic feedback system in which light sensitive detectors adjacent the LEDs detect the intensity of the LEDs and the intensity signal is used to adjust the LED operation and to monitor for faults. In order to do this each LED has a transparent lens holder for supporting a lens in front of the LED and through which LED light can travel to an adjacent detector. In addition, an opaque cover is fitted in front of the detector, in order to prevent changes in ambient light conditions affecting the output of the detector. The use of the transparent lens holder causes some of the LED light to be lost, which could otherwise be directed through the lens to form part of the light emitted by the light. In addition, ambient light is able to travel through the lens and lens holder and so will have some effect on the output of the detectors.

[0006] The intensity of light and the wavelength of light emitted by an LED is dependent to some extent on its temperature. To address this problem W02006/067267 discloses the mounting of the LEDs on a circuit board made of aluminium or a ceramic material having high thermal conductivity or directly onto a cooling plate. This document does not address the colour integrity of the LED light described therein.

[0007] According to the present invention there is provided a traffic control signal light device comprising an array of high flux light emitting diodes (LEDs) and an electro-optic feedback system which comprises a light detector and a first narrow band optical filter positioned so that LED light incident on the detector first passes through the first optical filter. There may be more than one light detector and/or more than one first optical filter. By passing light in the electro-optic feedback path through a narrow band optical filter, the feedback system is able to maintain the colour of the light emitted by the LEDs to within a desired range of wavelengths. For example, where the wavelength band of light passed by the first optical filter contains the dominant wavelength for perception of that colour by a human eye the wavelength of light emitted by the LEDs can be maintained at or around the dominant wavelength. This makes it easier for a plurality of people, each of whom will have variations in their colour perceptions, to more easily recognise the colour of light emitted by the device according to the present invention.

[0008] An optical sub-assembly may be associated with each LED and may comprise a second narrow band optical filter for filtering the light emitted by each LED before it is emitted by the signal light device. The use of a second narrow band pass filter between each LED and an observer of the device controls the colour of light perceived by the observer. It is preferred that the first and second narrow band optical filters have corresponding band pass characteristics so that the feedback system maintains the LEDs emitting in a range of wavelengths matched to the second filter, so that a high intensity of light is emitted through the second filter towards an observer. One way to ensure this is to select first and second narrow band optical filters which have the same band pass characteristics. Embodiments of the present invention can be envisaged in which the first and second optical filters are integrated to form a single optical filter.

[0009] In order to reduce light losses in the device, it is preferred that the optical sub-assembly comprises a light proof housing with a first opening, which may be orthogonal to an optical axis of the sub-assembly, via which light is emitted into the electro-optic feedback system and a second opening, which may be centred on the optical axis of the sub-assembly, via which light is emitted from the device.

[0010] According to the present invention, a signal light device of a selected colour may be provided wherein the wavelength band of light passed by the second optical filter contains the dominant wavelength for perception of that colour by a human eye and the band of wavelengths emitted by the LEDs contains the wavelength band of light passed by the second optical filter. In this case, the wavelength band of light passed by the second optical filter may be substantially centred on the dominant wavelength.

[0011] Each LED preferably generates an intensity of light of at least 30 lumens. In order to generate a narrow beam of light from the traffic control signal light device the optical sub-assembly for each LED may additionally include a collimating arrangement, which may be located between the LED and the second optical filter.

[0012] Light emitted by an LED may be tapped from the associated optical sub-assembly to the electro-optic feedback system in a direction substantially orthogonal to an optical axis of the sub-assembly. This method of orthogonal tapping helps to prevent any ambient light which enters the optical sub-assembly from affecting the electro-optic feedback system. In particular, the light emitted by an LED may tapped from the associated optical sub-assembly to the electro-optic feedback system at a location between the LED and the second optical filter, for example, at a location between the collimating arrangement and the optical filter. Then any ambient light incident upon the device has to pass through the second optical filter, undergo a direction change of around 90° and then pass through the second filter. This substantially reduces the effect of incident light on the optical feedback system.

[0013] The optical filters may pass a range of wavelengths of less than 25nms and preferably less than 10nm.

