

Nov. 27, 1945.

G. E. SLEEPER, JR

2,389,646

TELEVISION SYSTEM

Filed Aug. 30, 1943

3 Sheets-Sheet 1

Fig. 1.

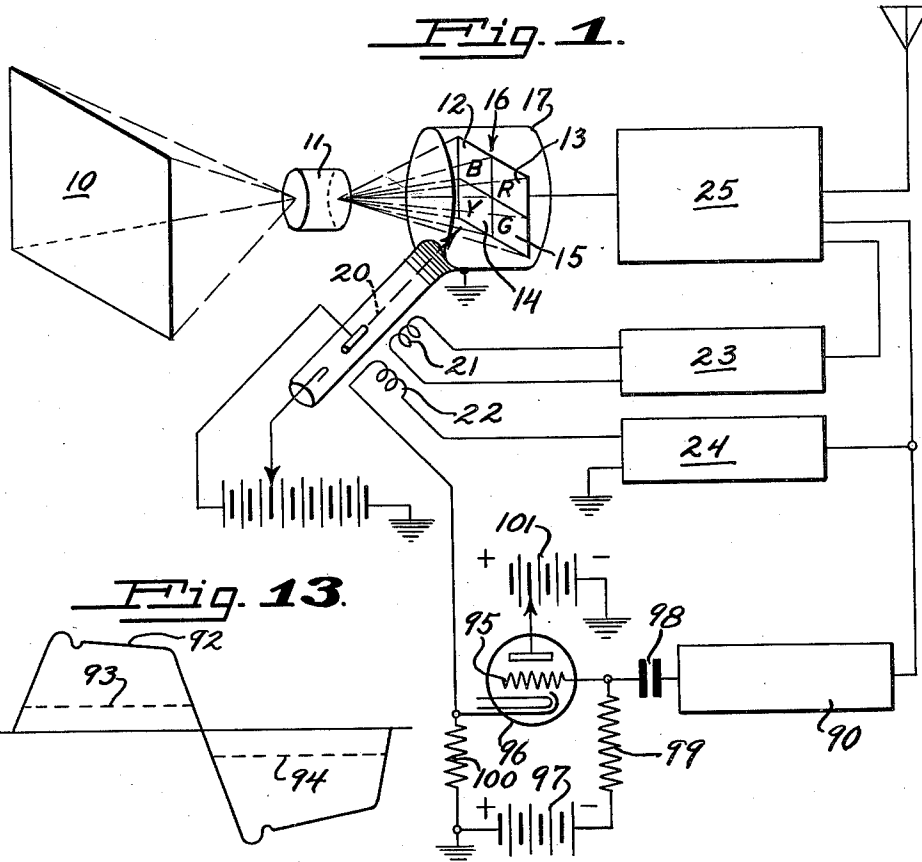


Fig. 13.

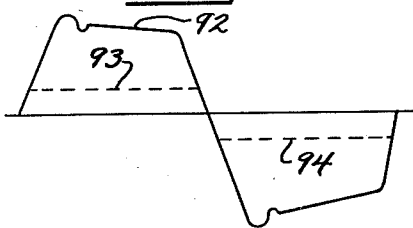
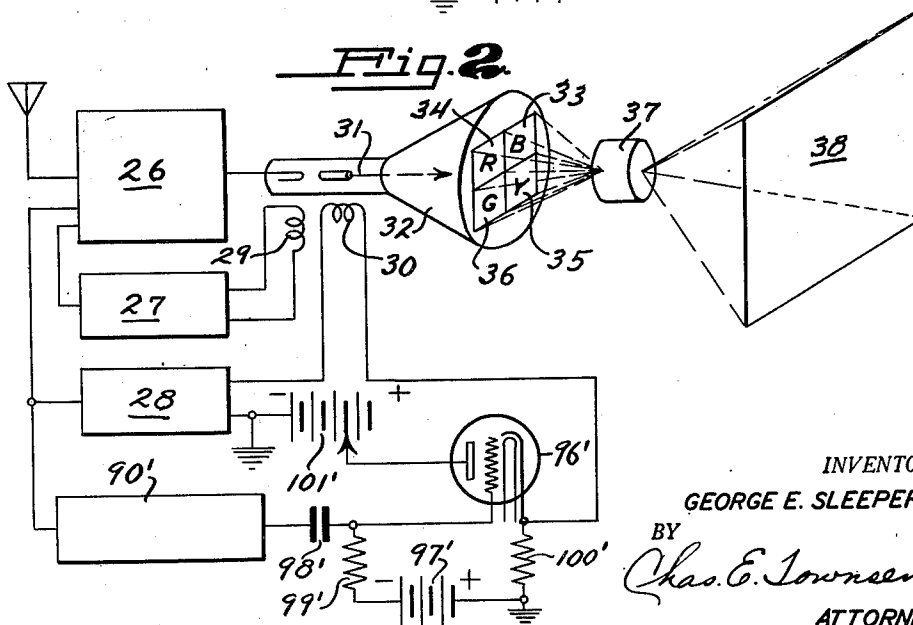


