This invention relates to lighting systems and, in particular, to new methods and apparatus particularly useful for television transmission systems and studio lighting of scenes to be transmitted in color.

In the past, transmission of colored pictures by television has utilized a rotating disk in front of a television camera, the disk carrying three filter sectors, each filter sector corresponding to one of the primary colors, the scene to be transmitted merely being illuminated with incandescent or arc light, that is, with white light. Coincident with the light transmitted sequentially by each filter, interlaced scanning of well known types of the scene is performed with the result that, for tricolor television, three trains of television signals were produced, each train representative of one of the primary colors. Various minor variations of the process were possible but in all of them the scene was illuminated by white light and successively or cyclically scanned through component-color (primary color) filters placed at the television camera. At the receiver means are provided for converting each of the trains of signals into a light image having a color corresponding to the transmission filter through which the scanning operation took place. The three reproduced colored images either simultaneously or superimposed upon one another to produce the colored picture finally observed.

Such systems suffer at the transmitting end from the necessity of supplying a rotating disk, and its drive motor, generally in necessarily close mechanical and electrical juxtaposition to the sensitive television camera. The mechanical complications of such a system have militated against an all-electronic method which is extremely desirable because the all-electronic method, being silent, permits the use of high sensitivity microphones on the set to provide the sound to accompany the pictures, and also avoids vibration of the camera tube. Moreover, all-electronic transmitting equipment can be made much more compact and so lends itself more readily to television program production work.

By my invention, I eliminate the necessity of the filter disk in front of or near the camera lens. Moreover, all mechanical and moving parts can be eliminated from the camera and yet my invention permits all of the benefits which arise from sequential scanning.

Moreover, my method and apparatus for lighting a scene may be adapted to provide means for obtaining increased depth of field in accordance with the IR system described in U. S. Patents No. 2,244,687 and No. 2,244,688, and, in addition, to offer the advantage of increased efficiency of the color lighting system for color television. In accordance with my invention, the illumination of the set, performed by flashing lamps, gives a selective and efficient radiation of an appropriately colored light, which with minimum filtering corresponds to the desired color component illumination. The illumination or flashing of lamps takes place during the blanking interval of the field scanning of the camera mosaic and the cyclic repetition of the red, green, and blue flashes from the lamps within the return line period of the field scanning may be made in any desired order within each cycle of operation. Thus, it will be observed that during the return line time a high intensity of red light will be projected upon the screen. The duration of the flash, being short, charges up the mosaic with an electrically stored image during the return line time of the field scanning. The mosaic is subsequently scanned to produce a train of signals which correspond to the red image. After the end of the scanning of the mosaic, a green flash of high intensity takes place during the return line time and the mosaic is then scanned to produce a train of signals corresponding to the green image. Following this, a high intensity blue flash of illumination is provided again during the return line time and the subsequent scanning provides a wave train of signals corresponding to the blue image. The cycle is then repeated. Since the scene is illuminated for each field by only one primary component of color, it will be understood there is no necessity for providing a filter disk in front of the camera, since the light source itself provides suitably color filtered illumination. If it happens that the spectral emission characteristics of the lamps are not identical with that desired for the three component colors, then they may be corrected by placing color filters adjacent to the lamps or coating the lamps with color filtering material, the absorption of the materials providing the proper correction. Since the lamps act only for a brief duration, it will be appreciated that increased efficiency is obtained, with the added advantage that the total heat dissipation in the studio is brought down to a very low value and thus reducing the difficulty of maintaining the studio at an appropriate temperature.

Accordingly, the main object of my invention is to provide a new and improved method and
apparatus for illuminating scenes for the transmission of color television pictures.

Another object of my invention is to provide apparatus for illuminating television scenes so that increased efficiency is obtained by the operation of the lamps to the blanking interval or the return line time of the field scanning of the television camera mosaic. Further increase in lighting efficiency results, as previously stated, from the use of selectively radiating lamps of inherent color approximating to one of the primary or component colors, thus minimizing the amount of color filtering and the consequent loss of light.

Another object of my invention is to provide apparatus for illuminating scenes for the transmission of the colored television pictures which operate in synchronism with a scanning apparatus and in which the set illumination takes place during restricted time intervals. Other objects of my invention will become clear upon reading the following detailed description, together with the drawings.