[0014] The electro-optic feedback system may comprises a light detector, such as a photo sensor, associated with a string of LEDs for generating an intensity signal indicative of the intensity of light generated by the string of LEDs, and:

where the intensity signal falls below a predetermined threshold, increasing the level of average current supplied to the LED; and

where the intensity signal rises above a predetermined threshold, decreasing the level of average current supplied to the LED.

[0015] In order to temperature stabilise the LEDs, the array of LEDs may be thermally coupled to a heat sink, formed with cooling fins, and the signal light device may additionally include a fan for generating a flow of air over the cooling fins. For example, at least one heat sensor may be provided for measuring a representative LED temperature, and a controller may be provided for receiving a signal from the heat sensor indicative of the temperature, wherein when the signal is indicative of a temperature above a predetermined threshold, the controller energises the fan. The heat sensor may be a thermistor or may measure the forward voltage V_F of the or each LED to generate an output signal indicative of the temperature.

[0016] The signal light device may additionally comprise a lens cover formed with a plurality of Fresnel lenses, one located in front of each optical sub-assembly for transforming the collimated light from each optical sub-assembly into a beam of light spread over a narrow angle.

[0017] The invention will now be described by way of example only and with reference to the accompanying schematic drawings, wherein:

Figure 1 shows a longitudinal cross-section through a traffic control signal light device according to the present invention;

Figure 2 shows a longitudinal cross-section similar but at right angles to that of Figure 1,

Figure 3 shows a front view of an array of optical sub-assemblies of the device of Figures 1 and 2;

Figure 4 shows an LED and its associated optical sub-assembly, an array of which are used on the device of Figures 1 and 2; and

Figure 5 shows a schematic view of a monitoring and control circuit used for each string of LEDs in the array of Figure 3.

[0018] Figures 1 and 2 shows orthogonal longitudinal cross-sections of the traffic control signal light device of the present invention comprising an array of optical sub-assemblies shown from the front of the light in Figure 3. As shown in Figures 1 and 2, the device comprises a light proof housing (12), closed at its forward end by a transparent lens cover (22), which is shown removed in Figure 3. The housing contains an array of nineteen optical sub-assemblies (1) each including a high flux LED (2) (See Figure 4).

[0019] High flux LEDs are larger and more powerful than the standard 3 or 5mm LEDs used in the signal light described in PCT/GB98/01242. They are also referred to as high current or high brightness LEDs in the art. One high flux LED can typically generate an intensity of light equivalent to that generated by around 20 standard LEDs. Examples of suitable high flux LEDs are the Osram Platinum Dragon ®, Cree XLamp ® and Luxeon Hi Power. A high flux LED will typically have an output of 30 to 60 lumens depending on the colour of light it emits. However, this output is constantly improving as LED technology advances.

[0020] One problem with high flux LEDs is that they generate a lot of heat so that the thermal management of such LEDs can be difficult. The wavelength and intensity of light output by a high flux LED is dependent on its temperature and so it is important to ensure that the high flux LEDs in the array, are maintained within a desired temperature range. In order to overcome this problem, the LEDs are mounted on a printed circuit board (28) having an aluminium core (29) so that each LED is thermally coupled to an aluminium heatsink (24) shaped with cooling fins and cooled by a fan arrangement (26) including an impellor (27). Such an arrangement facilitates a rapid rate of cooling of the LEDs which is required in order to maintain the LEDs within the required temperature range. The fan arrangement (26) is housed in a rear housing (11), formed with air inlet channels through which air can be drawn into the impeller (27) and air outlet channels via which air output from the impellor can be expelled from the rear housing.

[0021] LED temperature is monitored using a thermistor (40) to detect a temperature of the aluminium core (29) of the printed circuit board (28) which is representative of the operating temperatures of the LEDs (2) in the array. Then a controller is used which receives the output signals from the thermistor, which output signals are indicative of the temperature the LEDs. If the detected temperature begins to rise above a predetermined threshold of 0°c the fan arrangement (26) is switched on. The impeller (27) then rotates to draw air into the housing (11) through the input air channels, which air then passes over the cooling fins of the heat sink (24) before it is drawn into the impellor. The air expelled from the impellor (27) then passes out of the housing (11) through the air outlet channels. When the detected temperature falls below a predetermined threshold of 0°,c the cooling fan is switched off. More than one thermistor may be used. As an alternative to one or more thermistors the forward voltage V_F of each LED can be monitored to generate an indication of the temperature of each LED.