Fig. 2.



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3 Sheets-Sheet 2

Fig. 3.

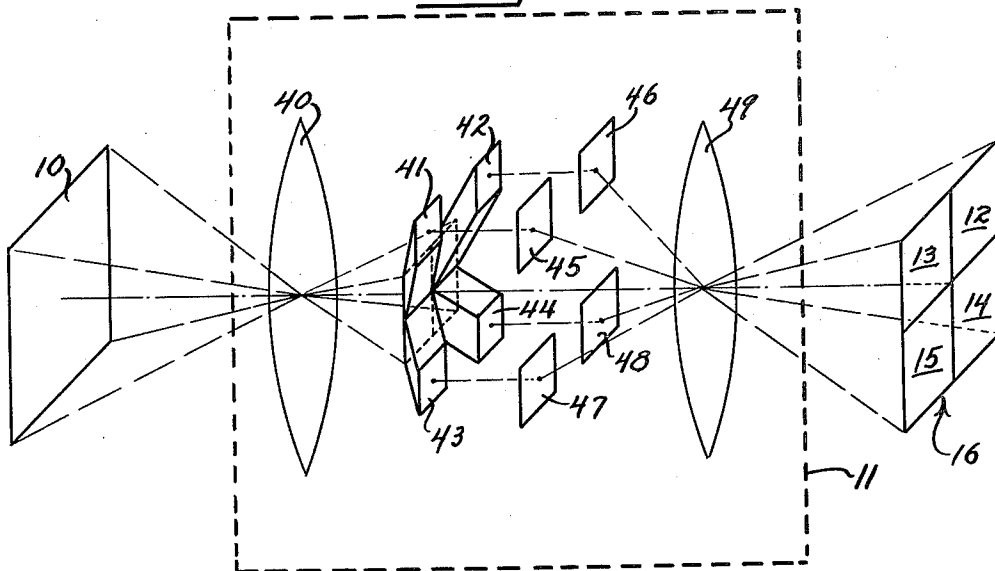
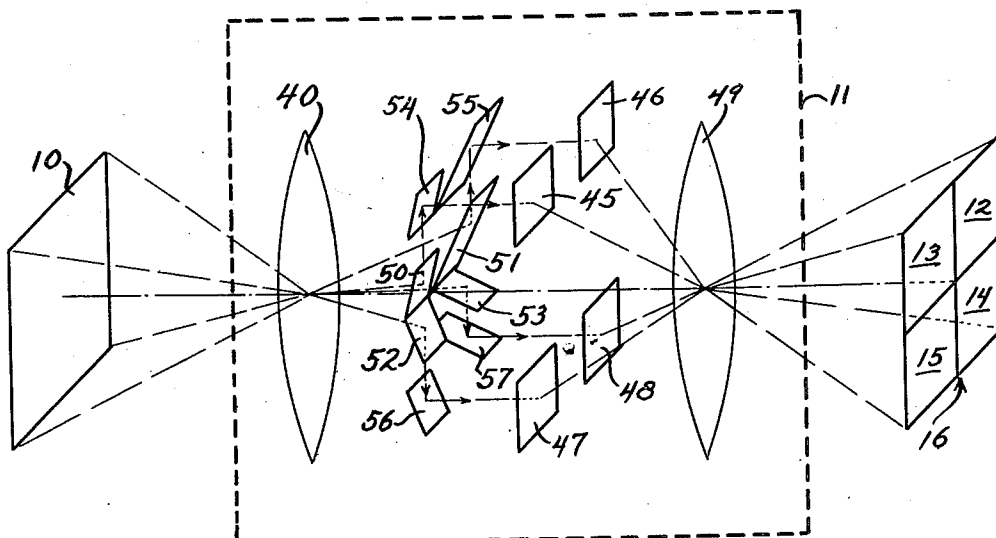


Fig. 4.