In the drawings, Figure 1 shows in graphical form the relationship between the sweep impulses for synchronizing the field sweep oscillator, the sweep wave, the light flashes, and the scanning periods; Figure 2 shows one arrangement of lamps suitable for use with my method and system of illuminating scenes; Figure 3 shows a modification of the embodiment of the lamp arrangement shown in Figure 2; Figure 4 shows a still further modification of the embodiment of lamps shown in Figure 2; Figure 5 shows schematically a circuit arrangement for actuating the lamps sequentially and in synchronism with the scanning apparatus, while Figure 6 shows diagrammatically the arrangements and apparatus for illuminating a scene taken together with the camera to show the inter-relation of the units used in my invention.

Turning now to Figure 6, it will be observed that the studio scene comprises the backdrops 51 and 52, the various pieces of furniture 53—63, and the actor 64. To television a scene, a camera 65, which may be of any conventional type known in the art, has its scanning operation controlled from the synchronizing generator 71. The scene is illuminated, for example, by a plurality of flood lights 66 and the spot light 67. The lighting units are supplied from the lamp supply source 75, and controlled by the flashing control units 73. The flashing control unit is synchronized from the synchronizing generator 71 so that the flashing takes place in synchronism with the scanning operation of the camera, that is to say, the flashing of the lamp is controlled to take place during the blanking interval of the scanning period. The flood lighting units may take the form shown in Figure 4, in which the three individual lamps 181, 183, 185 each have a predetermined restricted spectral emission, as, for example, red, green, and blue. The reflector 187 serves to direct the light from the lamps on the scene being illuminated. The lamps are closely adjacent to each other, and since the unit is usually positioned at some distance from the scene, the three lamps flashed sequentially appear to be equivalent to a single line source. The sequence of operation will be appreciated upon considering Figure 1.

In Figure 1 the sweep impulses 1, supplied from the synchronizing generator, serve to trigger the field oscillator periodically. The sweep wave of the oscillator has a long linear rising slope 3 and a short steep return portion 5 so as to provide rectilinear scanning in one direction of the mosaic of the camera mosaic. During the tube, the return portion 5 pulses are applied to the control grid of the scanning tube to reduce the beam intensity to zero. This interval is known as the blanking interval. Coincident with the turning off of the beam, the scanning tube, one of the lamps of each unit 65 of Figure 6 is flashed, as, for example, at 7. The lamp flashed during the interval shown in Figure 1 at 7 corresponding to the red light is of sufficient intensity to produce a stored charge image on the mosaic which thereafter is scanned during the time interval 13. Following the scanning of this image corresponding to the red image, the green lamp is flashed at the interval 9 and the mosaic is scanned during the interval 15. Following the completion of the scanning interval 15, the blue lamp is flashed at 11 and the resultant mosaic image scanned during the time interval 17. Thereafter the cycle is repeated. It will be appreciated that the light flashes 1, 3, 5, corresponding to the flashing of the lamps 111, 112, 113, respectively, of Figure 2 and of lamps 175, 176, 177, respectively, of Figure 3, and of lamps 181, 183, 185, respectively, of Figure 4. For spot lighting the lamp systems shown in Figure 2 and Figure 3 may be used advantageously. Thus, in Figure 2 there is shown an assembly of three lamps (red, green, and blue flashing lamps, respectively). Each lamp is mounted in its own container but the containers are mechanically combined as a unit in such fashion that they throw light on substantially the same portion of the set regardless of the color thereof. The lamps can be provided with an anti-parallactic adjustment whereby the axes of the respective beam can be shifted through a small angle relative to the central axis of the lamp system 171—173 in such fashion that the illuminated areas from each of the colored flashing lamps may be made to coincide with any desired degree of accuracy at the normal illumination. Figure 3 shows another embodiment of the composite lamps similar to the Figure 2, except that each of the lamps is mounted within the common cylindrical or other container 174 and occupies, or is placed at the end of, a cylindrical sectorial solid portion thereof as indicated, for example, by 175—177. A common condensing lens may be used for each of the three light sources. As before, anti-parallactic adjustments may be provided in this case as well, and these will comprise preferably the shifting of the light source in each sectorial portion in a direction perpendicular to the central axis of 174 (that is, radially outward in a line parallel to one of the bisectrices of the angles between the dividing planes separating the respectively colored lamp compartments).

As a further embodiment, the reflector illustrative of the functioning of flashing lamps and their suitable timing is shown in Figure 5. A mechanical system of timing is illustrated, although it should be understood that electronic timing methods are also available. For that purpose impulses derived from the blanking sequence of the television system might be employed. It is believed not necessary, however, to show an electronic timing.
system since it is no different in principle from the method shown in Figure 5.

