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(54) Title: LIGHTING CONTROL APPARATUS

(57) Abstract: A lighting control apparatus (10) has at least one luminous flux control (21, 22, 23) for setting a predetermined luminous flux of at least one coloured light channel. A modulator (30) cyclically modulates the predetermined luminous flux using at least one of a predetermined cyclic period, a predetermined waveform and a predetermined modulation amplitude. Colour saturation and illumination level control may also be provided. Preferably the apparatus controls both DMX-enabled lights and non-DMX-enabled lights.



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LIGHTING CONTROL APPARATUS

The present invention relates to a lighting control apparatus.

In known lighting control apparatus for producing varying colourwashes, for example, in architectural lighting, illumination is controlled by entering and storing different colour settings or scenes, comprising fixed luminous flux from red, green and blue, and neutral tone possibly yellow, light sources and cycling through the stored scenes. This requires the entering and storing of a large number of scenes, a laborious and time consuming process. Moreover, to maintain constant overall colour saturation or illumination these factors must be set for each scene created.

It is an object of the present invention to at least mitigate the aforesaid disadvantages in the prior art.

According to a first aspect of the present invention there is provided a lighting control apparatus comprising colour luminous flux setting means for setting a predetermined luminous flux of at least one coloured light channel and modulation means for cyclically modulating the predetermined luminous flux using at least one of a predetermined cyclic period, a predetermined waveform and a predetermined modulation amplitude.

Preferably, the at least one coloured light channel comprises at least one of a red light channel, a green light channel, a blue light channel and a neutral tone possibly yellow light channel.

Conveniently, the modulation means includes phasing means for phasing a cyclic period of a first coloured light channel with respect to a cyclic period of at least a second coloured light channel.

Advantageously, the lighting control system further comprises phasing adjusting means for at least one of reversing and freezing the phasing of the first coloured light channel with respect to the at least a second coloured light channel.

Conveniently, the modulation means comprises period setting means for setting the predetermined cyclic period.

Preferably, the modulation means comprises waveform selection means for selecting the predetermined waveform.

Advantageously, the waveform selection means is adapted for the selection of one of a plurality of waveforms preferably including a ramp, a sine and a peak waveform.

Preferably, the modulation means comprises modulation amplitude setting means for setting the predetermined modulation amplitude.

5 Conveniently, the lighting control apparatus further comprises dimming control correction means for converting a linear control signal to provide linear luminous flux control of a light source having a non-linear relationship between the linear control signal and luminous flux.

Advantageously, the lighting control apparatus further comprises fluorescent luminous
10 flux control means for controlling a minimum luminous flux of fluorescent light sources controlled by the apparatus.

Advantageously, the lighting control apparatus further comprises colour saturation control means for controlling a signal representative of luminous flux of at least one neutrally coloured light channel dependent upon a signal representative of luminous flux of the at least one
15 coloured light channel controlled by the apparatus; the colour saturation control means comprising processing means for determining a magnitude of a vector sum of signals representative of the luminous flux of the at least one coloured light channel and determining a value of a scalar signal representative of the neutral light channel to maintain the sum of the magnitude and the value of the scalar at a predetermined constant value, representative of a
20 predetermined desired colour saturation of a combination of light sources controlled by the apparatus.

Alternatively, the lighting control apparatus further comprises constant illumination level control means for maintaining a predetermined overall light output by varying a signal representative of a luminous flux of a neutrally coloured light channel dependant upon signals
25 representative of luminous flux of the at least one coloured light channel, the constant illumination level means comprising processing means for determining a value of the signal representative of the luminous flux of the neutrally coloured light channel such that a scalar sum of the signals representative of luminous flux of the at least one coloured light channel and of the scalar signal representative of the luminous flux of the neutrally coloured light remains a
30 constant as the signals representative of the luminous flux of the at least one coloured light channel vary.

Conveniently, the lighting control apparatus further comprises a Digital Multiplex (DMX) interface for controlling DMX-enabled light sources and a Manchester encoded digital interface for controlling non-DMX-enabled light sources.

According to a second aspect of the invention, there is provided a lighting control
5 apparatus comprising colour saturation control means for controlling a signal representative of
luminous flux of at least one neutrally coloured light channel dependent upon a signal
representative of luminous flux of at least one coloured light channel controlled by the apparatus;
the colour saturation control means comprising processing means for determining a magnitude of
a vector sum of signals representative of the luminous flux of the at least one coloured light
10 channel and determining a value of a scalar signal representative of the neutral light channel to
maintain the sum of the magnitude and the value of the scalar at a predetermined constant value,
representative of a predetermined desired colour saturation of a combination of light sources
controlled by the apparatus.