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3 Sheets-Sheet 3

Fig. 5.

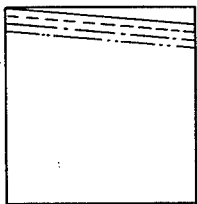


Fig. 6.

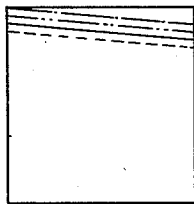


Fig. 7.

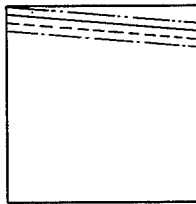


Fig. 8.

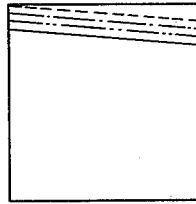


Fig. 14.

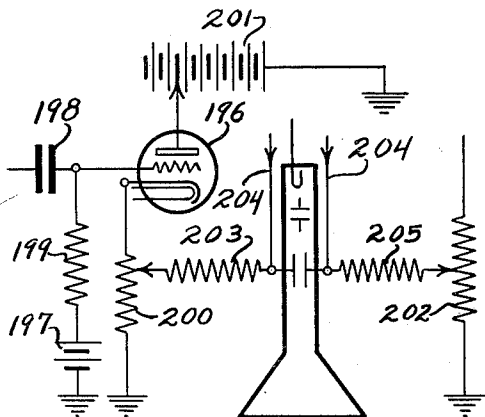


Fig. 10.

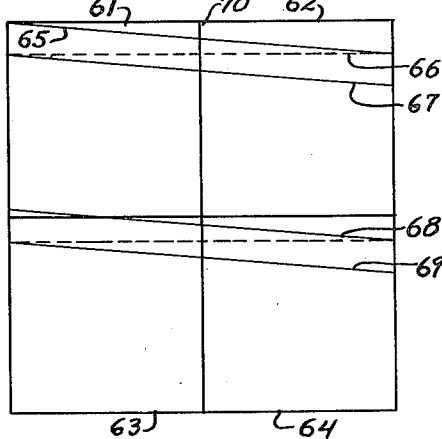


Fig. 11.

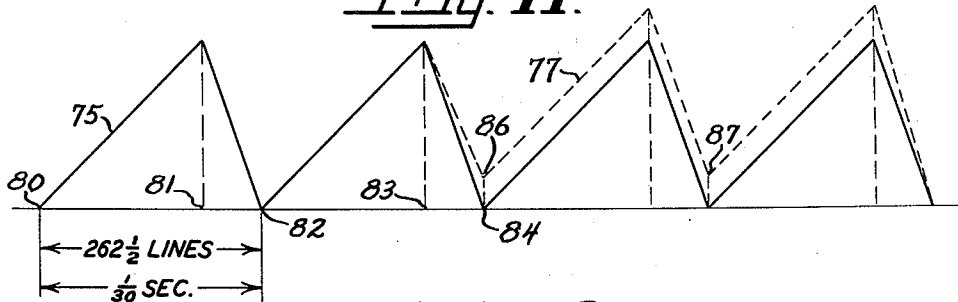


Fig. 12.



Fig. 9.

— RED
- - - YELLOW
· · · BLUE
· · · GREEN

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UNITED STATES PATENT OFFICE

2,389,646

TELEVISION SYSTEM

George E. Sleeper, Jr., Berkeley, Calif.

Application August 30, 1943, Serial No. 500,518

12 Claims. (Cl. 178—5.2)

This invention relates to television systems, and in particular to a system for transmitting pictures in color. This application is a continuation in part of my pending application Serial No. 474,787, filed February 5, 1943.

An object of my invention is to provide a television system which will eliminate the principal disadvantages inherent in present systems.

