July 20, 1943. M. K. GOLDSTEIN 2,324,773

COLOR REPRODUCTION

Original Filed June 4, 1935

Fig. 1

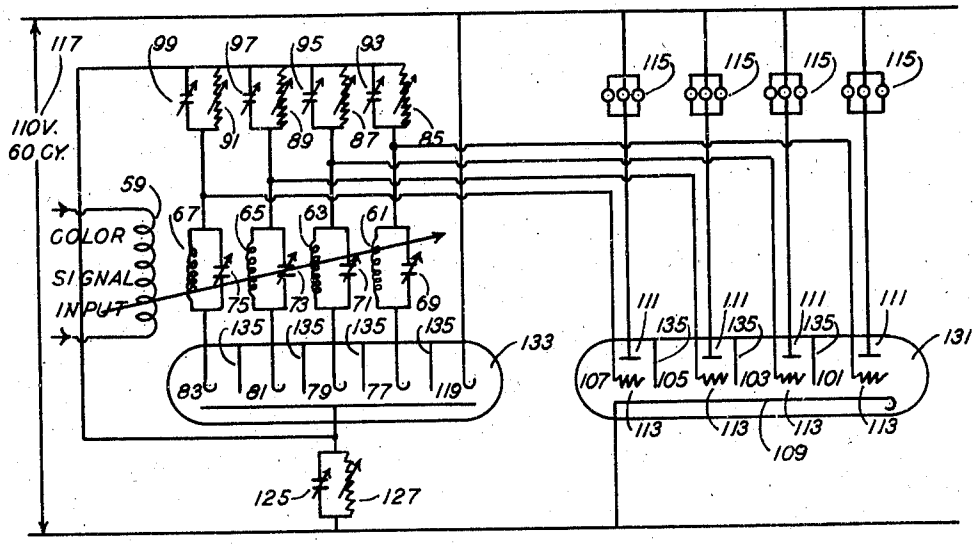
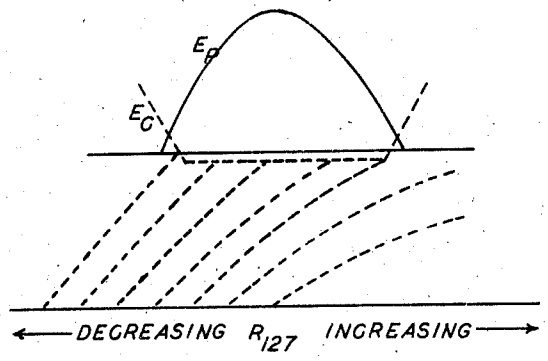


Fig 2



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Patented July 20, 1943 2,324,773

UNITED STATES PATENT OFFICE

2,324,773

COLOR REPRODUCTION

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Original application June 4, 1935, Serial No. 24,786. Divided and this application November 27, 1939, Serial No. 306,341

11 Claims. (Cl. 177—346)

This application is a division of my application Serial No. 24,786, filed June 4, 1935, and which has now become Patent No. 2,184,075, December 19, 1939. My invention relates to electron discharge devices, more particularly to the operation of lights or other devices by means of gaseous electron discharge tube circuits.

It is a further object of my invention to simultaneously control a plurality of devices, each in accordance with the intensity of a characteristic signal, by means of gaseous electron tube circuits.

It is a further object of my invention to improve the operation of gaseous discharge tube circuits.

Additional objects will be brought out in detail in the following description taken in conjunction with the accompanying drawing, in which:

Figure 1 illustrates schematically a circuit embodying my invention. Figure 2 shows a diagram illustrative of the operation of the gaseous discharge tube circuit shown in Figure 1.

In the production of moving pictures, musical programs, plays or the like, the effects which they are desired to produce on an audience could be materially heightened if such entertainment were accompanied with suitable and harmonizing color lighting effects, whereby the emotional reactions of the individual might be additionally stimulated to emphasize the effects which the program is intended to produce.