[0022] Each LED (2) mounted on the printed circuit board (28) is covered with an associated optical subassembly (1), as shown in Figure 4. The sub-assembly comprises a tubular light proof housing (30) which is mounted with one end surrounding the LED (2). The housing (30) houses a collimating lens or prism (32) which is positioned at a distance d_1 in front of the LED (2). The collimating lens (32) collimates the beam of light emitted by the LED (2) with a spread of approximately 120° to a narrow angle beam and so losses of the light emitted by the LED (2) are minimised. In addition, the housing (2) houses an optical bandpass filter (34) which transmits the desired small range of wavelengths. The optical bandpass filter (34) is positioned at a distance d_2 in front of the LED (2) further away from the LED than the collimating lens or prism (32). The bandpass filter (34) may, for example be a coated glass optical bandpass filter.

[0023] For a particular colour of signal light the dominant wavelength is known, ie. the wavelength of light for that colour which is most easily perceived as that colour by a typical human eye. The high flux LEDs (2) are chosen to emit light in a wavelength band which is, as much as possible, centred on the dominant wavelength. Then the optical band pass filter (34) is chosen to transmit light only in a narrow range of wavelengths, centred on the dominant wavelength and falling within the band of wavelengths emitted by the selected LEDs. For example, for a yellow signal light the bandpass filter (34) passes a 5nm range of wavelengths between 589nm and 594nm.

[0024] The lens cover (22) for the housing (20) is a single transparent plate formed with an array of circular Fresnel lenses, such that there is one Fresnel lens directly in front of each LED (2) in the array. The Fresnel lens for each LED (2) in the array generates a beam with a 6° spread from the collimated light incident on it which is output from the associated optical sub-assembly. The Fresnel lens also produces some scatter and this, as well as some refraction allows drivers to see the traffic signal light at short range, typically when viewed at an angle of around 45°.

[0025] In the embodiment shown in the Figures, the LED array consists of three strings of five electrically connected LEDs (2) and one string of four electrically connected LEDs, although any number of strings of any length may be used. The control circuitry for string (3) of LEDs (2) in the array is shown in Figure 5. The optical output of each LED string (3) is sampled by a light detecting device, for example a photo-transistor (18). The resulting voltage developed across the load resistors (13) is amplified by amplifiers (15). The output of the amplifiers provides the reference input for a voltage regulator (16). Resistor (10) limits the short circuit current of the regulator (16) so that the maximum LED current is not exceeded. Thus, by virtue of the optical portion of the electro-optic feedback loop shown in a dotted line in Figure 5, the optical output is maintained at a constant level determined by the setting or resistor (13). The band pass optical filter (38) having a very sharp cut off is included within the optical portion of the feedback loop to ensure that colour integrity is maintained.

[0026] A light detector (18), for example, a light dependent resistor or photodiode is associated with each string of LEDs (2). Light is tapped from the optical subassembly (1) of each LED (2) via a hole (36) in the tubular housing (30), which hole is located between the collimating lens (32) and the optical filter (34). The light tapped from the optical sub-assembly (1) passes an optical filter (38), with the same bandpass to the optical filter (34) of the optical sub-assembly. Thus, the light entering the light detector (18) is in the same wavelength range as the light transmitted from the optical sub-assembly (1) and thus from the traffic signal light of Figures 1 and 2.

[0027] The arrangement for venting the light from the optical sub-assembly (1) to the light detector (18) has the advantage of reducing the effects of any ambient light entering the light detector. This is because any ambient light entering the housing (20) via the lens plate (22) would have to pass through band pass filter (34), go through a direction change of 90° and then pass through band pass filter (38) before entering the light detector (18).