Preferably the lighting control apparatus of the second aspect of the invention further
15 comprises colour saturation selection means for setting the predetermined desired colour
saturation.

According to a third aspect of the invention, there is provided a lighting control apparatus
comprising constant illumination level control means for maintaining a predetermined
illumination level by varying a signal representative of a luminous flux of a neutrally coloured
20 light channel dependant upon signals representative of luminous flux of at least one coloured
light channel, the constant illumination level means comprising processing means for
determining a value of the signal representative of the luminous flux of the neutrally coloured
light channel such that a scalar sum of the signals representative of luminous flux of the at least
one coloured light channel and of the scalar signal representative of the luminous flux of the
25 neutrally coloured light remains a constant as the signals representative of the luminous flux of
the at least one coloured light channel vary.

Preferably the lighting control apparatus of the third aspect of the invention further
comprises illumination level selection means for setting the predetermined illumination level.

According to a fourth aspect of the invention, there is provided a lighting control
30 apparatus comprising a Digital Multiplex (DMX) interface for controlling DMX-enabled light

sources and a Manchester encoded digital interface for controlling non-DMX-enabled light sources.

Conveniently, the Manchester encoded digital interface is adapted for controlling fluorescent light sources.

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

Figure 1 shows a simplified schematic drawing of a lighting control apparatus according to the present invention;

Figure 2 shows a block diagram of the lighting control apparatus of figure 1;

10 Figure 3 shows a schematic drawing of the multiphase oscillator of Figures 1 and 2; and

Figure 4 is a colour space diagram helpful in understanding the invention.

In the figures, like reference numerals represent like parts.

Referring to Figures 1 and 2, a lighting control apparatus 10 has, for example, slider controls 21, 22, 23 for setting base values of luminous flux for red, green and blue light source channels respectively. Respective outputs from the slider controls are each connected to a
15 multiphase oscillator 30 such that the multiphase oscillator may modulate the base values set by the sliding controls. This is illustrated in Figure 1 as the output from the slider controls 21, 22, 23 being summed, by summing modules 41, 42, 43, with red, green and blue outputs 31, 32, 33 respectively from the multiphase oscillator 30, to give modulated outputs on lines 411, 421, 431
20 respectively. A modulation amplitude input 34 is provided to the multiphase oscillator 30 for selecting the depth or amplitude of the modulation generated by the multiphase oscillator 30. A period setting input 35 is provided for setting the length of a period through which the multiphase oscillator 30 cycles. As shown in the more detailed Figure 2, further inputs are provided: a waveform selector 36 to select a shape of waveform of the modulation; a colourwash
25 selector 37, possibly with associated signal lamps, to select one of a plurality of types of colourwash to be described below, generated by the multiphase oscillator, and a cycle direction selector 38 for selecting freezing of the colourwash cycles, or a direction in which the colourwash cycles through the colours, which may have associated indicator lamps to indicate a selected status.

Modulated three-phase output on lines 411, 421, 431 from the multiphase oscillator 30, one phase corresponding to each of the red, green and blue light channels respectively, is input to a pastel control module 50. The pastel control module 50 also has as an input a pastel, or colour saturation, level selector 51.

5 An output from the pastel, or colour saturation, control module 50 is input as a neutral light channel together with the red, green and blue outputs from the multiphase oscillator 30 to a blackout module to allow blacking out one or more of the light channels controlled by a blackout selector input 61, which may have an associated signal lamp such as a light emitting diode (LED) to indicate when blackout is operational. Output from the blackout module 60 is fed, preferably
10 using a four-wire buss, directly to linear controlled light sources and in parallel to the inputs of a linear power conversion module 71 to apply a dimmer curve for, for example, incandescent and halogen lamps, to a cold cathode conversion module 72 to apply a dimmer curve for cold cathode neon lamps and to a fluorescent conversion module 73 to apply a dimmer curve for fluorescent lamps. The output to fluorescent lamps may be through a digital interface using
15 Manchester encoding and the output to other lamps may use a known Digital Multiplexer (DMX) protocol for lamp dimming control.

That is, the apparatus may have two separate digital outputs, a first using a known RJ12 connection system to drive digital fluorescent display units and a second to provide DMX output simultaneously to drive DMX-controlled lighting systems such as incandescent lamps, light-
20 emitting diodes or cold cathode lighting. Thus DMX-controlled dimming packs can be used to control incandescent loads fitted with RGBY dichroic or other filters and similar dimmers may be used to drive suitable neon transformers for the control of RGBY neon/argon lighting. Alternatively, or in addition, an analogue voltage protocol, in combination with a digital/analogue converter, may be used. Suitable fluorescent light sources may have fluorescent
25 tubes sleeved in red, green, blue and neutral, possibly yellow filters to provide RGB mixing with variable warmth using the yellow source. Data connection to the fluorescent unit may be by a known daisy-chained RJ12 plug and socket system.

