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COLOR DISPLAY APPARATUS

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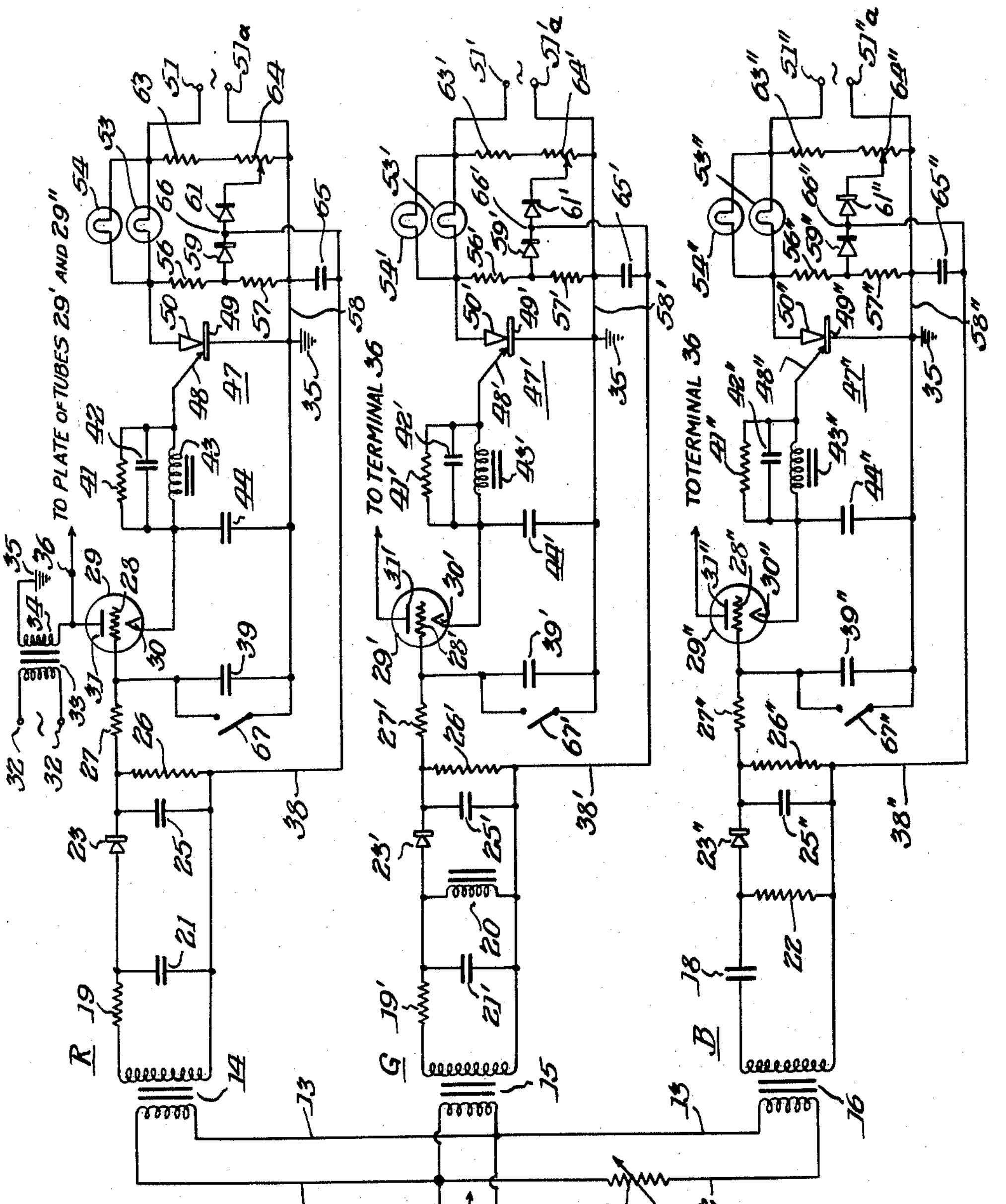

Inventor:
Clifford A. Shank
By Merriam, Smith & Marshall
Attys.