[0028] An alternative method of generating light in a narrow band of wavelengths is to combine the light from a plurality, for example, three different colour high flux LEDs. For example, the light from a red, a green and a blue LED could be combined to generate white light. The drive voltage V_F of each of the LEDs can be adjusted to tune the wavelength range emitted by each LED in order to ensure the desired narrow band of wavelengths for the white light generated by combining the light from the three LEDs. In this embodiment it may be desirable to filter the light from each of the LEDs before it is combined and/or it may be desirable to filter the resultant light beam once the light from the three LEDs has been combined.

Claims

1. A traffic control signal light device comprising an array of high emitting diodes (LEDs) and an electro-optic feedback system comprising a light detector and a first narrow band optical filter positioned so that LED light incident on the detector first passes through the first optical filter.

2. A device according to claim 1 wherein an optical sub-assembly is associated with each LED and comprises a second narrow band optical filter for filtering the light emitted by each LED before it is emitted by the device.

3. A device according to claim 1 or claim 2 wherein the first and second narrow band optical filters have corresponding band pass characteristics.

4. A device according to claim 3 wherein the first and second narrow band optical filters have the same band pass characteristics.

5. A device according to any one of the preceding claims wherein each LED generates an intensity of light of at least 30 lumens.

6. A device according to any one of the preceding claims wherein the optical sub-assembly for each LED additionally includes a collimating arrangement between the LED and the second optical filter.

7. A device according to any one of the preceding claims wherein light emitted by an LED is tapped from the associated optical sub-assembly to the electro-optic feedback system in a direction substantially orthogonal to an optical axis of the sub-assembly.

8. A device according to any one of claim 2 or claims 3 to 7 when dependent on claim 2 wherein light emitted by an LED is tapped from the associated optical sub-assembly to the electro-optic feedback system at a location between the LED and the second optical filter.

9. A device according to claim 6 or claims 7 or 8 when dependent on claims 6 wherein light emitted by an LED is tapped from the associated optical sub-assembly to the electro-optic feedback system at a location between the collimating arrangement and the optical filter.

10. A device according to any one of the preceding claims, wherein the optical filter passes a range of wavelengths of less than 25nms.

11. A device according to any one of the preceding claims, wherein the electro-optic feedback system comprises a light detector associated with a string of LEDs for generating an intensity signal indicative of the intensity of light generated by the string of LEDs, and:

where the intensity signal falls below a predetermined threshold, increasing the level of average current supplied to the LED; and
where the intensity signal rises above a predetermined threshold, decreasing the level of average current supplied to the LED.

12. A device according to any one of the preceding claims, wherein the array of LEDs are thermally coupled to a heat sink, formed with cooling fins, and the device additionally includes a fan for generating a flow of air over the cooling fins.

13. A device according to claim 12 additionally comprising at least one heat sensor for measuring a representative LED temperature, and a controller for receiving a signal from the heat sensor indicative of the temperature, wherein when the signal is indicative of a temperature above a predetermined threshold, the controller energises the fan.

14. A device according to claim 13 wherein the heat sensor is a thermistor.

15. A device according to claim 13 wherein the heat sensor measures the forward voltage V_F of the or each LED to generate an output signal indicative of the temperature.

16. A device of a selected colour according to any one of the preceding claims wherein the wavelength band of light passed by the second optical filter contains the dominant wavelength for perception of that colour by a human eye and the band of wavelengths emitted by the LED contains the wavelength band of light passed by the second optical filter.

17. A device according to claim 16 wherein the wavelength band of light passed by the second optical filter is substantially centred on the dominant wavelength.

17. A device according to any one of the preceding claims additionally comprising a lens cover formed with a plurality of Fresnel lenses, one located in front of each optical sub-assembly for transforming the collimated light from each optical sub-assembly into a beam of light spread over a narrow angle.