One such system employs rotating color filter discs in the transmitter and receiver. This involves mechanical difficulties and the problem of synchronization. In my system no mechanically moving parts are used. Systems which require projecting images of successively different colors on the photo-sensitive screen of the pick-up tube do not produce true color pictures because the discharge lag, especially in the storage-type tube, causes a carry-over of one color image to the next, with an undesirable mixing of colors. This objection is overcome in my system by allotting separate areas of the screen to each color, so that each area is always receiving images of the same color. Another system employs a separate tube for each color which has the disadvantages of increased cost and the difficulty of placing the tubes close enough together. My system employs a single tube for pickup and a single tube for picture production.

Another object of my invention is to make it possible to employ a standard black and white television system for transmitting color pictures by the addition of simple parts which effect the conversion. I accomplish this by introducing into the optical system which projects the images onto the screen of the pickup tube, a suitable means for simultaneously producing a plurality of images of the object, filtering each of these images for a different color, and projecting each color image on a separate area of the screen. These images are then scanned in a group as one picture in the same manner as a single black and white picture.

The tube in the receiver reproduces in black and white separate images corresponding to the color images in the pick-up tube. These images lack only color; they have the correct detail and intensity. The color is restored to each image by collecting it through a color filter and then by a suitable optical means the color images are superimposed on the viewing screen to produce a picture of the original object in its natural color.

It will be noted that the conversion of a standard television system to color is accomplished simply by adding an optical means at the transmitter which will project a plurality of images of different color into the tube and by adding a similar optical means at the receiver which reverses the process and assembles the picture.

However, although this conversion can be simply effected, it will be apparent that in making the combination, a complete system of color television is created which has the advantages pointed out above.

I will now disclose by reference to the accompanying drawings, an apparatus in which my invention is embodied.

Figure 1 shows schematically the transmitting portion of the system.

Figure 2 shows the receiving portion.

Figure 3 shows diagrammatically in perspective, one means for producing a plurality of images of different color of the object.

Figure 4 shows another means for this purpose.

Figures 5 to 8 are diagrams illustrating how the lines are arranged in the color fields.

Figure 9 is a key to the color symbols.

Figure 10 is a diagram which illustrates the method of scanning the quadchromatic field.

Figures 11 and 12 illustrate the production of the deflection coil curve.

Figure 13 illustrates the curve produced by the timing pulse generator.

Figure 14 shows a modified circuit for use in an electrostatic deflection system.

The number of color images obtainable by my system is a matter of choice. For purposes of illustration, I have disclosed four. I shall, therefore, refer to the lens system which produces the four images as a quadchromatic lens.

Referring to Fig. 1, the object 10 is picked up by the quadchromatic lens 11, which projects four images 12, 13, 14, 15 of different color onto the photoelectric screen 16 of the pick-up tube 17. The images 12, 13, 14, 15 may be blue, red, yellow, and green, respectively. The four images are conveniently grouped in a quadrangle. An important feature of my system is that the images do not overlap. The area of the screen 16 upon which any particular color image is projected continuously receives and responds to images of that same color.

The pick-up tube and transmission equipment may be of the conventional construction employed for black-and-white television and comprises the cathode ray tube 17, operated in the usual manner for developing picture signals and provided with a photo-sensitive mosaic screen 16. The electron beam 20 is projected onto the screen 16 and is caused to scan the screen in the usual manner by means of deflection coils 21, 22, connected to line and frame deflection generators 23, 24, respectively. The responses from the photo-sensitive screen are conveyed to the amplifier and radio transmitter 25.

The radio receiver 26 (Fig. 2) is connected to the line and frame deflection generators 27, 28 which are connected to the deflection coils 29, 30,

respectively, which deflect the electron beam 31 of the cathode ray tube 32 in the usual manner. The picture signals supplied to the tube produce four pictures 33, 34, 35, 36, corresponding to the four images 12, 13, 14, 15. These pictures are black-and-white but reproduce the detail and intensities of the originals.

A quadchromatic lens 37 which may be similar to the lens 11, but reversed, collects the four pictures, supplies the appropriate color to each by a filter, superimposes the four color images and projects a picture in natural color of the object 10 on the viewing screen 38.