The A. C. generator 101 supplies power to the mains 102, 103. A high-voltage D. C. source is illustrated by A. R. in the upper portion of the figure, this being a conventional full-wave high-voltage rectifier system. The transformer 168, 169, 171 supplies power to the anodes 114, 115 of the rectifiers 111, 112, which may be of any conveniently available type, e. g., thyratrons. The high-potential transformer 110, 116, which is center-grounded at 117, is connected to the anodes 114, 115 of the rectifier. The neutral point 106 of the secondary of the filament transformer 105, 107 is connected to the anode 126 of the flashing gas lamp 125. These lamps which are well known at this time as applied to stroboscopic illumination, are generally filled with one or more inert rare gases, e. g., neon, argon, krypton, at low pressure. Connected across the terminals 126, 127, of the lamp is the high potential condenser 128, the periodic discharge of which produces the desired flashes of light from the lamp. The high resistance 129 is connected across 126, which is shunted by the connections 126 when the lamp is not in use, thus minimizing the danger of electric shock to the operating personnel. The cathode 127 is connected through a resistance 130 of appropriate value to the ground 131. The rectifier R. is connected across 126, which is discharged each time (that is, 1/60 of a second between successive discharges of the same lamp of a given color), a suitable alternator frequency might be 60 cycles or, preferably 120, 180, or a higher number of cycles. These values are purely illustrative. If the number of fields per second is increased beyond 60, (as will generally be the case for tricolor television), the frequency of alternator 101 may be correspondingly increased. It is necessary that there shall be a sufficient number of charging waves between discharges to bring the condenser 128 to a suitably high potential adequate for the operation of tube 125.

The triggering or discharge of such tubes can be accomplished in various manners, one of the simplest of which is to provide an auxiliary external or internal electrode 132 as shown in one portion of the tube and then applying a brief high-potential pulse to the electrode 132. The initial ionization thus produced within the tube by the pulse in question will initiate the discharge which rapidly follows and which, in general, lasts only a few microseconds.

In Figure 5 a typical ignition-coil system is shown for producing the high-voltage pulse on the auxiliary or trigger electrode of the lamp. The circuit of primary 136 of the step-up transformer 134, 135 starts with ground 136, passes to high voltage 136, high voltage to high voltage 134, to conduct segment 141, intermittently to brush 142 through D. C. source 145, and back to ground 144. The condenser 139 is connected across the intermittent contact 141, 142 to reduce sparking. Whenever the contact 141, 142 is closed, the high voltage is produced in secondary 134 which triggers lamp 125. It will be noted that the commutator assembly of slip rings and segments associated with brush 142 is driven synchronously by a motor in the direction 146 at a speed such that one of the segments 141, 145, or 146 passes under 142 once per color field of the scanning and at a time (phase) substantially in the middle of the blanking period preceding the corresponding color scanning, as shown in Figure 1 at 1, 9, 11.

The lamp 125 is assumed to be rich in red light and, if necessary, to be filtered further to produce substantially the primary additive red illumination of the set. Lamps 150 and 151 are similar except that they produce light rich in green and blue respectively, preferably, and are, if necessary, color filtered to produce the corresponding primary additive green and blue respectively. Lamps 125, 160, and 161 correspond to the three flashing lamps which would be used in the assemblies shown in Figures 2 and 3.

The rectifying units R2 (160) and R3 (164) are not shown in detail since they are substantially identical with R1. They feed respectively the lamps 150 and 151 in a manner entirely similar to that in which R1 feeds lamp 125; nor have I shown the connections from 147 and 140 of the flashing or triggering commutator to the trigger electrodes 155 and 157 respectively of the lamps 150 and 151, inasmuch as the circuit is identical with that already disclosed in connection with lamp 125.

It will be appreciated of course that for spot lighting the lamps may take a form of a helix in which, for example, there may be provided three separate concentric turns, each turn corresponding to one of the primary colors. Again, coaxial or concentric circular lamps may be provided, each ring again corresponding to one of the three primary colors. It will also be appreciated that while, for example, a mechanical type of commutator has been shown for supplying pulses to initiate the discharge of the lamps; in synchronism with a scanning operation, an electronic commutator of the Shumard or Roy & Mayer type described in U. S. Patents 2,146,822 and 2,089,430 may be provided.