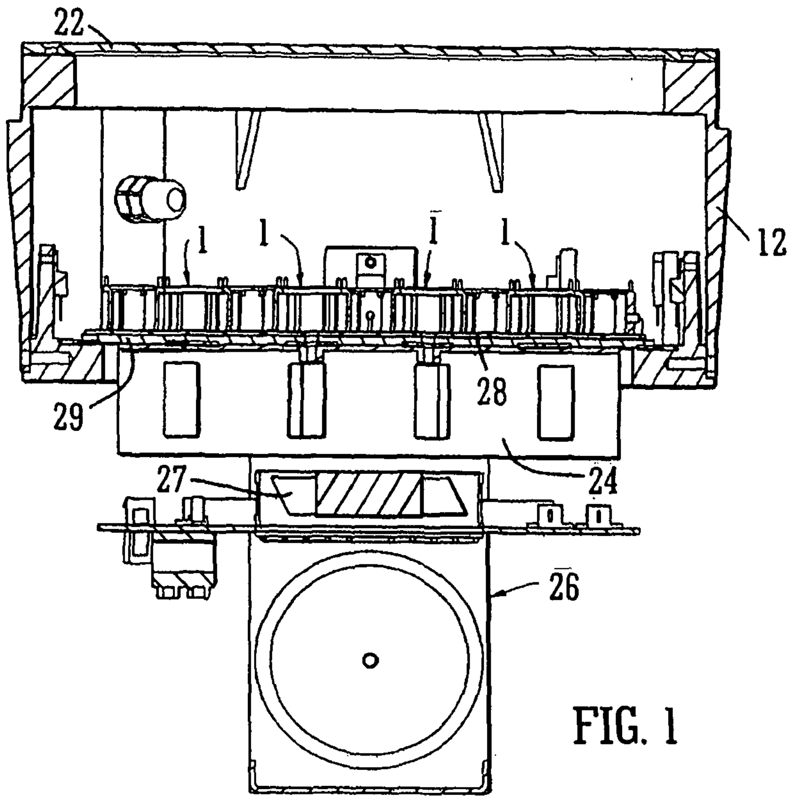

FIG. 1

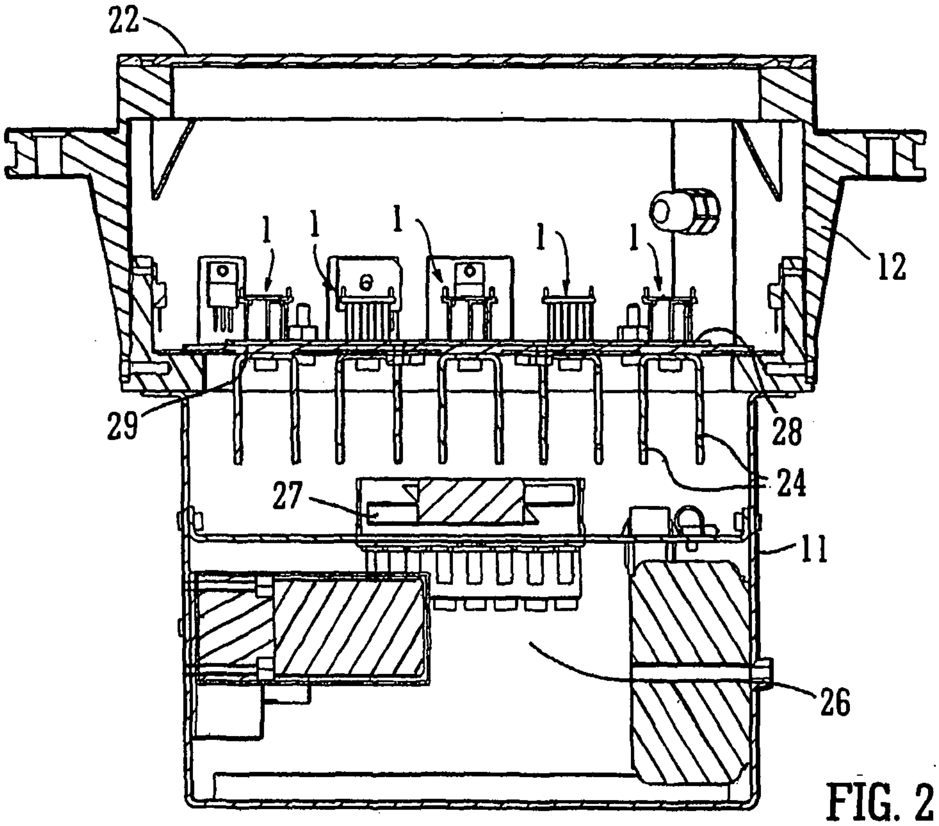

FIG. 2

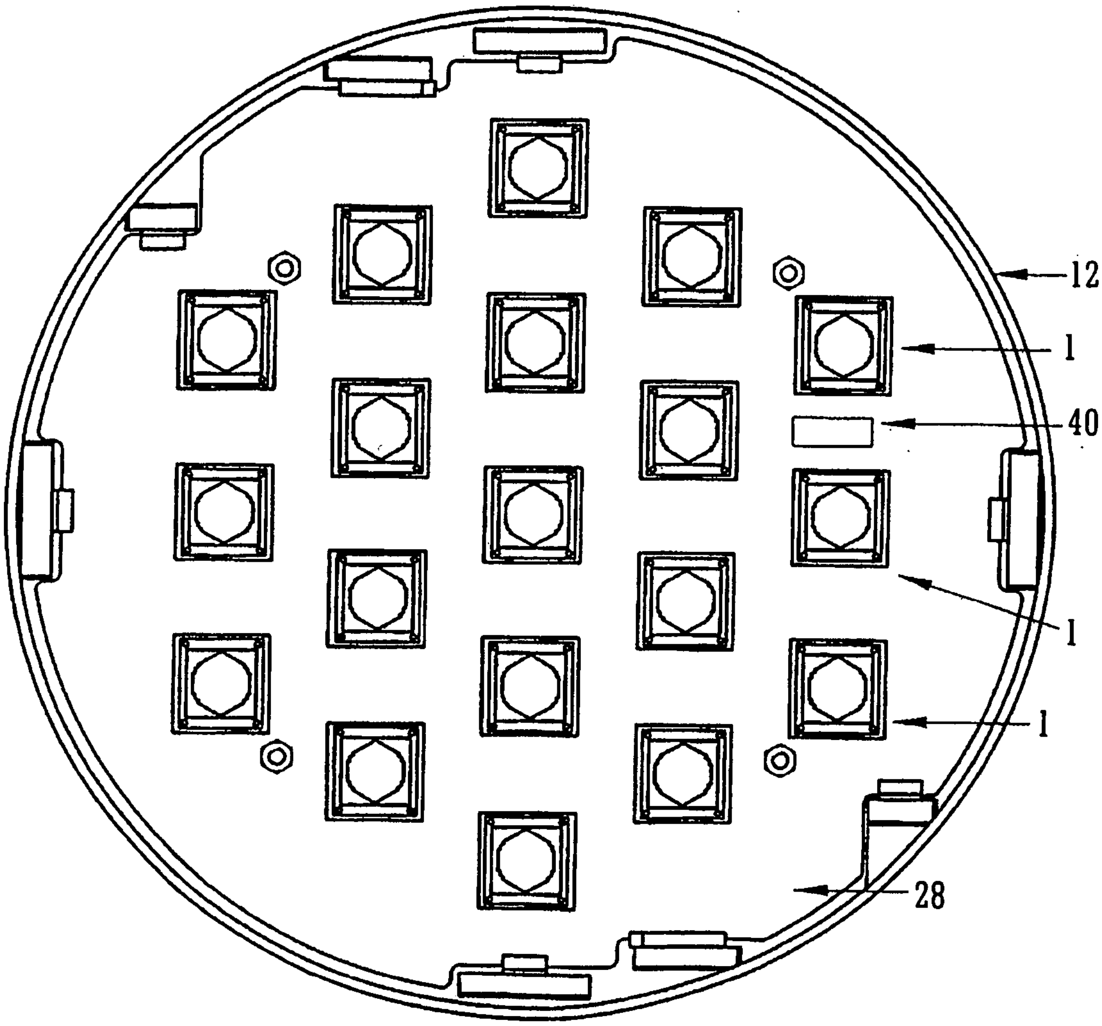

