Dec. 19, 1939. M. K. GOLDSTEIN 2,184,075

COLOR TRANSMISSION

Filed June 4, 1935 2 Sheets-Sheet 1

Fig. 1

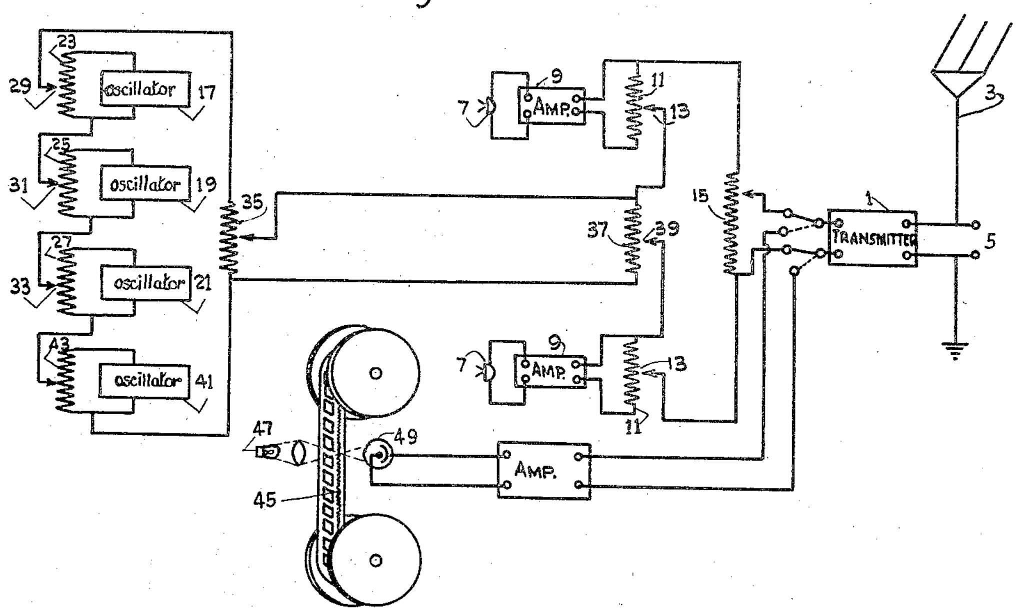
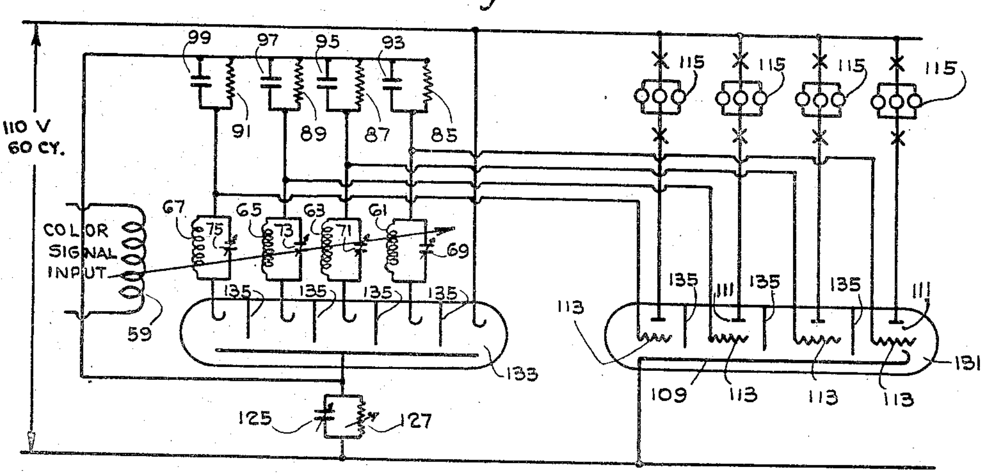


Fig. 3



WITNESSES:

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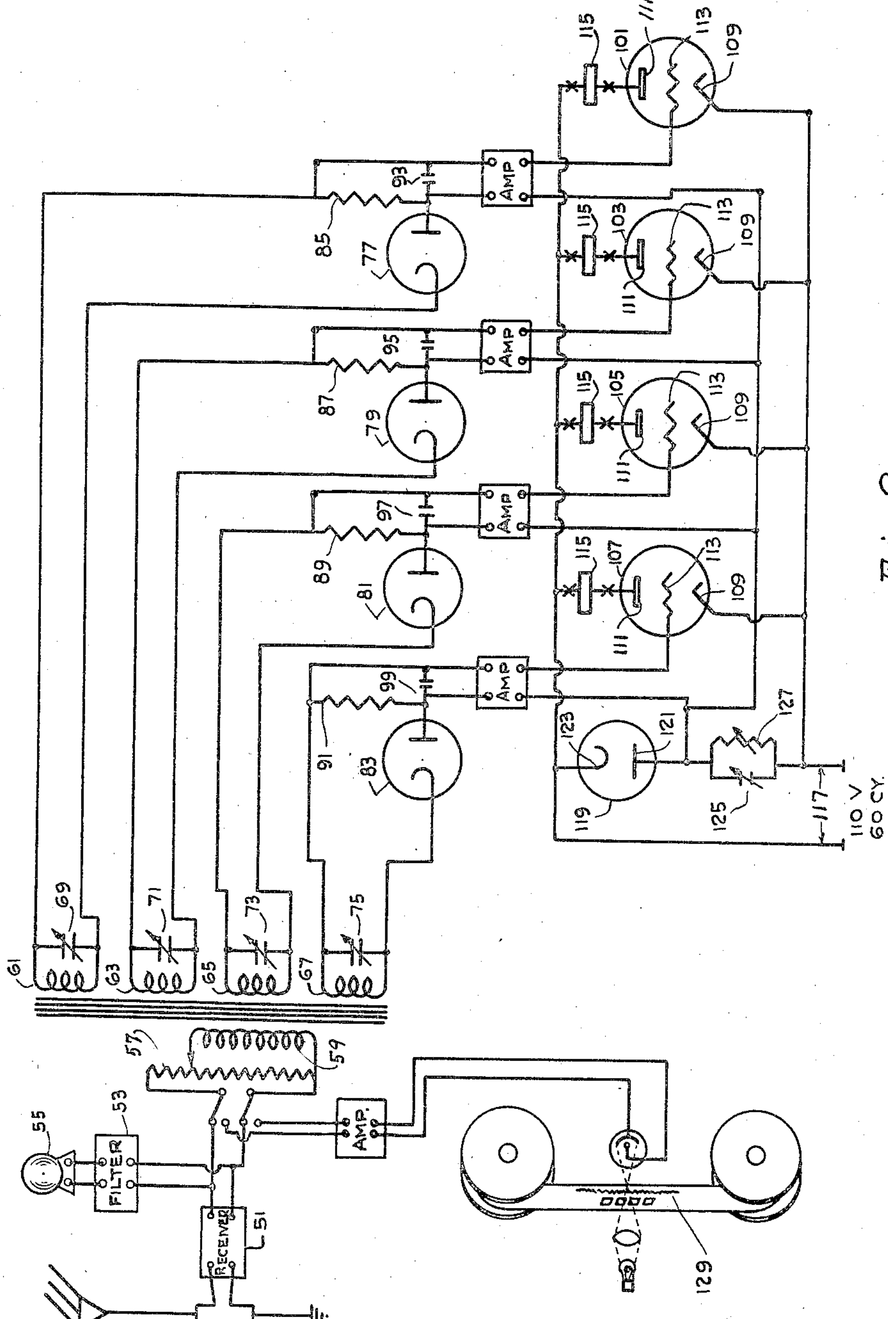

Fig. 2

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Patented Dec. 19, 1939

2,184,075

UNITED STATES PATENT OFFICE

2,184,075

COLOR TRANSMISSION

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Application June 4, 1935, Serial No. 24,786

9 Claims. (Cl. 179—2.5)

My invention relates to the transmission of color effects, more particularly as such effects may be transmitted by means of radio or over wire lines.

It is an object of my invention to provide means for the transmission of color effects to a remote destination.

Another object of my invention is to provide color effects by remote control means.

Another object of my invention is to provide means for accompanying radio programs or the like with harmonizing color effects.

A further object of my invention resides in the provision of means for producing the program and harmonizing color effects from a common source.

A further object of my invention is in the provision of means for simultaneously transmitting on a common carrier a program, together with accompanying harmonizing color effects.

A still further object of my invention resides in the method for accomplishing any of the above objects.