The fluorescent conversion module 73 is also provided with a minimum fluorescent level selector 731 for use in a manner to be described.

30 In use, base levels of red, green and blue light channel levels are selected using the respective colour selectors 21, 22, 23 to produce a required basic hue to be modulated. The pastel control selector 51 is set to produce a required colour saturation to generate desired warmth of

colour. The depth or amplitude control 34 is set to determine a required percentage or depth of modulation to be imposed on the base levels of red, green and blue by the multiphase oscillator 30. The depth of change can be set in the range 0% - 100%, to give either subtle changes of hue or dramatic colour changes. The waveform selector is set to determine a shape of modulation wave, e.g. sine, ramp or peak wave, to be imposed by the multiphase oscillator 30 on the base values of the red, green and blue values selected. The waveform selector may be designed to act individually on each of the light channels, so that different waveforms may be selected for each light channel, or may be designed simply to select the same waveform for all channels, which is normally sufficient. The period of the selected waveform, for example between 10 seconds and 24 hours per complete cycle, is selected using the period setting selector 35. A desired colourwash type, that is the relative phasing of the RGB or, using an additional yellow light channel, RGBY waveforms, for example an RGB colour cycle, in which a three-phase waveform is fed to the three colour outputs, or a RGBY colour chase cycle, using a four-phase waveform sequence, is selected using the colourwash type selector 37 and the order of the cycle selected using the cycle direction selector 38.

In principle, the depth or amplitude of modulation and the period of the cycle of the waveform can be selected differently for each light channel, but in practice it is found sufficient to select the same depth and period for each light channel. Setting the period the same for each light channel results in a repeatable colour cycle, this is usually considered desirable. In practice, the absolute depth of modulation is likely to be different for each colour channel as the modulated signal is a product of the percentage depth of modulation and the base level set for that colour.

The operation of the multiphase oscillator 30 is best understood by reference to Figure 3. The multiphase oscillator 30 includes a clock generator 301 for generating a clock signal, the period of which may be varied by the period setting selector 35. The clock signal output from the clock generator 301 is input to a counter 302, which is controlled by input from the cycle direction selector 38 to select whether the counter cycles forwards or in reverse or cycling is frozen. Multiple outputs from the counter are input to waveform lookup tables 303 for generating waveforms through which the light channels are to be cycled with the period set by the period selector 35. The type of waveform selected from the waveform lookup tables is determined by a setting of the waveform selector 36 which has three line bus input to the waveform lookup tables corresponding to the three light channels, indicating the type of waveform selected and relative phases of the three light channels.

The three phases of a three-phase output from the waveform lookup tables 303 are output on separate lines corresponding to the three separate light channels to respective modulation depth multipliers or amplitude modulators 341, 342, 343, controlled in parallel by the depth or amplitude control 34 to set the amplitude of the selected waveform to be used to modulate the base levels of the light channels set by the respective colour selectors 21, 22, 23, as described above.

In order to modulate the base level signals from the respective colour selectors 21, 22, 23, respective outputs from the depth multipliers or amplitude modulators 341, 342, 343 are input to respective base colour multipliers or amplitude modulators 211, 221, 231 which also receive respective inputs from the base colour selectors 21, 22, 23. Respective outputs from the colour multipliers or amplitude modulators 211, 221, 231 are then summed by the respective summing modules 41, 42, 43 with the base colour signals from the base colour selectors 21, 22, 23 to form respective modulated phased colour channels on respective output lines 411, 421, 431, as described above.

In order better to understand the operation of the lighting control apparatus automatically to control colour saturation or overall illumination, reference may be made to Figure 4, which is a representation of colour space, in which directions of vectors represent colour or hue and the length of vectors represent colour saturation, i.e. the proportion of colour to white light. The length of the vectors is weighted according to the relative strengths of the RGB sources and by a factor to account for varying sensitivity of the human eye to different colours. The figure shows vector addition of a red light component R, a green component G and a blue component B, with a light green resultant.

Modulated signals on lines 411, 421, 431 for the red, green and blue output from the multiphase oscillator 30 are input to the pastel, or colour saturation, control module 50 and a value of the neutral colour channel is selected such that a sum of the magnitude of a vector sum of the red, green and blue levels and the scalar neutral level remains constant, as determined by the value selected by the pastel or colour saturation level selector 51. It will be understood that such a pastel control may be used with any known RGB colour mixing system automatically to vary the intensity of a fourth neutrally coloured light source (preferably white or yellow) to provide a range of precisely controlled pastel shades, that is, colour saturations.