The quadchromatic lenses referred to above could be constructed in different ways. For example, four separate lens systems could be employed, each provided with a filter. Each of these lens systems would project an image of the object in a different color on the screen of the pick-up tube. This means is thought to be readily understood without illustration.

An alternative means is shown in Fig. 3 where the object 10 is picked up by a lens 40, behind which are located four prisms 41, 42, 43, 44, adjusted relative to the lens 40 and to each other so as to produce four images of the object. Associated with the prisms are color filters 45, 46, 47, 48. A second lens 49 projects the four color images 12, 13, 14, 15 on the screen 16.

In the modification of Fig. 4, mirrors are substituted for the prisms. Four images of the object 10 are reflected by the mirrors 50, 51, 52, 53, onto mirrors 54, 55, 56, 57, which reflect the separate images through the color filters 45, 46, 47, 48, to the lens 49.

As previously explained, the quadchromatic lenses 11 and 37 (Figs. 1 and 2) are substantially identical but are used oppositely.

The foregoing matter is disclosed in the above identified application.

I will now disclose a method and means for scanning which is particularly adaptable to the previously disclosed color television system, but which has features useful in black and white television. For illustration, I have selected a scanning system which produces 525 lines in the color frame. That is, the picture produced on the screen 38 (Fig. 2) would consist of 525 lines. This means that the beam 31 in producing the quadchromatic field comprising the images 33, 34, 35, 36, will be required to operate at $262\frac{1}{2}$ lines. Similarly, the screen 16 (Fig. 1) will be scanned with the same number of lines. As will presently be explained more in detail, the choice of an odd number of lines in the frame results in an odd-line interlace after the second scanning. A special means is then employed to shift the scanning grating one line vertically and to maintain it so displaced during the third and fourth scanning cycles. An important result obtained by my invention is that each of the lines in the screen 38 goes through the complete cycle of four colors in the course of four scanning cycles. The result to be obtained is illustrated diagrammatically in Figs. 5, 6, 7 and 8. The color key is shown in Figure 9.

The first scan will produce a first color frame on the screen 38 (Fig. 2), the first four lines of which will be red, yellow, blue, green, in that order, as shown in Fig. 5. The second color field shown in Fig. 6 will have the first line blue, the second line green, the third line red, and the fourth line yellow, and so on through the four cycles, as illustrated in Figs. 5 to 8.

Fig. 10 illustrates diagrammatically the quad-

chromatic field which comprises the four color images of the object, the red image may be in the first quadrant 61, the blue image may be in the quadrant 62, the green image in the quadrant 63 and the yellow image in the quadrant 64. In the first scanning of this quadchromatic field the beam will traverse the red image in 61, as indicated by the line 65, and will then traverse the blue image in 62. During the fly-back time the line is blanked out, as indicated by the broken line 66. The next line 67 begins four lines down from the first line 66. In other words, the second line in the scan is the fifth line in the field. The red and blue field of 61 and 62 are scanned in this manner until the beam reaches the yellow field 64, as indicated by the line 68. This first line in the yellow field is an even line in the color frame (see Fig. 5) where it is shown as being the second line. After the fly-back the next line 69 traverses both the green field 63 and the yellow field 64. As shown in Fig. 5, the green line is the fourth line. It is to be noted at this point that in the first scanning odd lines in the fields 61 and 62 were scanned and even lines were scanned in the lower fields 63 and 64.

When the four images are colored by the quadchromatic lens 37 (Fig. 2), the color lines are optically interlaced, as illustrated in Fig. 5, so that the first line in Fig. 5 is a red line taken from the field 61 (Fig. 10); the second line is a yellow line taken from the field 64; the third line is a blue line taken from the field 62; the fourth line is a green line taken from the field 63. It is to be noted that by arranging the images in a quadrangle and scanning the quadchromatic field the lines in each of the four fields are scanned in such a position that when the images are optically superimposed an optical interlace results on account of the fact that all the lines scanned in the upper two fields are odd, whereas all the lines scanned in the lower two fields are even.

The result thus obtained I shall term seriate color line composition; that is, I compose the final color frame appearing on the screen 38 by arranging lines of different color in consecutive order or in series, so that, in the first color frame produced, as illustrated in Fig. 5, the lines in numerical order are red, yellow, blue, green, red, yellow, etc. There are certain factors responsible for this result: producing a plurality of separate images of the object; arranging the images in such a way and scanning the group of images in such a way that when optically superimposed the lines from the several images will be optically interlaced in proper order to produce a seriate color line composition.