Additional objects of my invention will be brought out in detail in the following description of the same, taken in conjunction with the accompanying drawings, in which:

Figure 1 represents a transmitting system embodying means for transmitting broadcast programs accompanied by suitable color accompaniment, in addition to an alternative scheme for transmitting both program and color accompaniment from a common source;

Fig. 2 is a circuit illustration of a receiver station incorporating means for producing the color variations desired either in combination with receiving apparatus for the reproduction of programs or directly from a recording at the receiving station; and

Fig. 3 illustrates a simplification of the color transposing circuit at the receiving station utilizing a multiplex type of tube to supplant the individual tubes shown in the circuit of Fig. 2.

In the production of moving pictures, musical programs, plays or the like, the effects which they are desired to produce on an audience can 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. Calm and tranquil scenes, for example, might be accompanied to advantage with a slow but principally continuous change of colors of the lighter shades, emphasizing principally the yellow portion of the color spectrum, whereas scenes of the more somber type or storm scenes might be represented in the color spectrum by slow or rapid changes, respectively, of combinations of the darker colors involving the blues and reds, the intermediate shades and combinations being reserved for such portions of these programs lying between these two extremes.

Referring to the circuit of Fig. 1, there is disclosed therein, in a very schematic manner, a broadcast station comprising a transmitter **1**, the output of which feeds into either an antenna **3** or a wired system represented by terminals **5**, depending upon whether the transmitting station is employed in connection with radio broadcasting or carrier current communication. The transmitter is modulated by suitable microphone controlled circuits comprising, in this instance, a pair of individual microphones **7**, the output of each of which is fed through an amplifier **9**, each amplifier feeding into a resistance load **11**, these resistances being variably connected in series by means of adjustable contacts **13** and connected across a terminating resistance **15** from which the modulating potentials are tapped off by means of an adjustable tap and fed to the input circuit of the transmitter.

For use in conjunction with the broadcast program, and to provide suitable harmonizing color changes to accompany the reproduction of the program at a receiving station, I provide a plurality of sources of oscillations, **17**, **19**, **21**, each of a frequency differing somewhat from each other, each to represent preferably one of the primary colors, although it should be clear that each oscillator may be made to represent any colors or combinations thereof. These sources of oscillations may be designed to operate at any desired frequencies, although in a system as described by me, they will preferably be of a very low order of frequency, for example, in the neighborhood of frequencies below 65 cycles, and may comprise suitable alternating-current generators or very low frequency vacuum tube oscillators. In lieu of employing individual sources of oscillations each to represent a primary color, it is possible to employ a single source of a very low frequency and utilize the fundamental and the lower harmonics for the purpose. This second method assures practically constant frequency separation between the primary color frequencies.

As stated above, each of the primary colors is assigned a particular frequency, the intensity of the primary color being represented by the amplitude of oscillation of the particular frequency assigned to it. The output of the individual frequency sources is impressed across associated potentiometers **23**, **25**, **27**, these potentiometers being connected in series through variable contacts **29**, **31**, **33**, across an output potentiometer **35**. The amplitude of oscillation obtained from each of the frequency sources corresponding to a particular primary color may be varied in accordance with the intensity of the primary color by adjustment of the variable contact associated with each of these resistors. These may be controlled by means of a suitable keyboard, whereby the various intensities of the primary colors may be obtained by merely pressing the associated keys the proper amount in accordance with some prearranged schedule, the keys being represented schematically by the shiftable contactors **29**, **31**, **33** etc. A color monitoring circuit, similar to that to be described in connection with the circuit of Fig. 2, might be provided within view of the operator, thus enabling him to check the color representations being broadcast.

Across the output resistor **35**, therefore, one will obtain a voltage drop of a wave form which, if analyzed, would comprise a plurality of voltages each at a frequency representing a primary color, and of a magnitude representing the intensity of that color entering into the make-up of the resultant color which it is desired to transmit. The potential across this output resistor might conveniently be referred to as the color potential. From this resistor, the potential is obtained representing the color desired to be transmitted, and it is impressed across another resistor **37** in series with the voice modulating potential resistors, whereby it becomes mixed with the program modulations and transmitted simultaneously therewith. The magnitude of the color potential may be adjusted by means of a variable contact **39** to the resistor of the series connected resistors, whereby one may suitably proportion the color potential to the program potentials and obtain the proper percentage of modulation.

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, and, once so provided, it will be connected in series with the other sources of oscillation as described. The oscillator **41** is intended for this purpose and its output feeds into a resistor **43** which is similar in construction and purpose to resistors **23**, **25** and **27**.