Alternatively, as shown in broken lines in Figure 2, an illumination control module 80, controlled by an illumination setting input 81, may be provided to maintain an overall constant

illumination level from the light sources controlled by the apparatus as the colourwash passes through a cycle. In this case, a value of the neutral colour channel is varied such that a scalar sum of the red, green, blue and neutral level remains constant, at a value selected by the illumination setting input 81. It will again be understood that such a constant illumination level control may be used with any known RGB colour mixing system automatically to vary the intensity of a neutrally coloured light source (preferably white or yellow) to provide a range of precisely controlled illumination level. A master illumination level control may be provided (not shown) to scale all outputs in the range 0-100% of the value entering a four-wire buss to the blackout module 60.

Thus the multiphase oscillator is used to perturb the base RGB levels to produce a controlled trajectory through the colour space shown in Figure 4. Software in the pastel control module or the illumination control module respectively then uses a fourth neutral light source to provide automated control of either the colour saturation or illumination, so that one of these characteristics is controlled during colour cycling.

In the embodiment of the invention illustrated in Figure 2, the resultant instantaneous level of the neutral light channel is input with the red, green and blue modulated outputs from the multiphase oscillator to the blackout module 60 which may be used to extinguish all the light outputs by reducing the control outputs to zero, if desired.

Output from the blackout module 60 is fed directly to DMX-enabled lamps for varying the luminous flux from blue, green, red and neutral coloured lamps. The output is also fed in parallel to the inputs of a linear power conversion module 71 to apply a dimmer curve for linear power conversion, to a cold cathode conversion module 72 to apply a dimmer curve for cold cathode lamps and to a fluorescent conversion module 73 to apply a dimmer curve for fluorescent lamps. The output to fluorescent lamps may be through a digital interface using Manchester encoding and the output to other lamps may use a known Digital Multiplexer (DMX) protocol for lamp dimming control. In this manner DMX-enabled lamps and non-DMX enabled lamps may be simultaneously controlled by the same controller.

Controllers for fluorescent light fittings conventionally have a 'cut-off' light level below which the fluorescent tube is extinguished to extend tube life. While this feature may be included with the present invention, in order to prevent fluorescent lamps controlled by the lighting control apparatus from switching off at low luminous intensity, a minimum luminous flux may be set for the fluorescent lamps by the minimum fluorescent level selector 731 connected to the

fluorescent conversion module 73. Although a slightly reduced chromacity range results from this adaptation, near low-light level operation is much smoother as the tubes are not switched off and on in normal operation during a cycle of the colourwash.

5 The invention therefore provides a digital colourwash lighting system for the synchronised colourwashing of fluorescent, cold cathode neon and other dimmable light sources. This synchronised control is achieved by direct digital control of fluorescent light sources and the use of DMX protocol to control of other DMX-enabled dimmable light sources.

CLAIMS

1. A lighting control apparatus (10) comprising colour luminous flux setting means (21, 22, 23) for setting a predetermined luminous flux of at least one coloured light channel and modulation means (30) for cyclically modulating the predetermined luminous flux using at least one of a predetermined cyclic period, a predetermined waveform and a predetermined modulation amplitude.
2. A lighting control system as claimed in claim 1, wherein the at least one coloured light channel comprises at least one of a red light channel, a green light channel, a blue light channel and a neutral tone light channel.
3. A lighting control system as claimed in claim 2, wherein the neutral tone light channel is a yellow light channel.
4. A lighting control system as claimed in any of claims 1 to 3, wherein the modulation means includes phasing means for phasing a cyclic period of a first coloured light channel with respect to a cyclic period of at least a second coloured light channel.
5. A lighting control system as claimed in claim 4, comprising phasing adjusting means (38) for at least one of reversing and freezing the phasing of the first coloured light channel with respect to the at least a second coloured light channel.
6. A lighting control apparatus as claimed in any of the preceding claims, wherein the modulation means comprises period setting means (35) for setting the predetermined cyclic period.
7. A lighting control apparatus as claimed in any of the preceding claims, wherein the modulation means comprises waveform selection means (36) for selecting the predetermined waveform.
8. A lighting control apparatus as claimed in claim 7, wherein the waveform selection means is adapted for the selection of one of a plurality of waveforms preferably including a ramp, a sine and a peak waveform.