After completely scanning the four fields 61-64 and after the vertical fly-back, the first cycle concludes at the end of $262\frac{1}{2}$ lines. This means that the second scanning will begin at the upper left-hand corner 70 of the field 62, so that the first line in the second color frame will be blue, as shown in Fig. 6, and the third line will be red so that an odd-line interlace is automatically obtained by selecting an odd number of lines in the frame and in addition an automatic interchange of colors is obtained. Notice that in the first color frame (Fig. 5) the first line is red, whereas in the second color frame (Fig. 6) the first line is blue. Thus a second seriate color line composition is produced which differs from the first in order of colors. In order to bring the green and yellow into the first line in the last two scannings it is necessary to shift the scanning

grating one line vertically. This is done, as will now be explained, by introducing a direct current pulse into the vertical deflection coils in order to move the grating of lines upwardly or downwardly whichever is desired.

Assuming that generator 24 of the vertical deflection coil 22 causes a standard saw-tooth curve 75, such as shown diagrammatically in Fig. 11, the result is obtained by super-imposing a pulse, such as that shown in Fig. 12 at 76, to alter the curve 75 to the shape shown at 77 in broken lines. Reviewing the operation so far by referring to Fig. 11, the first scanning of the quadchromatic field begins at the point 80. From 81 to 82 is the vertical fly-back time, and from the beginning 80 to the end 82 of the first scanning cycle is $262\frac{1}{2}$ lines. This causes an odd-line interlace during the second scanning from 82 to 83. During the fly-back time from 83 to 84 at the end of the second cycle the D. C. pulse 85 (Fig. 6) is introduced into the deflection coils so that the current is increased, as indicated by the point 86 in the broken line curve 77 (Fig. 11). This, as pointed out above, causes vertical shift of the grating in order to pick up the even lines in fields 61 and 62 (Fig. 10) and the odd lines in fields 63 and 64. At the end of the third cycle (point 87) on account of the fact that the cycle is $262\frac{1}{2}$ lines long, the fourth cycle will begin one-half a line from the beginning of the third cycle.

The vertical shifting of the grating is effected electronically as will now be described.

Referring to Fig. 1, a timing pulse generator 90 is supplied with a 60-cycle synchronizing pulse from the transmitter 25. The timing pulse generator 90 consists essentially of a conventional multivibrator circuit which generates a timing pulse of the frequency required to obtain the time interval shown in Fig. 12. In the present instance which has been chosen for illustration, this interval is one-fifteenth of a second because, as will be recalled, it is necessary to hold the grating displaced for two scanning cycles. Accordingly, a $7\frac{1}{2}$ cycle timing pulse is required.

The output of the multivibrator circuit is illustrated by the curve 92 (Fig. 13). If necessary, the output of the multivibrator circuit may be amplified to obtain sharp cut-off, and reshaped, as indicated in broken lines at 93 and 94 in Fig. 13, by clipping off the tops of the curves.

The timing pulse generator is connected to the grid 95 of a tube 96 which has a negative cut-off bias provided by the battery 97. The time constant of the coupling condenser 98 and resistor 99 is such as to pass the pulse to the said tube. The tube is connected to ground through a resistance 100 which is relatively small so as not to impair the normal operation of the deflection coil circuit. The power for the D. C. pulse is obtained from the battery 101.

The tube 96 (Fig. 1) merely acts as a switch to turn the current on and off through the tube and resistor 100. The coupling circuit, made up of the condenser 98 and the resistor 99, is such as to pass the triggering pulse to the grid of tube 96. The bias voltage on the grid is set so that no current flows in the tube until the positive half of the pulse cycle reaches the grid. When this occurs maximum current flows through the tube producing a voltage across the resistance 100 for one-fifteenth of a second and so producing the required direct current pulse.