In order to provide such a color accompaniment each of the primary colors is assigned a discrete frequency. Since every color is made up of one or more of the primary colors, such as red, green and blue, in varying proportions, only three separate and independent frequencies will be necessary to represent these components and thus to enable one to build up any desired color. In transmitting the color white, which comprises all of the primary colors combined, it would, therefore, be necessary to combine potentials at these three frequencies of oscillation. In order to simplify this operation somewhat, I might provide a fourth frequency to represent the color white.

These several discrete color-representative frequencies may be used to modulate a carrier wave and in this form, or otherwise, are directly or indirectly impressed across the primary **59** of a multi-winding transformer, there being as many secondary windings to this transformer as there are frequencies assigned to the color components. By indirectly is meant that these discrete color-representative frequencies or their equivalents may be derived from recordings, the modulations of carrier wave translating devices and similar sources well known in the art. Ordinarily, the multi-winding transformer will have three such windings, **61**, **63**, **65**, respectively, but where a separate frequency is provided at the transmitter for the color white or additional specific colors, there will correspond additional windings like **67**. Each of the secondary windings is accordingly tuned by means of a condenser **69**, **71**, **73** and **75**, respectively, to a frequency corresponding to the frequencies assigned to the primary and the additional colors. Thus, each tuned secondary winding will pass energy at the frequency at which it is tuned and in amount proportional to the intensity of the energy at that frequency, which is present in the energy appearing across the primary winding **59**.

The energy thus passed by the tuned circuits is rectified through a rectifying device such as the diode equivalents **77**, **79**, **81**, **83**, and impressed across a poteniometer or resistor **85**, **87**, **89**, **91**, respectively, in series therewith. Thus, for each tuned secondary winding there will be such a rectifying circuit and corresponding output resistor. Across each of these resistors, therefore, will appear a voltage representative of a magnitude of the intensity of the primary color which it represents in the particular color which is being transmitted at the moment. Condensers **93**, **95**, **97**, **99** are connected, one across each of these resistors, to filter out the alternating component, thus giving to the potential across the resistor a more or less steady value.

In order to utilize these various voltage components in the reproduction of the color desired, there are utilized gaseous discharge devices **101**, **103**, **105**, **107**, there being one device for each color component represented. Each of these devices comprises the common cathode **109**, anode **111** and control electrode **113**, the anode circuits of each discharge device including an electric light or lights of the primary color corresponding to the frequency of the tuned circuit with which that particular discharge device is associated, except for the lights in the anode circuit of the discharge device **107** which will be white or any other specific color. Anode potential is supplied directly from an alternating current source **117**, such as a 110 volt 60-cycle system. Across this 110 volt circuit there is placed the diode equivalent **119**, the cathode being connected to that side of the alternating-current circuit which is connected to the anode circuits of the various gaseous discharge devices. The other side of the line is tied to the anode of the rectifying device

119 through a parallel arrangement of a condenser 125 and a shunting resistor 127.

This condenser and shunting resistor is common to the input or grid circuits of all the gaseous discharge devices, these grid circuits differing from each other, however, in that each one includes in series with this resistor shunted condenser 125, that resistor 85, 87, 89 or 91, corresponding to the particular color represented by the light in the plate circuit of each of the tubes. Each of these resistors and its associated condenser may be made variable to permit of independently adjusting the intensity of its associated lighting effect. Suitable control of these variable resistors and an appropriate potentiometer common to them will also permit of dimming a theater or auditorium through a gradual dimming of the component color lighting effects in any desired sequence or simultaneously.

The condenser 125 and the resistor 127 may be made variable, and in operation, are so designed and adjusted that the condenser will practically completely charge during each negative half cycle of the impressed 60 cycle voltage, and will discharge completely during the positive half cycle, during which half cycle the rectifying tube becomes non-conductive and positive potential is applied to the anodes of the various gaseous discharge devices 101, 103, 105 and 107.

In Figure 2, the curve E_p represents the potential on the anode during the positive half cycle, and E_c represents the grid potential required to make the gaseous discharge device conductive.