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COLOR DISPLAY APPARATUS

Clifford A. Shank, Santa Monica, Calif., assignor to Shafford Electronics & Development Corporation, Santa Monica, Calif., a corporation of California
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This invention relates to apparatus adapted to produce visible color indications which tend to simulate audible effects and provide rhythmic color representations of the intelligence contained in musical compositions. The apparatus is particularly adapted for use in conjunction with sound reproducing equipment whereby the same modulation which controls the production of audible effects is also adapted to control concomitant visual effects which to the optic nerves of the looker react similarly to the sound effects upon the auditory nerves.

It has been known in the art for some time that light effects may be varied under the control of audible signals. Various attempts to achieve pleasing effects with a precise relationship between audio signal modulation and the observable light have been tried in the past. Various systems have heretofore been proposed for appealing to the sense of sight as well as to the sense of hearing in connection with musical reproductions in particular. Such reproductions produced a control of a plurality of different colored lights which caused a color lighting display to change from time to time as the reproduced sound effects also changed.

In general, however, it has been found that prior art types of controls for the most part depended upon a control exercised by saturable core reactors serving to supply modulated power to the lighting instrumentals. Such components have been extremely heavy, costly, large and, generally speaking, unreliable. The mechanism and circuitry to achieve the results in the past have been extremely critical as to the adjustment with respect to audio sound level and the line voltage operating the device. The result has been, practically without exception, that operators were required to continually maintain an adjustment of the circuitry if even reasonably satisfactory relationship was to be had between sound reproduction and the color effects visible.

Because of coordination between high and low frequencies as obtained in sound is desirable when visual effects are being recreated, it has been found that the user of the equipment soon recognizes that the added dimension of music in visual representations of high fidelity reproduction of aural high fidelity signals greatly enhances both the enjoyment and appreciation of the music being heard. The possibility of being able to see, as it were, suitable passages of a symphony in corresponding delicate hues of color brings to the listener and observer a new enjoyment which has not heretofore been possible.

In accordance with the proposal of the present invention, received audio modulations are supplied into the apparatus and divided generally into separate frequency ranges which are coordinated with different colored primary lighting sources. Although the invention is not restricted to any specific number of light sources, provided the segregation of frequency bands commensurate with the number of sources chosen is preserved, the principles upon which the invention is based will be explained herein by making reference to circuitry segregating the complete frequency range of the incoming audio signal modulation into three distinct frequency bands.

In this instance, these frequency bands will encompass the lowest frequency through to a frequency value something less than the middle frequency reproduced. This band, which will herein be termed, for convenience, low frequency, is coordinated with lighting mechanisms to produce light in the color red. A mid-band of frequencies covering the middle range and thus corresponding to medium frequencies of those received is also selected and coordinated with a reproducing light source about midway in the visual spectrum. Illustratively, this may be considered to be green light. Lastly, the higher frequency ranges are appropriately selected by suitable filtering mechanisms and coordinated with suitable light sources to produce blue light.

In the operation of the mechanism and circuitry, the light issuing from the separate light sources producing red, green and blue, respectively, with the low, intermediate and high frequencies are visually mixed on a suitable screen of translucent glass or, illustratively, by directing the lights resulting from activation through a water spray, such as a fountain or falling body of water, so that the mixing of the several light colors is automatically achieved.

In the reproduction of music, as the proportion of the different frequencies and their amplitudes change with respect to each other, so do the light representations which are produced come to change. The result is a substantially ever changing non-repeating and different light level color combination which accurately represents the music to be desired. To illustrate still further, the red illumination which results from the selection of the lower frequency components generally results from the lower frequencies and might be designated, therefore, as the rhythmic component. On the other hand, the higher frequencies which are selected and which is portrayed as the blue illumination, according to the plan above-suggested, result from control by the higher frequency instruments such as trumpets, violins, piccolos and the like. When all of these lightings are combined in a dynamic fashion, there is a visual representation, when accurately portrayed, which competes with the aural enjoyment of the music being reproduced.