Since the amount of current required to shift the deflection field one scanning line is relatively small, the ohmic resistance of resistor 99 may

be of a small value with respect to the ohmic impedance of the deflection coils. The amplitude of the current introduced into the deflection coils circuit is controlled by adjusting a slider tap on resistance 100. A second method would be to adjust the resistance as a whole to a value so that the right amplitude of pulse was produced. A third method is to vary the plate voltage and so control the maximum amount of current flowing through the tube and resistance 100. When a centering current is also required in the low frequency coil circuit there may be additional direct current flowing in the resistance 100 but the bias effect of this may be counteracted by adjusting the bias voltage either in a positive or a negative direction as the case may be. The bias on the grid of tube 96 should always be great enough to keep it cut off regardless of the scanning voltage and the exciting pulse on its grid should always be great enough that maximum current flows through the tube during its positive swing. This insures that the tube is only operating as a switch and not as an amplifier. The voltage on tube 96 must be well regulated. The circuit could be adjusted to act as an amplifier but the regulation of the amplitude of the pulse is more difficult. The direction of deflection which this pulse will give to the scanning field may be altered by connecting it in on one side or another of the grounding point of the scanning coils.

A similar means is employed in the receiver, as shown in Fig. 2. The transmitter sends out a sixty-cycle synchronous pulse which is received in the receiver and supplied to the timing pulse generator 90', which is similar to generator 90 employed in the transmitter. Likewise, the tube 96', with a condenser 98', is connected through a resistance 99' to a negative bias battery 97' and through a resistance 100' to ground. A battery 101' supplies the power which is switched by the tube 96' into the deflection coil 30 to provide a D. C. pulse in synchronism with the D. C. pulse at the transmitter.

As a result, during the third scanning a third seriate color line composition is produced, as illustrated in Fig. 7, where the first line is green and the order of colors differs from that in the first and second (Figs. 5 and 6). At the conclusion of the third scanning the odd-line interlace effect changes the order of colors for the fourth scanning so that a fourth seriate color line composition is produced, as illustrated in Fig. 8 where the first line is yellow. At the end of the cycle of four scanings each line has gone through the cycle of four colors.

The system described above may be varied as to picture frequencies, interlace ratios, etc. Below is a table of different systems, the first of which is the one just described:

Table I

System	1	2	3	4	5	6
Quadchromatic fields per sec.	30	60	30	60	60	120
Lines per quadchromatic field	$262\frac{1}{2}$	$131\frac{1}{4}$	525	$262\frac{1}{2}$	525	$262\frac{1}{2}$
Color fields per sec.	120	240	120	240	240	480
Color frames per sec.	30	60	30	60	60	120
Lines per frame	525	525	525	525	525	525
Electronic interlace ratio	1:1	2:1	1:1	1:1	1:1	2:1
Optical interlace ratio	4:1	4:1	2:1	4:1	2:1	4:1
Direct current pulse per sec.	$7\frac{1}{2}$	$7\frac{1}{2}$	15	15	30	30

For convenience, the above terms may be defined as follows:

Quadchromatic field—one scanning raster of the quad of images;

Quadchromatic line—one scan line horizontally across adjacent images in a quadchromatic field;

Color field—one scanning raster of lines covering an image of one filter color;

Color frame—four color fields of one quadchromatic field superimposed upon one another optically as at receiver; and

Frame—one full complement of lines over an entire assembled picture area similar to that in black and white television.

For introducing the direct current pulse into an electrostatic system a circuit, similar to that described above, is employed, as shown in Fig. 14. In this case the voltage across the resistance 200 is introduced into the deflection plates through coupling resistor 203. Scanning voltage may be introduced into the deflection plates from an electrostatic generator (not shown) connected to leads at 204. I have shown a coupling resistor 205 connected to a deflection plate and to a conventional centering potentiometer circuit 202 which may be connected to a D. C. voltage source (not shown). The desired polarity of field deflection may be obtained by introducing the pulse at the bottom of either one of the coupling resistors.

I claim:

1. The method of reproducing a picture of an object by television which comprises, producing a plurality of images of said object, arranging said images in a group, electronically scanning said group of images as a single picture with a single electron beam, transmitting the signals derived from said scanning, reproducing a group of images from said signals, and optically interlacing the lines of the reproduced images to produce a composite picture of the object.