Disregarding for the moment the effect of the color component potentials appearing across the resistors 85, 87, 89, 91 in the rectifying circuits, it will be apparent that at some point during the discharge of the condenser 125 through the shunting resistor 127, the various gaseous discharge devices will become conductive and, therefore, permit current to flow through the lights in their respective plate circuits. The discharge of the condenser 125 through resistor 127, for several adjustments thereof, is represented by the dotted oblique lines of Figure 2. This conductivity of the gaseous device takes place only during a portion of the positive half cycle, since the various devices are biased beyond cut-off during the first portion of the discharge period of the resistance shunted condenser. Under these conditions, the lights in the various plate circuits will glow for a portion of every positive half cycle, and, due to the persistency of vision, this glow will appear of constant duration and of a certain intensity, each light being similar in this respect.

By shifting the voltage level of the grid of the gaseous discharge device with respect to the cathode side of the 110 volt system, which change in level can be accomplished by adding to or subtracting from the voltage appearing across the condenser 125, one can readily change the apparent intensity of the lights in the plate circuits of these devices. In the circuit described the various resistors develop voltages representing the intensity of the primary colors at any instant, perform this function each voltage developed across these resistors serves to vary the voltage level of the grid of its associated discharge device, thereby causing conductivity of the device for a greater or less portion of the positive half cycles of impressed plate voltage and thus altering the apparent intensity, as it is perceived by the eye.

At this point, we have in the respective plate circuits of the electron discharge devices primary colors representing the components of the color being transmitted, the intensity of each component being proportional to the intensity of the component of the color desired. By mixing these various colors appearing in the plate circuits of the tubes, one will thereby obtain a reproduction of the particular color desired.

It will be apparent to those skilled in the art that even greater linearity control of the intensity of the color lights with respect to the magnitude of the respective color signals input can be accomplished by inserting or substituting suitable non-linear resistors or amplifiers or the like in series with the grid resistors of each gaseous discharge device. By means of these non-linear devices it is thus possible to further control the degree of response of the color light intensity to the color signal input.

The tubes 131 and 133 are preferably of the type described in my Patent No. 2,052,617 of September 1, 1936, consisting of a plurality of groups of electrodes, each capable of being utilized independently as a rectifier or a three-electrode or multi-electrode tube and having an electrode such as a cathode common to all the groups. Special shielding means schematically indicated by the reference numeral 135 are embodied in these tubes to assure independent functioning of the various electrode groups, without feed back or other disturbing influences occurring between the various electrode groups.

The specific tube 131 comprises a plurality of groups of two electrodes having a cathode common thereto to constitute the equivalent of a plurality of triodes. The multi-rectifier tube 133 involves a plurality of cathodes and an anode common thereto. Electrode shielding is provided in both cases preferably in accordance with the teachings of my cited patent.

While I have described my invention in great detail I do not desire to be limited in my protection to such details as may be necessitated by the prior art and the appended claims.

I claim:

1. A system for interpreting electrical impulses in terms of color which comprises a source of impulses external to said system, said impulses having varying amplitude and frequency, means comprising a plurality of frequency selective circuits for segregating said impulses in accordance with the frequency thereof, means associated with each of said frequency selective circuits to produce a direct current potential which varies in magnitude with the intensity of the impulses in the associated frequency selective circuit, a plurality of sources of light each capable of producing a color differing from the others, a plurality of discharge devices each having a cathode section, anode and control electrode a source of alternating current potential, means for impressing said alternating current potential, on said anodes with respect to said cathode sections, means for periodically rendering said control electrodes negative with respect to said cathode sections and means for impressing the direct current potentials developed in connection with each of said frequency selective circuits, upon the grid of one of said discharge devices to alter the conductivity thereof in accordance with said impressed direct current potentials, said sources of light being connected to respond to said changes in conductivity of said discharge devices.

2. A system for interpreting electrical impulses in terms of color which comprises a source of

impulses to the interpreted, said source being external to said system, means for rectifying and filtering said impulses to produce a direct current potential which varies in magnitude with the intensity of the impulses derived from said source, a source of light capable of producing a color and means responsive to said varying direct current potential for controlling the duration and intensity of operation of said light source, comprising an electron discharge device, a source of periodic potential and means for simultaneously applying said varying direct current potential and said periodic potential in series to control the conductivity of said electron discharge device substantially in accordance with the magnitude of said signal potentials.