According to the present invention, criticality of adjustment is overcome by the use of controlling feed-back circuitry of a character such that the feed-back is integrated over an appropriately chosen time cycle to provide dynamic modulation from any sound level or frequency and any operating line voltage. Further, the control of the lighting effects produced is established, according to the present invention, by the provision of a suitable level of control to apply and provide a residual light level in the complete absence of sound. In addition, the present invention also makes provision for smoothing to reduce unpleasant flicker effects which would tend to result were the lighting to follow the instantaneous audio modulation. To this end, the apparatus herein disclosed makes provision for selecting between what will illustratively be termed low, intermediate and high frequencies; then suitably detecting the selected audio frequencies; then controlling a suitable amplifying circuit through a silicon control rectifier (commonly called an "SCR") acting through a voltage divider and feed-back circuit thereby to give the reliability of the operation.

The invention, in one of its preferred forms, has been diagrammatically illustrated by a single figure of the accompanying drawing wherein the various components have been schematically represented in one suitable form.

Referring now to the drawing, three separate signal channels have been shown. For reasons of identification and to exemplify the relationship between signal modulation and resultant light effects, the separate channels are conveniently designated as "R," "G" and "B." These channels respectively select from the audio frequency signal range of the applied signals, the lower frequencies

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for reproduction as red, the middle frequencies for reproduction as green and the high frequencies for reproduction as blue. Generally speaking, the signal channels duplicate each other except for the selection circuits in the form of filters hereinafter to be designated.

For the purpose of understanding the invention, however, a single channel only need be explained (except for the filter selection circuits) since the components within the separate channels are functionally similar. The filters select frequency ranges, as will be noted. For reference, the channel "R" to produce the red light signal will first be explained, with note being made that those components in the so-called "green" channel "G" will be designated by prime numbers and those components in the channel "B" to produce blue light will be designated by double prime numbers.

Referring now specifically to the particular embodiment illustrated, audio signal modulation from any desired signal source, such as an amplifier, audio receiver, record reproducer or the like (not shown) is applied to the input terminals 11 from which the signals are passed by separate conductors 12 and 13 to flow through the primary winding of the transformers 14, 15 and 16 for the channels R, G and B, respectively. A master gain control in the form of the variable resistor 17 is serially included in the circuit with all transformer primary windings.

Each of the transformers 14, 15 and 16 is of a generally standard type used frequently as an audio transformer, such as the normal plate-to-voice-coil transformer used for sound reproducers. However, it will be noted that in order to provide voltage step-up for supplying the input filter to the various channels, the transformers 14, 15 and 16 are used in a relationship to provide step-up rather than the more usual step-down. Considering now, first the lower frequency channel, the secondary winding of the transformer 14 is arranged to supply its output to a low-pass filter circuit comprising the series resistance 19 and the shunt capacity 21. The output of this low-pass filter combination is then supplied through a diode rectifier 23 usually in the form of a germanium diode, such as the type IN34A, which then supplies its output to the smoothing filter represented by the combination of the shunt-connected condenser 25 and resistor 26. The smoothing filter serves to smooth the rectified output from the diode 23 so that the voltage applied via the resistor 27 to the grid 28 of the amplifier tube 29 is a relatively low frequency pulsating signal producing what approaches a direct current condition.

The tube 29 may be of any desirable type but one suitable form is that shown as the type 12BH7. In this tube, the cathode element 30 (the heater circuit of which is not here shown but which may be supplied from an A.C. source in well known fashion) connects, as will later be explained, with the silicon control rectifier, generally designated 47. The plate or anode 31 of the tube 29, with plate potential supplied by means of connecting an A.C. source, not shown, at the terminals 32 of the primary winding of transformer 33 whose secondary winding 34 has one terminal grounded at 35 and the other terminal connected to the tube plate 31.