9. A lighting control apparatus as claimed in any of the preceding claims, wherein the modulation means (30) comprises modulation amplitude setting means for setting the predetermined modulation amplitude.
10. A lighting control apparatus as claimed in any of the preceding claims, comprising dimming control correction means (71, 72, 73) for converting a linear control signal to provide linear luminous flux control of a light source having a non-linear relationship between the linear control signal and luminous flux.
11. A lighting control apparatus as claimed in any of the preceding claims, further comprising fluorescent luminous flux control means (731) for controlling a minimum luminous flux of fluorescent light sources controlled by the apparatus.
12. A lighting control apparatus as claimed in any of the preceding claims, further comprising colour saturation control means for controlling a signal representative of luminous flux of at least one neutrally coloured light channel dependent upon a signal representative of luminous flux of at least one coloured light channel controlled by the apparatus; the colour saturation control means comprising processing means for determining a magnitude of a vector sum of signals representative of the luminous flux of the at least one coloured light channel and determining a value of a scalar signal representative of the neutral light channel to maintain the sum of the magnitude and the value of the scalar at a predetermined constant value, representative of a predetermined desired colour saturation of a combination of light sources controlled by the apparatus.
13. A lighting control apparatus as claimed in any of claims 1 to 11, further comprising constant illumination level control means (50) for maintaining a predetermined overall light output by varying a signal representative of a luminous flux of a neutrally coloured light channel dependant upon signals representative of luminous flux of at least one coloured light channel, the constant illumination level means comprising processing means for determining a value of the signal representative of the luminous flux of the neutrally coloured light channel such that a scalar sum of the signals

representative of luminous flux of the at least one coloured light channel and of the scalar signal representative of the luminous flux of the neutrally coloured light remains a constant as the signals representative of the luminous flux of the at least one coloured light channel vary.

14. A lighting control apparatus as claimed in any of the preceding claims further comprising comprising a Digital Multiplex (DMX) interface for controlling DMX-enabled light sources and a Manchester encoded digital interface for controlling non-DMX-enabled light sources.
15. A lighting control apparatus comprising colour saturation control means for controlling a signal representative of luminous flux of at least one neutrally coloured light channel dependent upon a signal representative of luminous flux of at least one coloured light channel controlled by the apparatus; the colour saturation control means comprising processing means for determining a magnitude of a vector sum of signals representative of the luminous flux of the at least one coloured light channel and determining a value of a scalar signal representative of the neutral light channel to maintain the sum of the magnitude and the value of the scalar at a predetermined constant value, representative of a predetermined desired colour saturation of a combination of light sources controlled by the apparatus.
16. A lighting control apparatus as claimed in claim 15, further comprising colour saturation selection means for setting the predetermined desired colour saturation.
17. A lighting control apparatus comprising constant illumination level control means for maintaining a predetermined illumination level by varying a signal representative of a luminous flux of a neutrally coloured light channel dependant upon signals representative of luminous flux of at least one coloured light channel, the constant illumination level means comprising processing means for determining a value of the signal representative of the luminous flux of the neutrally coloured light channel such that a scalar sum of the signals representative of luminous flux of the at least one coloured light channel and of the scalar signal representative of

the luminous flux of the neutrally coloured light remains a constant as the signals representative of the luminous flux of the at least one coloured light channel vary.

18. A lighting control apparatus as claimed in claim 17, further comprising illumination level selection means for setting the predetermined illumination level.
19. A lighting control apparatus comprising a Digital Multiplex (DMX) interface for controlling DMX-enabled light sources and a Manchester encoded digital interface for controlling non-DMX-enabled light sources.
20. A lighting control apparatus as claimed in claim 19, wherein the Manchester encoded digital interface is adapted for controlling fluorescent light sources.