Where facilities are not available for the generation of color components, such as described above in combination with the broadcasting of original programs, it is within the contemplated scope of my invention to provide and utilize a recording of the color accompaniment alone; or a recording **45** on which both program and color accompaniment may be registered on the same track. The method of recording on a film is not a feature of the present invention. Any known method is applicable, reference being made to the patent to Fritts, No. 1,203,190 of October 21, 1936, for a prior art disclosure of such methods.

In the case where the program and color are recorded, the modulations representing the color accompaniment might well be mixed with the program modulating potentials in the process of recording the same, and these would appear on the sound track of the film or other device such as a disc or steel wire record on which such recordings may be made. With such a recording, the program and color accompaniment may very readily be broadcast, or transmitted over a wired system by scanning the recording by means of a light source **47** or similar agency, and a photocell circuit **49**, or utilizing a phonograph pick-up in the event that the recording is on a disc record, and impressing the resulting electric impulses upon the input circuit of the transmitting apparatus after amplifying the same, if necessary. Whether the program and color accompaniment be an original or a reproduction from a recording, the modulated output energy will be the same in either case.

In receiving the energy so broadcasted, the combined program and color accompaniment is received on a common receiver **51**, wherein it is detected and the program and color impulses are derived from the carrier component and appear in the output circuit of the receiver in mixed form. At this point, the respective program and color frequencies must be separated and this may be readily accomplished by placing a filter **53** in the circuit to the sound reproducing device **55**, this filter being so designed as to pass all audio frequencies above the highest frequency assigned to the primary colors.

The energy representing the color accompaniment is impressed across a potentiometer **57**, and adjustably connected to this potentiometer is 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. Ordinarily, there will be three such windings, **61**, **63**, **65**, respectively, but where a separate frequency is provided at the transmitter for the color white, there will be a corresponding additional winding **67** at the receiving station. 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 colors at the transmitting station. 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 a two-element tube **77**, **79**, **81**, **83**, and impressed across a potentiometer 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 is utilized a plurality of tubes **101**, **103**, **105**, **107**, of the gaseous discharge type, there being one tube for each color component represented. Each of these tubes comprises a cathode **109**, anode **111** and control electrode **113**, the anode circuits of each including an electric light or lights **115** 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 tube 107 which will be white in 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 a rectifying device 119 comprising an anode 121 and cathode 123, 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 121 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 may be made variable to permit of independently adjusting the intensity of its associated lighting effect. Suitable control of these variable resistors 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.

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. This takes place only during a portion of the positive half cycle, since the various tubes 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 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 tubes. In the circuit described, the various resistors representing the intensity of the primary colors at any instant perform this function, each one serving to raise or lower the voltage level of the grid of its associated discharge device, thereby causing conductivity of the tube 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.

Should it be desired to obtain broader and more delicate shades than may be represented by the color impulses sent over from the transmitter, one can employ additional color reproducers such as disclosed in Fig. 2, and by off tuning the circuits corresponding to tuned circuits 69, 71, 73 and 75, such increase in delicacy of shading can be obtained without in any way altering the transmitting end of the system.

The intensity of all of the components can be varied simultaneously by manipulating the adjustable contact of the primary winding 59 thereby offering a method of adjusting the overall light intensity to suit conditions.

Should even greater light intensity be desired than can be obtained by adjustment of the primary winding contact on the resistor 57, lamps of lower voltage rating might be substituted in lieu of those which might normally be used; or full wave rectification of the 110 v. supply source voltage could be employed to advantage for this purpose in combination with full wave rectification of the color signal potentials.

Thus, simultaneously with the reproduction of the received programs on the loud speaker, one is able to obtain harmonious color lighting effects. If there are no facilities for receiving broadcast programs or programs transmitted over land wires, one can obtain the same type of entertainment locally by means of a recording 129, such as a film-recording, on which may be printed the voice modulations as well as color modulations indiscriminately and utilizing any type of scanning or pick-up system for transforming the recording into corresponding electrical impulses and utilizing these impulses in the same manner as one would utilize the output of the receiver as described above.

I have shown the program and color recording as occupying the sound track of a motion picture film, whereby during the projection of a picture in a theatre, the theatre may be flooded with an accompanying program of harmonious color light-effects.

In lieu of placing the component primary color lights directly in the plate circuits of the various gaseous discharge devices, one may connect therein a relay which, in turn, will close a circuit to some lighting system. As an alternative arrangement, one can also operate the customary theatre dimming circuits, utilizing dimming reactors in the plate circuits of these gaseous discharge devices. These are well known expedients in the art and may well be represented by the rectangle 115 in the plate circuits of the tubes 101, 103, etc.