Moreover, it will be appreciated that the generator 101 may be an electronic oscillator capable of supplying sufficient power, for example, tuned transformers and rectifiers to provide sufficient voltage step-up for charging the condenser. Such oscillators have the advantage of rendering the flashing characteristic of the lamp somewhat more stable in view of the fact that the ripple voltage becomes relatively unimportant when the frequency of the generator becomes large compared with the cyclic time of the discharge of the lamps. It is believed unnecessary to illustrate such an oscillator since such oscillators and rectifying systems are well known in the art.

It will be appreciated that if the storage of the camera tube mosaic is excessive, a spurious signal may be generated following the scanning of one of the colored fields by the next colored field, since interlaced scanning is used. In ordinary practice this effect does not arise, but, if it is present, then its effects can be obviated by flooding the mosaic with electrons or light of appropriate intensity to restore it to a datum potential after each scanning and before the next illuminating flash, as indicated schematically by Fig. 1, with the datum level of potential shown as W (that is, for instance, white light) which follows each of the scanning periods R, G and B and slightly precedes the flash periods 7.
4. 2,843,971

and it for the different primary color lamps corresponding to the red, green and blue. In addition to flooding the mosaic, any of the other well known means to restore all of the elemental areas of the mosaic to an equilibrium potential may be used. These methods are well known in the art and it is considered unnecessary to illustrate them, it being appreciated, however, that the restoration of the mosaic to a datum potential must take place following the scanning of the field and before the flashing of the lamp.

Various alterations and modifications of the present invention may become apparent to those skilled in the art and it is desirable that any and all such modifications and alterations be considered within the purview of the present invention except as limited by the hereinafter appended claims.

Having now described my invention, what I claim is:

1. The method of transmitting color television pictures which includes the steps of illuminating the scene to be transmitted sequentially with a series of primary component color lights, producing an electric charge image representative of the scene by each illumination, limiting the illumination duration to a period relatively short compared to the time duration between the sequential illuminations of the scene.

2. The method of illuminating scenes for transmission of color television pictures which includes the steps of briefly illuminating sequentially the scene by lights of different colors and controlling the period of illumination so that it is short as compared to the period between the sequential operations of the lamps.

3. The method of transmitting color television pictures which includes the steps of sequentially illuminating the scene to be transmitted with a series of primary component color lights, producing an electric charge image representative of the scene by each illumination, limiting the illumination duration to a period relatively short compared to a scanning cycle, scanning the charge image between the illuminations of the scene, producing a train of electrical signals representative of each scanning, and transmitting the produced image signals.

4. The method of illuminating scenes for transmission of color television pictures which includes the steps of cyclically illuminating the scene by light of a first, a second, and a third predetermined spectral emission, and controlling the time period of illumination so that it is short as compared to the time duration between the sequential illuminations of the scene.

5. The method of transmitting color television pictures which includes the steps of sequentially illuminating the scene to be transmitted with a series of primary component lights, producing an electric charge image by each illumination, interrupting the illumination, then scanning the charge image between the illuminations of the scene to produce electrical image signals, maintaining the scanning period relatively long compared to the duration of each illumination to synchronize the initiation of illumination with the termination of the scanning of the charge images, and transmitting the produced image signals.

6. The method of illuminating scenes for transmission of color television pictures which includes the steps of briefly illuminating sequentially the scene to be scanned for transmission by lights of different colors, controlling the inception of illumination to occur during the period between scanings and restricting the duration of illumination so that it occurs during a short time period as compared to the time period of scanning.

7. Apparatus for transmitting color television pictures comprising means for illuminating the scene to be transmitted sequentially with a series of flashing lights of primary component color, means for producing an electric charge image of the scene by each illumination, means for establishing the period of illumination by each primary color to a period relatively short as compared to each scanning cycle, means for scanning the charge image between the illuminations of the scene to produce a train of electrical signals representative of each scanning, and means for transmitting the produced image signals.

8. Apparatus for illuminating scenes for transmission of color television pictures comprising means for cyclically illuminating the scene by light of a first, a second, and a third predetermined spectral emission, and means for controlling the time period of illumination so that it is short as compared to the period between the sequential illuminations of the scene.

9. Apparatus for transmitting color television pictures comprising means for illuminating sequentially the scene to be transmitted with a series of primary component color lights, means for producing an electric charge image by each illumination, means for scanning the charge image between the illuminations of the scene, and means for maintaining said scanning period relatively long compared to the duration of each illumination.