3. In combination, a gas discharge device having an anode, grid and cathode, a grid circuit including a resistance shunted condenser, a source of alternating current, means for applying said source of current in circuit with said anode and cathode, means for rectifying current from said alternating current source and passing it through said resistor shunted condenser in a direction to build up a negative charge on said grid during the application of the positive half cycles to said anode and means for impressing signal potentials on said grid in series with said condenser, said signal potentials being in a direction to oppose the negative charge on said condenser whereby said discharge device will become conductive during more or less of the period of application of the positive half cycles to the anode in accordance with the magnitude of said signal potentials.

4. A control system comprising a source of impulses of varying amplitude and frequency and means comprising a plurality of frequency selective circuits for segregating said impulses in accordance with the frequency thereof and means associated with each of said frequency selective circuits to produce direct current potentials which vary in magnitude with the intensity of the impulses in the respective frequency selective circuits, a gas discharge device having an anode, grid and cathode, a grid circuit including a resistance shunted condenser, a source of alternating current, means for applying said source of current in circuit with said anode and cathode, means for rectifying current from said alternating current source and passing it through said resistor shunted condenser in a direction to build up a negative charge on said grid during the application of the positive half cycles to said anode and means for impressing said varying direct current potential on said grid in series with said condenser, said varying potential being in a direction to oppose the negative charge on said condenser whereby said discharge device will become conductive during more or less of the period of application of the positive half cycles to the anode in accordance with the magnitude of said varying potential.

5. The method of operating a gaseous tube circuit including a tube having a control element, which comprises periodically rendering said tube conductive and simultaneously therewith impressing signal potentials on said controlling element in a manner to cause said signal potentials to increase the duration of conductivity in accordance with the magnitude of the signal potentials, said signal potentials being derived from a source of impulses external to said tube circuit.

6. The method of operating a tube circuit comprising a tube having a control element, periodically rendering said tube conductive and simultaneously therewith adding signal potentials to said control element in a manner which controls the duration of conductivity substantially in accordance with the magnitude of said signal potentials, said signal potentials being derived from a source of impulses external to said tube circuit.

7. The method of operating a tube circuit including a tube having a control element and a load circuit which comprises periodically rendering said tube conductive and simultaneously therewith adding signal derived potentials to said control element in a manner which controls the load current of said tube circuit substantially in accordance with the magnitude of said signal potentials, said signal potentials being derived from a source of impulses external to said tube circuit.

8. A circuit comprising a gaseous discharge device having a cathode, a grid and an anode, means for impressing alternating current voltages between the anode and cathode, means for periodically impressing on said grid a variable cut-off potential having the same amplitude at the beginning of each positive half cycle on the anode, means for causing the cut-off potential to gradually decrease throughout the said positive half cycle and means for impressing variable signal derived voltages between said grid and cathode and thereby rendering said tube conductive during fractions of said positive half cycle, said fraction being substantially proportional to the magnitude of said signal.

9. A circuit comprising a gaseous discharge device having a cathode, grid and anode and a load circuit, means for impressing alternating current voltages between the anode and cathode, means for periodically impressing on said grid a variable cut-off potential having the same amplitude at the beginning of each positive half cycle of the anode, means for causing the cut-off potential to gradually decrease throughout the said positive half cycle and means for obtaining control potentials derived from signal voltages said control potentials being impressed on said grid to render said tube conductive in a manner whereby the load circuit current is controlled substantially in proportion to the magnitude of said signal voltage.

10. A circuit comprising a plurality of gaseous discharge devices each having a cathode section, grid, and anode, a load for each of said devices, a source of potential, means for connecting the cathode, anode, and load of each of said devices across the source of potential, a rectifier device having its anode connected through a load circuit to the cathode side of said source of potential, said load circuit comprising a condenser shunted by a resistor, a source of signals for each gaseous device and means for connecting each grid to the anode of said rectifier through a source of signals, whereby said gaseous discharge devices are rendered conductive in accordance with said signals.

11. A method of control utilizing electrical impulses including a tube having a load, which comprises periodically rendering said tube conductive, simultaneously therewith impressing signal impulses to alter said conductivity in a manner to control the load current substantially in accordance with the magnitude of said impulses said impulses being derived from signals external to the source of said load current.

MAXWELL K. GOLDSTEIN.