This same transformer may supply voltage to the plates or anodes of similar tubes in the other two channels indicated and thus, at the output terminal 36, suitable connections to the tubes of the other channels may be made in the fashion schematically indicated.

The input signals available at the terminals 11 are supplied concurrently also to the so-called "green" channel G by way of transformer 15. In this instance, the combination of the series resistor 19′, the shunt capacity 21′ and the shunt connected choke 20 constitute a band-pass filter having a lower frequency cutoff approximately corresponding to the higher frequency accepted by the low-pass filter combination in the red channel. The upper frequency cutoff for the band-pass filter comprising resistor 19′, condenser 21′ and choke 20 is approximately that frequency which corresponds to the lowest frequency accepted by the high-pass filter in the so-called "blue" channel B.

The high-pass filter which accepts the highest range of audio signals supplied at the input terminals 11 is supplied through the transformer 16 and comprises the series capacitor 18 and the shunt resistor 22 tuned as above-stated.

The output from the band-pass filter of the channel G is supplied through the diode 23′ to the tube 29′ in a fashion similar to the signal passage in the red channel R. Similarly, signals in the upper frequency range accepted by the high-pass filter comprising capacitor 18 and the resistor 22 of the blue channel are passed through the diode rectifier 23″ to control the current flow through the tube 29″ in a fashion similar to that above-explained for the "red" channel.

Signal input to the tube 29 to the input grid 28 through the resistor 27 which has the capacitor 39 connected at one side to the resistor and grid and at the other side to ground at 35. The capacitor 39 and resistor 27 provide an integrating filter having a time constant sufficiently long to reduce flicker which might be present were the signal modulation applied to the grid 28 of the tube 29 in such manner as to cause the output to follow instantaneously the input modulating signal input. Illustrative of the properly selected time constant, the resistor 27 may be one of the order of one megohm, with the capacitor about 0.25 mf.

Bias for controlling the tube 29 is supplied through the resistor element 26 of the smoothing filter by way of the conductor 38 in a fashion later to be explained. The tube 29 provides a cathode-coupled output signal which is supplied through the filter and phase shift combination comprising resistor 41, the capacitor 42 and the inductor 43 all parallelly connected with respect to each other but serially connected relative to the gate 48 of the silicon control rectifier 47 and across which the integrating capacitor 44 is provided. The circuit comprising these filter elements serves both as a smoothing filter for the output signal from the tube 29 and also acts as a phase shifter circuit to obtain a smooth modulation of the rectifier 47. Signal output from the tube 29 is thus applied to control the gate 48 of the rectifier 47 and controls the current flowing between the anode 50 and the cathode 49 which are connected to be energized from an alternating current supply source connected at the terminals 51 and 51*a* with terminal 51*a* being grounded at 35, as is cathode 49, and the terminal 51 connected to the anode 50 through the lamp 53. The lamp 53 is shunted by an indicating lamp 54.

In connection with the channel herein being discussed, it will be apparent that the lamp 53 gives off red light in response to signal modulation applied. The shunting lamp 54 is one which is normally placed upon the control panel of the control rack or unit in which the circuitry heretofore described is positioned, with the lamp 53 being arranged externally of these components so as to be readily observable to lookers desiring to sense the color effect of all signal modulation falling within the spectral range of signals accepted by the low-pass input filter of this channel.

The circuit comprises in the connection between the anode 50 and the cathode 49 or ground 35, a pair of series-connected resistors 56 and 57 forming a voltage divider which serves to supply a suitable amount of inverse feed-back to the control grid of the tube 29, as will be explained. It can be seen that if the light 53 tends to increase in its intensity the voltage available across the combination of the resistors 56 and 57 in series will be reduced so that the potential at their junction point drops relative to ground. The diode 59 connects with its anode terminal poled toward the junction of resistors 56 and 57 and its cathode connected to conductor 38 and through capacitor 65 to the lower side terminal of resistor

57 and to ground through conductor 58. Thus, with lamp 53 at higher intensity there is less voltage across resistors 56 and 57 so that less positive voltage is developed across them through diode 59 so that the negative bias on conductor 38 increases to decrease the lamp intensity.