FIG. 3

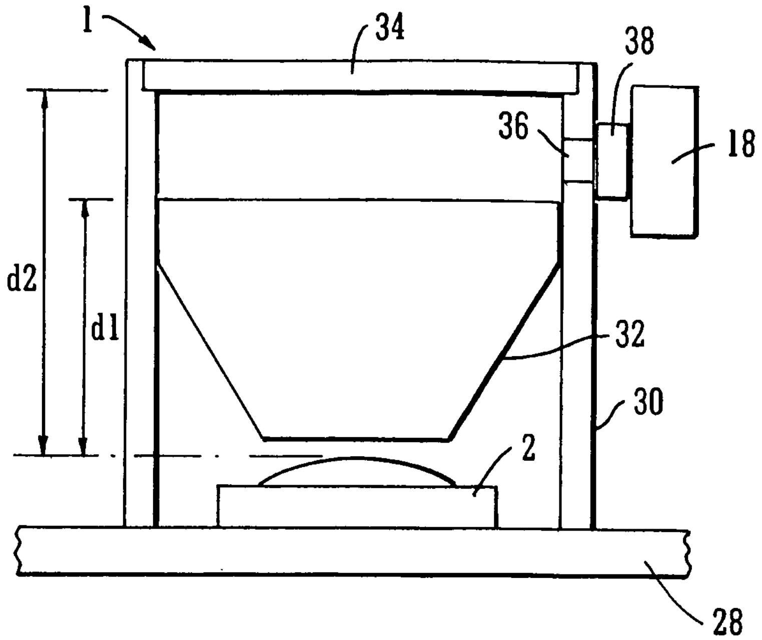

FIG. 4

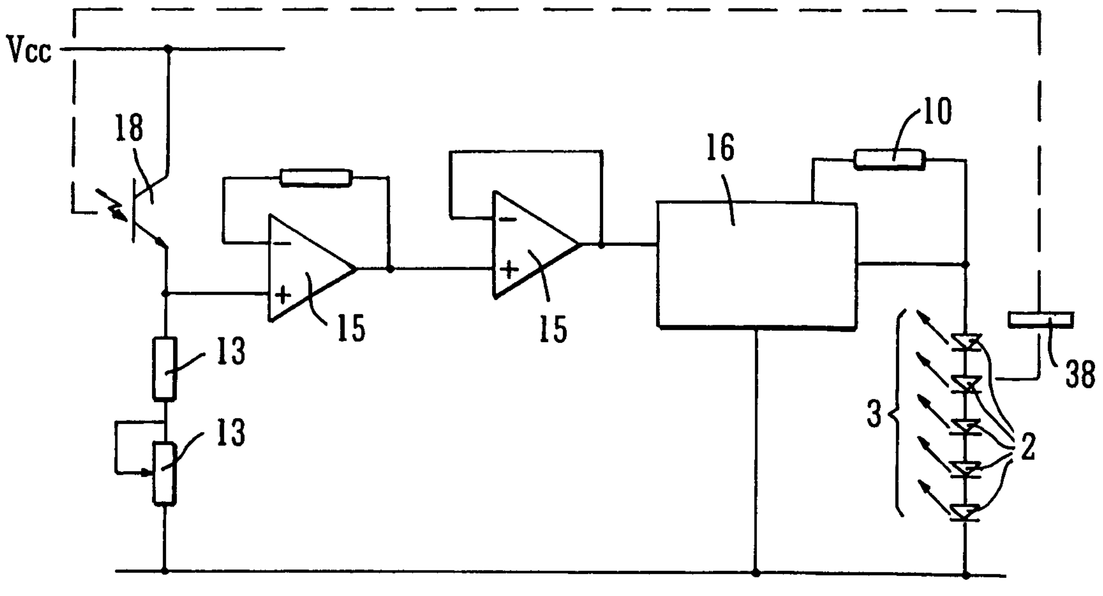

FIG. 5

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	10 July 2008	Maicas, Jesús

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