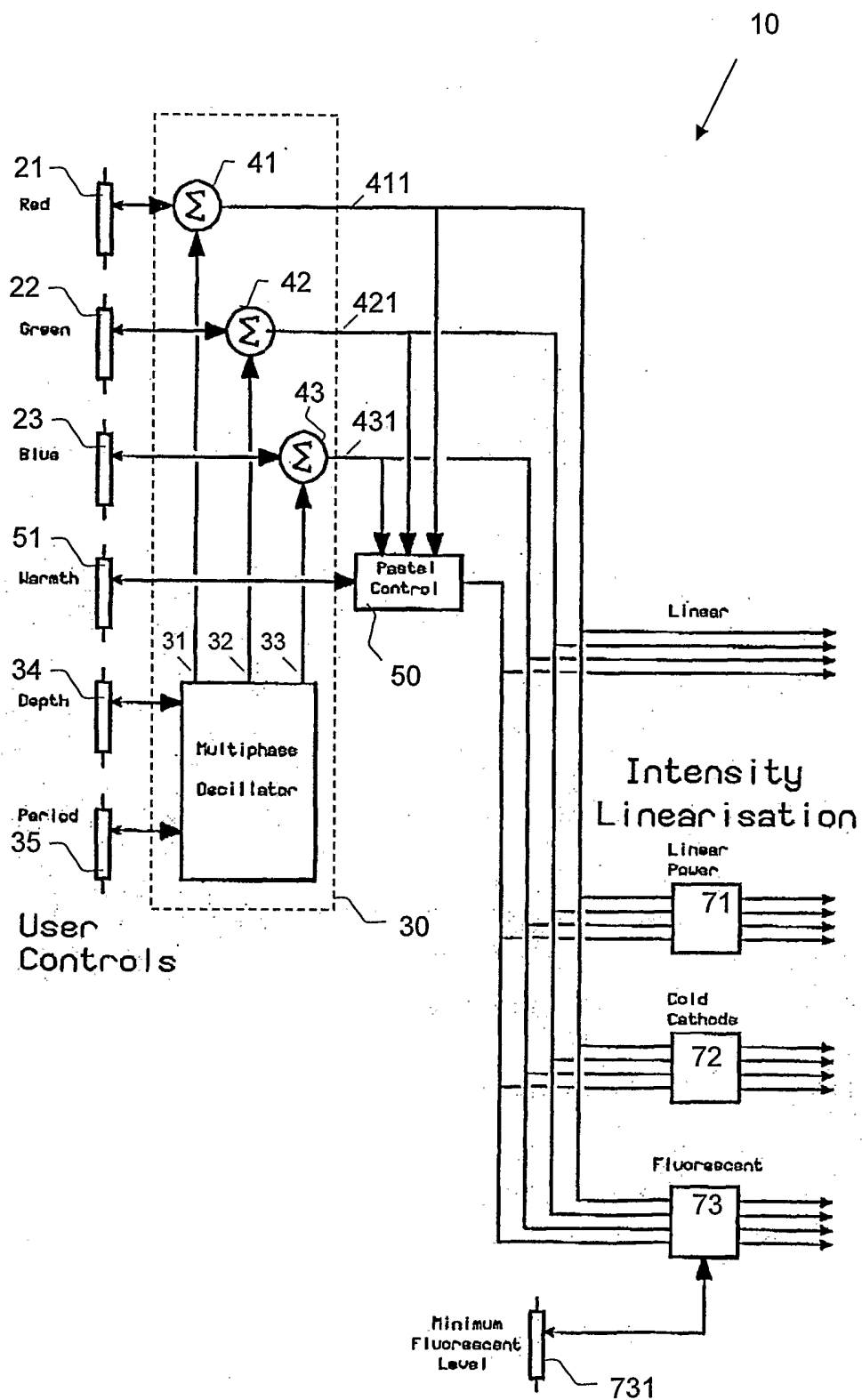


Figure 1