The opposite side of the lamp 53 is connected through a resistor 63 and a potentiometer 64 also to ground 35, as indicated. The potentiometer 64 is suitably tapped by a variable connection made from the cathode side of the diode 61 whose anode is connected serially with the cathode terminal of the diode 59 the connection being at the junction 66. With this form of circuit connection, the combination of the resistors 56, 57 and capacitor 65 and the diode 59 provides the inverse feed-back from the lights, with the capacitor element serving to provide a long time constant which acts to give long term reset action to line voltage and average audio level changes, but allows much dynamic modulation for normal sound modulation.

The potentiometer 64 which is connected as one element in shunt with the A.C. input available at the terminal 51 serves to determine the setting of the residual light level when no sound signal is present. Under these circumstances, a potential is developed at the point 66 which represents the summation voltage of the voltages developed in conjunction with the current flow through resistors 63, 64 and the diode 61 on the one hand and the resistors 56, 57 and the diode 59 on the other hand. This provides a reset voltage as a bias applied through the conductor 38 and resistors 26 and 27 to the grid or control electrode 28 of the tube 29 which keeps the modulation level reasonably constant even in the face of long term line voltage changes in the system and the long term average audio signal level voltage change. The A.C. applied to the tubes 29, 29′ and 29″ and the A.C. applied to the terminals 51, 51′ and 51″ for controlling the illumination of the lamps is such that the bias effective through the conductor 38 is normally indicative, to greater or lesser extent, of the relationship of the current flowing through the diode 61 as compared to diode 59.

The average bias is determined by a selectable setting of the tapping point on the potentiometer 64. Considering the circuitry still further, the light effect produced through the lamp 53 is set to constant residual level in the absence of audio modulation. With the capacitor 65 included in the circuit it acts in a way to hold the inverse feed-back represented by the potential at point 66 fairly constant even with rapid changes in line voltage and audio level changes.

This means that for normal audio modulation, there is effectively included little or no inverse feed-back, but for long time changes in audio level, various conditions such as readjusting the volume control to the user (not shown) supplying the input at terminals 11, average voltage at the point 66 readjusts to a new level and tends to keep the average light output constant.

Considering now still further the control exercised at the end of the silicon rectifier 47, it will be appreciated that this element acts generally somewhat like the normal "thyratron" so that when the element is once arranged to pass current, the only way that cutoff occurs is by removing the positive anode voltage. Under the circumstances, power modulation is obtained when the rectifier 47 is caused to fire at various angular degrees through the positive half-cycle of the alternating current applied to the plate or anode 31 of the tube 29.

If, for instance, a variable direct current modulating voltage should be applied to the gate 48 of the silicon control rectifier 47, it is apparent that only 90° or thereabouts firing point on the positive half of the cycle would be achieved which would, of course, provide only about half modulation. To achieve the effect of 180° effective modulation from a device which basically can only provide 90°, the circuit described provides for superimposing a properly phase-shifted A.C. component on the D.C. modulation.

By providing A.C. on the plate 31 of the tube 29, an output wave results at the tube cathode 30 which is a half-wave rectified voltage. Then, by properly proportioning the values of the resistor 41, the capacitor 42 and the inductor 43 and capacitor 44, the end result is a D.C. signal imposed upon an A.C. available at the gate 48 and modulation is provided in the range from zero power to maximum power.

While indeed this circuitry is explained herein in connection with a control of the illumination of a lamp, such as lamp 53, it will be appreciated that this portion of the circuit is particularly applicable as a general control whereby minute power signals are caused to control and modulate large amounts of power in systems particularly applicable for use as light dimmers, motor controls, temperature controls, servo systems and generally related types of components one desires.