In Fig. 3, I have illustrated a simplified form of circuit, simplified in the sense that I have employed tubes of the multiplex type in lieu of the many rectifiers and electron discharge devices disclosed in the circuit of Fig. 2. Similar elements in the circuit disclosed and that of Fig. 2 bear like reference numerals. The tubes employed may preferably be of the type described in a copending application of mine, Serial No. 656,659, filed February 14, 1933, now Patent No. 2,052,617 of September 1, 1936, wherein 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, are housed in a single blank. 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 pending application cited.

A tube of the type disclosed in my copending application, referred to above, may very well be utilized at the transmitting end to simplify the circuits employed in the generation of the color frequencies. Each group of electrodes can be connected up to constitute an oscillator or frequency generator. By reason of the elaborate and efficient shielding provided in my tube construction, interaction of the electrode groups will be minimized, particularly so, if the shielding construction is negatively biased.

In my discussion of the invention above, I have disclosed the transmission and reproduction of color effects in synchronism with programs including musical and cinema productions. I have also disclosed where the programs are reproduced from some recording, that by assigning to the component colors a frequency band outside of that encompassed by the program modulations, that the color frequencies might be recorded on the same record and together with the program recordations.

Where the color accompaniment is to be transmitted for use in accompanying cinema productions, no change will be necessary in the picture producing or projecting apparatus, since the modulations representing the color accompaniment may either be taken from the standard sound track of a moving picture film or from an independent recording of the same and reproduced in synchronism with the projection of the pictures on the screen.

As it is intended that the color reproducing circuit disclosed by me might be used in conjunction with the production of broadcast programs, it becomes desirable that the color reproducing apparatus be made as independent as possible from the program producing apparatus. While both the color and the sound reproducing circuits might be embodied into a common apparatus, the color reproducing apparatus might just as well be constructed as a separate unit and so designed as to be readily tied in with a broadcast receiver, without the necessity of causing owners of such receivers to incur expenses in the remodeling of their receiving sets. This might be readily accomplished by employing adaptors constructed in the form of wafers which might be placed under a tube or tubes in the audio frequency stages of the receiving set. By connecting such adaptors to the color reproducing apparatus, the signals representing the primary colors will be transmitted to the color reproducing apparatus.

The wafer adapter will contact the pins of the tube in connection with which it is used, and conductors embedded in the adapter and connected to such contacts will enable one to tie in another audio amplifier in parallel, the output circuit of which can be coupled to the color reproducer.

Even should the wafer device not be relied on to obtain the color potentials from the receiving set, it is apparent that it would require very little in the way of alterations to connect the color reproducing apparatus to the receiving set. All one has to do is to connect the input leads represented in the drawings by the leads to the primary winding of the multi-winding transformer to some circuit in the audio frequency stages from which the audio potentials may be obtained. The resulting color lighting effects may be played upon a screen built into the radio receiving cabinet, which screen may conveniently occupy the space in front of the loud speaker, or the screen may be built into the cabinet housing the color reproducing apparatus, should such apparatus be housed in a separate cabinet.

While I have disclosed the transmission of color potentials simultaneously with the transmission of program modulations, the operation of the color reproducing circuit at the receiver does not necessarily have to rely on the presence of color modulations in the received signals. One can design the tuned circuits of the color reproducer so as to have band pass characteristics, each circuit being capable of responding to a different band of frequencies within the audio frequency specrum. When so adjusted, the color reproducer will interpret the program potentials in terms of color thereby adding to the entertainment value of the program being received on the loud speaker or being projected on a screen.

The idea of interpreting the program potentials in terms of color, in lieu of broadcasting a special color accompaniment is particularly suitable for musical programs since the band pass circuits of the color reproducer might be so designed as to match the colors to the music. For example, the lowest frequency band pass filter might be so connected as to control the heavier or darker colors and their combinations, and when so connected will respond to the fundamentals of the lowest tones.

For fundamental frequencies higher in the scale, the colors may be shaded gradually towards the lighter and brighter colors.

Since harmonics appearing in musical tones are of lower volume and of higher pitch than the fundamentals, it will be apparent that the presence of strong harmonics will serve to add a small amount of a lighter color to the heavier colors representing the fundamental tones thereby producing delicate shading and blending of colors in accompaniment with with the musical program.