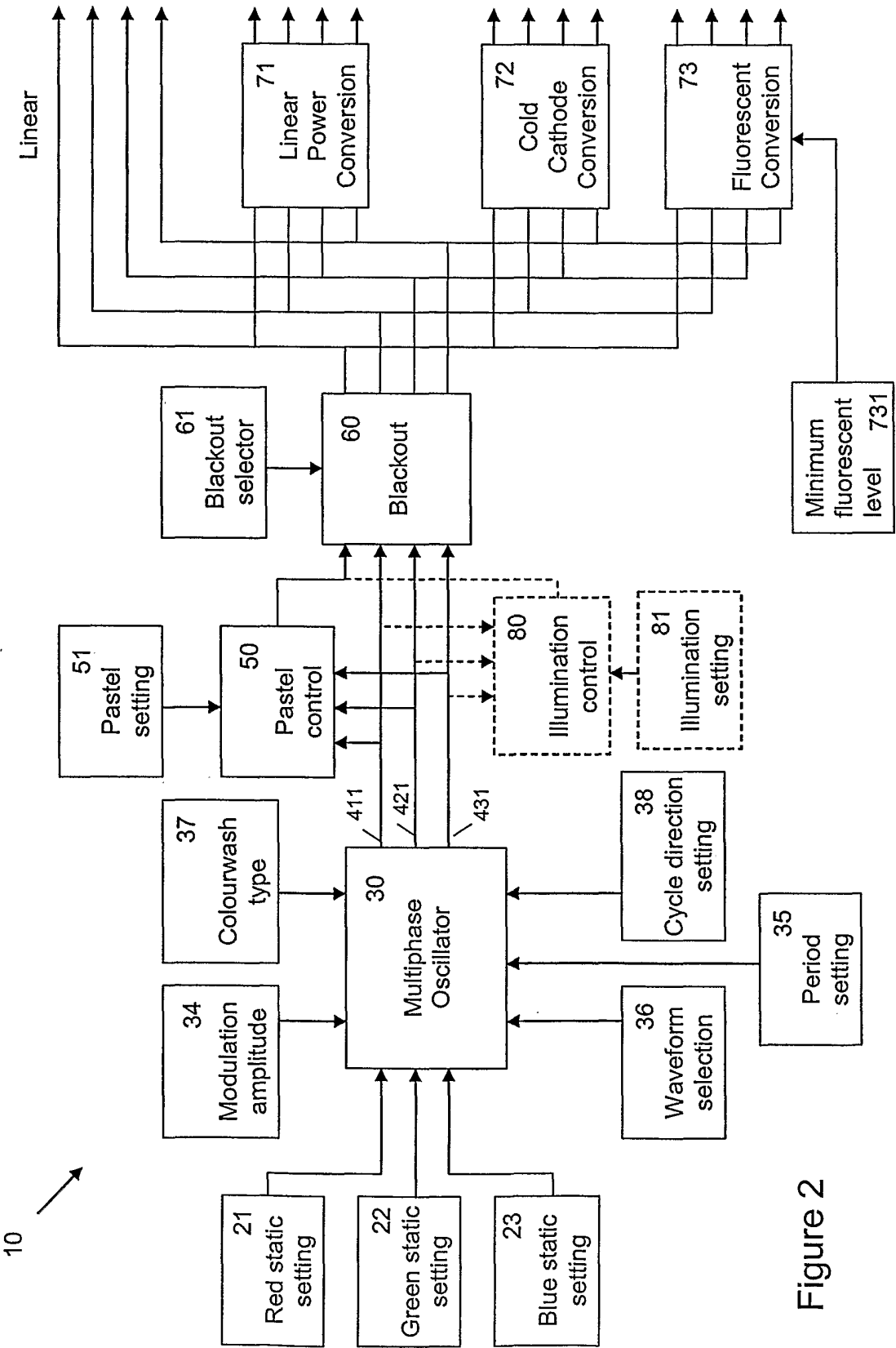


Figure 2

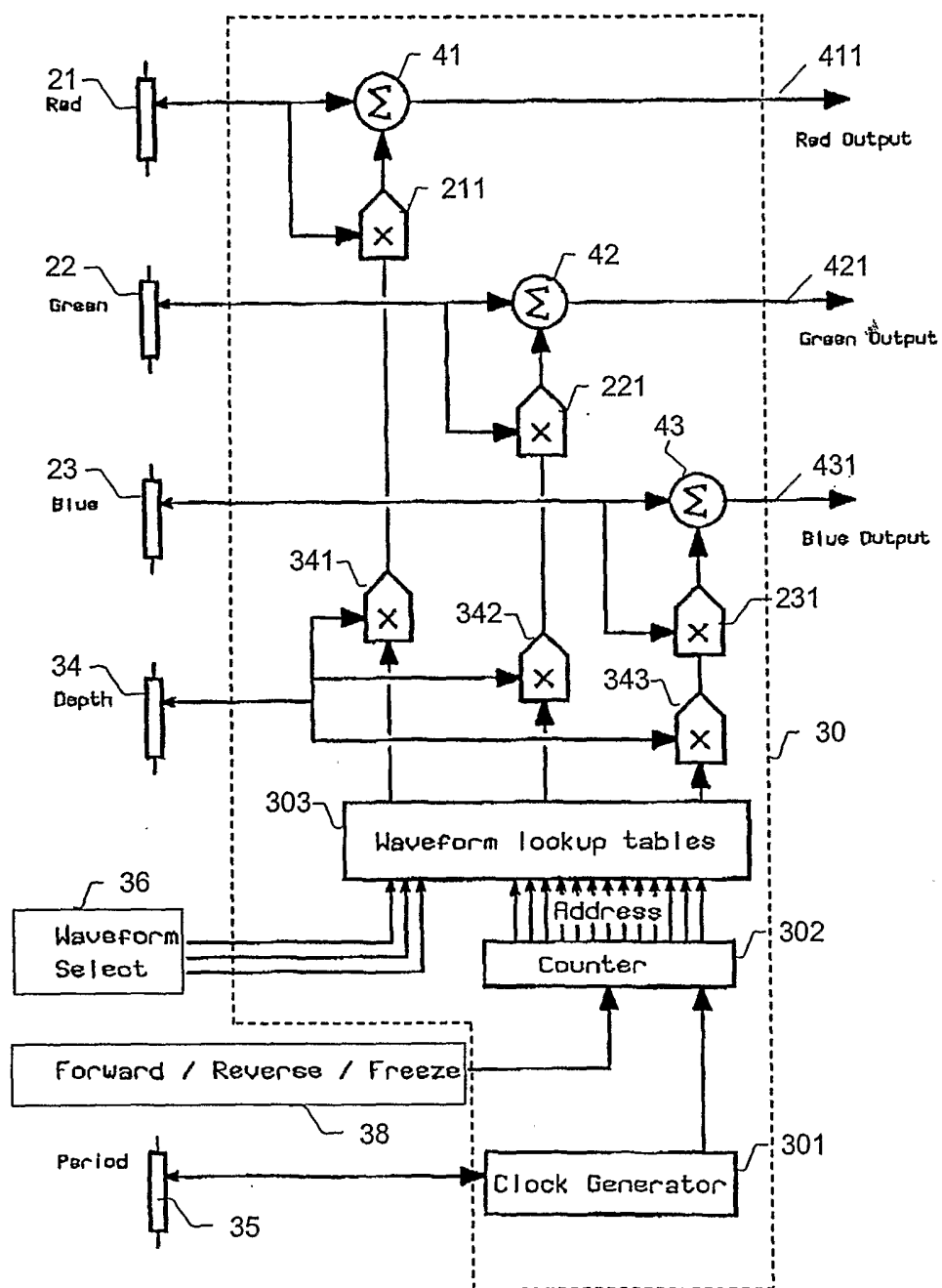