Further, in accordance with this invention, provision is made so that at times all of the lights such as 53, 53′ and 53″, for instance, may be switched on full intensity as selected. Where the lights are to be individually switched on, individual switches 67, 67′ and 67″ may be utilized. Where, however, it is desired to switch all of the lights concurrently, the switches may be provided in the form of a three-pole switch serving simultaneously to short circuit and by-pass condensers 39, 39′ and 39″ and thus immediately removing the effect of the applied bias as controlled by the time constant circuit in the form of the smoothing filter including the resistor 27 and the capacitor 39.

While not here shown, for convenience, the lamps 53, 53′ and 53″ may be of any desired type and size commensurate with the type of operation desired. Generally speaking, the lamps may be colored to provide immediately light in the desired component color or the lamps may be arranged to emit light through filters and properly chosen primary colors of desired density. In each event, it is usually desirable to locate several lamps within a viewing region and to scatter the lamps so that when the light from them is directed to fall upon a translucent surface to be viewed, the light from each lamp in its full intensity will be substantially uniformly distributed over the entire viewing area whereby with changes in the illumination following the modulation or whereby with simultaneous energization of all of the lamps, the colors will tend to merge into one.

This invention is primarily concerned with the circuitry for control of the light and color effects produced rather than the precise arrangement of the lighting. For full intensity of illumination of each of the different light sources, it will be appreciated that the over-all color observable is determined also in accordance with the balance of color desired. The exact proportion of the red, green and blue light herein assumed to be generated for the three-channel system can be varied in any proportion desired. Because the same intensity of red, green and blue are so rarely present due to the frequency content of the supplied signals and because of proportioning selected by the observer, the likelihood of any "washed out" areas appearing with illumination is extremely slim. There is a great flexibility in the finalized arrangement of the resultant lighting. The precise arrangement is usually a subjective one and affected largely in accordance with the aesthetic tastes of the operator.

Having now described the invention, what is claimed is:

1. Display apparatus for simulating in color a wide frequency range of audible effects originating with a preselected signal source comprising a plurality of signal responsive channels and selector circuits adapted to be supplied with the source signals for segregating discrete signal frequency ranges of the source signals into separate signal channels, a device for producing light in a selected

color associated with and responsive to the signals in each separate channel, each of the colors of light produced being different and each light color being related to and generally proportional in frequency to the frequency selection of the selector circuits, a detector in each channel for detecting the selected signals, a gating device responsive to the detected signals for controlling the illumination of the light source, a thermionic device responsive to the detected signals and connected for controlling the gating device, means to supply said device with operating potential from an alternating current source to limit current flow therethrough to selected cyclic periods and thereby normally to similarly control the gating device, a filter and phase shift circuit connected between the thermionic device output and the gating device for determining the gate operating period and for phase control thereof, a voltage divider responsive to current flow through the gating device for establishing the level of feed-back voltage, storage means to integrate feed-back voltage thereby to provide dynamic modulation from any gating output, and feed-back means to control the gating device and for establishing a static threshold light level.

2. The device claimed in claim 1 comprising, in addition, means to supply alternating current to the thermionic tube to control the current flow through the gating device and the light producing device, a level control associated with the voltage divider for determining feed-back potential in the absence of impressed signal input to the rectifying device, means for summing voltages obtained from the voltage divider connected with the gating device, and resistive elements connected with the voltage summing means for setting the residual light level to maintain substantially constant feed-back potential in the absence of signal modulation and fluctuating voltage.

3. The apparatus claimed in claim 2 comprising, in addition, filter means in the feed-back path for smoothing the detector output and reducing flicker from the light producing device tending to result from low frequency modulation of the gating device.

4. The device claimed in claim 3 comprising, in addition, means serially connected with the detector to establish full intensity of the light producing means at desired time periods.

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