Another feature of advantage to be derived from interpreting program potentials in terms of color resides in the fact that the color reproducer will "play" along with and in synchronism with the program, and this is particularly advantageous in connection with the production of a musical selection. It is apparent that should the threatre or auditorium be bathed in a slowly changing color effect during the rendition of a fast tempo, the effect on an individual is quite apt to be negative in that the slowly changing light is likely to impede his emotional reactions to the music. Asynchronism between the musical rendition and the color interpretation of the same in the system disclosed by me cannot occur, since the lighting effect will inherently keep in step with the music.

In the above discussion of my invention, I have disclosed modulation of a carrier wave or carrier current with color representative variations. My invention is not limited to the modulation of these two types of carriers only, as it is intended for application to telephone systems or the like wherein a direct current would be modulated in lieu of one having alternating characteristics.

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

I claim as my invention:

1. In a system for the transmission of color effects, means for creating electrical impulses at a plurality of discrete frequencies, each discrete frequency representing a primary color component of the color effect to be transmitted, means for simultaneously modulating a single carrier with said primary color representative impulses in desired proportions and transmitting the same to a destination, means at said destination for transposing said representative impulses into corresponding primary colors and mixing the same to obtain the desired color.

2. The method of transmitting a program and color accompaniment which comprises modulating a carrier with program impulses lying within a certain band of frequencies, assigning discrete frequencies outside of said band of frequencies to represent components of the colors to be transmitted, and simultaneously and directly modulating said same carrier with impulses at those frequencies which represent the color accompaniment.

3. The method of transmitting programs and accompanying continuous color effects which comprises recording said program and color effects on a common record in a manner which distinguishes the program from the color effects, creating therefrom a series of electrical impulses having components representing the program and color effects, the character of the color components of said electrical impulses representing in turn the color and intensity of the color effects, modulating a carrier with said impulses and transmitting the same to a destination, subsequently removing the carrier component and separating the resultant components into those representative of the program and those representative of the continuous color effects and simultaneously translating said impulses into the program and color effects.

4. The method of transmitting programs and accompanying continuous color effects which comprises recording said program and continuous color effects on a common record in a manner which distinguishes the program recording from the color effects recording, creating therefrom a series of electrical impulses having components representing the program and color effects, the character of the color components in turn representing the color and intensity of the color accompaniment, transmitting said impulses over a common medium and converting said impulses into their representative program and color effects.

5. In a system for the transmission of program and accompanying continuous color effects wherein the program and color effects have been transmitted over a common medium in a manner which distinguishes the program from the color effects, the method for reproducing the program and color effects comprising creating from said system of transmission a series of electrical impulses having components representing the program and color effects, the character of the color components in turn representing the color and intensity of the color effects, and translating and converting said impulses into their representative program and color effects.

6. The method of transmitting program and accompanying continuous color effects which comprises the creating a series of electrical impulses having components representative of the program and components representative of the color effects, the character of the color components representing in turn the color and intensity of the color effects, transmitting said impulses over a common medium, and translating and converting said impulses into their program and color effects.

7. The method for transmitting unified productions of programs and accompanying continuous color effects which comprises recording said programs and color effects on a common record in a manner which distinguishes the program recordings from the color effects recording, deriving from said record a series of electrical impulses having components representative of at least one program of said programs and components representative of the color effects the character of the color effects components in turn representing the color and intensity of the color effects, transmitting said impulses over a common medium, converting said impulses into their representative program and color effects and simultaneously reproducing the remaining programs in said unified production to obtain the desired reproduction of unified programs and accompanying continuous color effects.

8. In a system for reproducing unified productions of programs and accompanying continuous color effects wherein said color effects and program are reproduced from a series of electrical impulses having components representative of the program and color effects, the method which comprises converting the program into a series of electrical impulses, generating discrete series of electrical impulses the character of each discrete series representing the color and intensity of a primary color component of the color effects to be recorded, combining the program and accompanying continuous color effects impulses into a combined series, recording the same on a common record from which the unified production of program and accompanying color effects may be reproduced.

9. In a system for reproducing unified productions of programs and accompanying continuous color effects wherein said color effects and at least one program are reproduced from a series of electrical impulses having components representative of the program and of the color effects, the method which comprises converting at least one program of said programs into a series of electrical impulses, generating discrete series of electrical impulses the character of each discrete series representing the color and intensity of a primary color component of the color effects to be recorded, combining the program and color effects impulses and recording the combined impulses and the remaining programs in said unified production on a common record from which the unified production of programs and color effects may be reproduced.

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