Figure 3

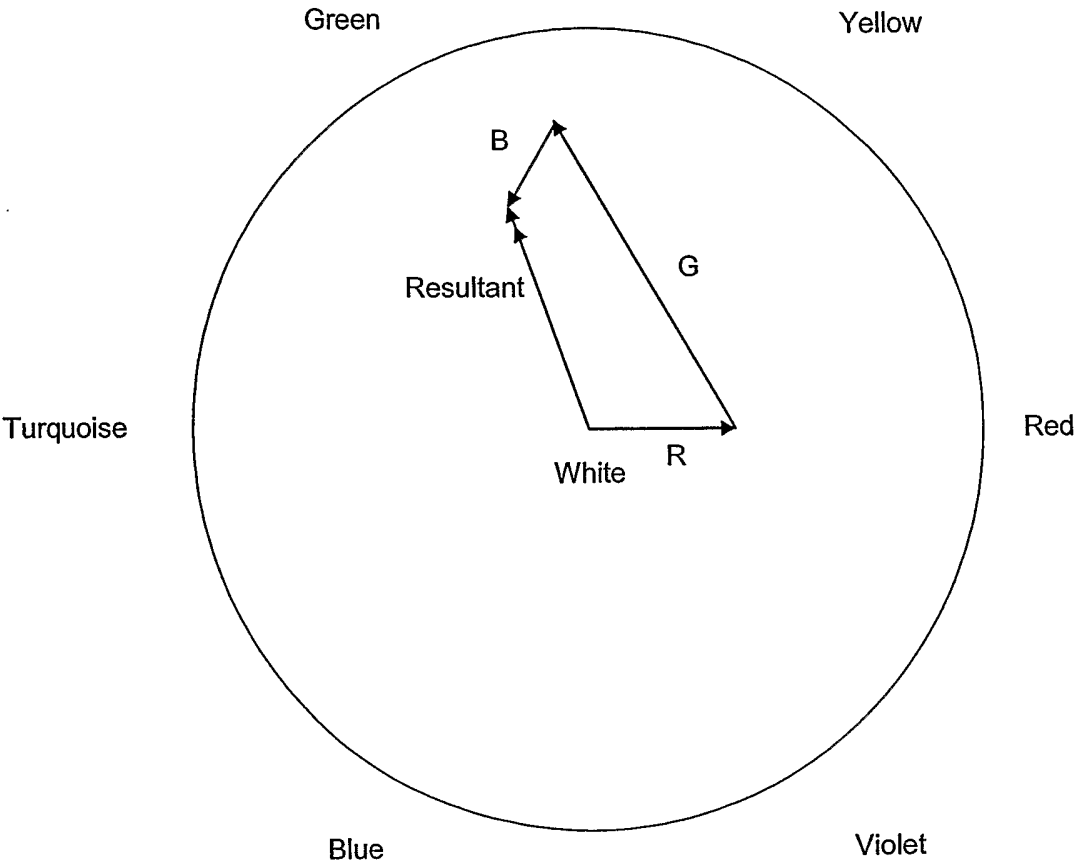


Figure 4