10. Apparatus for illuminating scenes for transmission of color television pictures comprising means for briefly illuminating sequentially the scene by lights of different colors and means for controlling the period of illumination so that it is short as compared to the period between the sequential operation of the lamps.

11. Apparatus for transmitting color television pictures comprising means for illuminating the scene to be transmitted sequentially with a series of primary component lights, means for producing an electric charge image representative of the primary color light value of the scene for each illumination in the separate colors, means for scanning the charge image between the illuminations of the scene to produce electrical image signals, means for maintaining the scanning period relatively long compared to the duration of each illumination, means for synchronizing the initiation of illumination with the termination of the scanning of the charge images, and means for transmitting the produced image signals.

12. Apparatus for transmitting color television pictures comprising means for briefly illuminating sequentially the scene to be transmitted by lights of different colors, means for controlling the inception of illumination to occur during the period between scanings, and means for restricting the duration of illumination to a short time period as compared to the time period of scanning.

13. Color image apparatus comprising a scene of which a colored image is destined, a bank of light sources for illuminating the scene, each source having a predetermined restricted spectral emission, means for scanning said scene at a predetermined scanning repetition cycle, means to synchronize the initiation of the illumination of the scene with a predetermined portion of the
operational cycle of the scanning means, and
means for restricting the duration of the illumina-
tion to a minor fractional part of the scan-
ing cycle.

14. Color image apparatus comprising a scene
of which a colored image is desired, a bank of
light sources for illuminating the scene, each
source having a predetermined restricted spe-
tral emission, means for scanning said scene,
commutator means to synchronize the illumina-
tion of the scene with the scanning means and
means for restricting the duration of the illumina-
tion to a minor fractional part of the scan-
ing cycle.

15. Color image apparatus comprising a scene
of which a colored image is desired, a bank of
light sources for illuminating the scene, each
source having a predetermined restricted spec-
tral emission, means for scanning said scene,
electric commutator means to synchronize the
illumination of the scene with the scanning
means and means for restricting the duration
of the illumination to a minor fractional part
of the scanning cycle.

16. Color image apparatus comprising a scene
of which a colored image is desired, a bank of
light sources for illuminating the scene, each
source having a predetermined restricted spectral
emission, means for scanning said scene, a com-
mon synchronizing means to initiate cyclic opera-
tion of said sources and said scanning means and
means for restricting the duration of the illumina-
tion to a minor fractional part of the scanning
cycle.

17. Color image apparatus comprising a scene
of which a colored image is desired, a bank of
light sources for illuminating the scene, each
source having a predetermined restricted spectral
emission, means for scanning said scene, and control
means to initiate said scanning means and to restrict the operation of said
sources to time periods between successive scan-
nings.

18. The method of illuminating scenes for
transmission of color television pictures which
includes the steps of briefly illuminating sequen-
tially the scene by lights of different primary
colors and controlling the period of illumination
so that it is short as compared to the period be-
tween the sequential illuminations of the scene.

19. A method of television transmission which
comprises illuminating a scene of action by a se-
ries of lights of primary component colors se-
quently illuminated, producing on a scanning
element an electric charge image of the scene of
action as a result of each illumination, interrupt-
ing the illumination period by each of the pri-
mary component lights promptly after initiation,
scanning the produced charge image during pe-
riods of illumination interruption to produce out-
put electrical image signals representative of the
scene of action, restoring all charge images to a
predetermined datum level immediately subse-
quently to each scanning, then repeating the cycle
of illuminating, scanning and datum level resto-
ration, synchronizing the sequence of datum level
restoration and the initiation and termination of
illumination with predetermined periods of the
scanning cycle, and transmitting the pro-
duced signal energy.

20. A television transmission system compris-
ing a plurality of light sources of each of a plu-
arity of primary colors, means for illuminating
a scene of action by sequentially illuminating
the said lights, an image scanning element, means
for producing on said scanning element an elec-
tric charge image of the scene of action for each
illumination, means for interrupting the illumina-
tion period of each of the primary component
lights, said scanning element including means for
scanning the produced charge image during peri-
ods of illumination interruption to produce out-
put electrical image signals representative of the
scene of action, electric means for restoring all
charge images to a predetermined datum level
immediately subsequent to each scanning, dis-
tributor means for causing the cycle of illumina-
ting, scanning and datum level restoration to
repeat in sequence, means for synchronizing the
sequence of datum level restoration and the ini-
tiation and termination of illumination with
predetermined periods of the scanning cycle, and
means for transmitting the produced signal
energy.

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