2. The method of reproducing a picture of an object by television in color which comprises, producing a plurality of images of said object in different colors, arranging said different color images in a group, electronically scanning said group of color images as a single picture with a single electron beam, transmitting the signals derived from said scanning, reproducing a group of images from said signals, restoring the colors to said images, and optically interlacing the color lines of the reproduced images to produce a seriate color line composition.

3. The method of reproducing a picture of an object by television in color which comprises, producing a plurality of images of said object in different colors, arranging the different color images in a group, electronically scanning said group of color images as a single picture with a single electron beam, transmitting the signals derived from said scanning, reproducing a group of images from said signals, restoring the colors to said images, optically interlacing the color lines of the reproduced images to produce a seriate color line composition, and changing the sequence of scanning said different color images to effect a change in the order of color lines in successive seriate color line compositions.

4. The method of electronically scanning images of a field of view in a cathode ray tube which consists in scanning the field with a single electron beam, employing an odd number of lines in the field to obtain geometrically an odd-line interlace during two successive scanning cycles, shifting the scanning grating one line from its original position before the beginning

of the third scanning cycle, maintaining the scanning grating in its shifted position during the third and fourth scanning cycles, and shifting the scanning grating back to its original position before the beginning of the fifth scanning cycle, and repeating the scanning operation.

5. The method of televising an object in color which comprises, producing images in different colors of the object, disposing the color images side by side, scanning said color images as a single picture with a single electron beam, employing an odd number of lines in the field to obtain an odd line interlace, transmitting signals derived from said scanning, reproducing images from the transmitted signals, and forming a composite picture of the images reproduced.

6. A method of televising an object in color which comprises, optically producing four images of different color, arranging said images in a quadrangular field, electronically scanning the field four times, beginning the first line in a different field each time, repeating the series of scanings cyclically, transmitting the signals derived from said scanings, reproducing four images from the transmitted signals, and optically producing a composite picture from said four reproduced images.

7. The method of reproducing a picture of an object by television in natural color so that each line of the picture will successively register four colors which comprises, optically producing four images of different color at the transmitter, arranging the four images side by side without overlapping in a quadrangular field, electronically scanning the field in a cycle of four scanings so that in the first scanning the first line begins in the first color field, in the second scanning the first line begins in the second color field, in the third scanning the second line begins in the first color field, in the fourth scanning the second line begins in the second color field, transmitting the signals derived from the scanning, reproducing four images from said signals, and forming a composite picture by combining said reproduced images.

8. In a television system, an electronic scanning device having horizontal and vertical deflection coils, means for controlling the flow of current in said coils to cause a scanning operation, and means for cyclically introducing additional current in the vertical deflection coil to displace vertically the pattern of scanning lines on the field in order to scan lines left unscanned in the previous scanning operation comprising means controlled by an alternating current circuit for electronically opening and closing a circuit containing a direct current source of power which is thereby periodically connected to the vertical deflection coil circuit.

9. In a television system, an electronic scanning device having horizontal and vertical deflection coils, means for controlling the flow of current in said coils to cause a scanning operation, means for cyclically introducing additional current in the vertical deflection coil to displace vertically the pattern of scanning lines on the field in order to scan lines left unscanned in the previous scanning operation, comprising means controlled by an alternating current circuit for electronically opening and closing a circuit containing a direct current source of power which is thereby periodically connected to the vertical deflection coil circuit, an electronic reproducing device in the receiver having vertical and horizontal deflecting means responsive to signals

derived from the transmitter, vertical deflection means including an alternating current circuit operable in synchronism with the corresponding circuit in the transmitter by means of synchronizing signals, and an electronic device for employing said alternating current circuit in the receiver to control the flow of direct current periodically into the vertical deflection coil in synchronism with the corresponding pulses of direct current in the deflection coil of the scanning device in the transmitter.

10. In a television system, an electronic scanning device having horizontal and vertical deflection coils, means for controlling the flow of current in said coils to cause a scanning operation, and means for cyclically introducing additional current in the vertical deflection coil to displace vertically the pattern of scanning lines on the field in order to scan lines left unscanned in the previous scanning operation, comprising means controlled by an alternating current circuit for electronically opening and closing a circuit containing a direct current source of power which is thereby periodically connected to the vertical deflection coil circuit, including an electron tube, and means to place a negative bias on the grid thereof to prevent operation of the tube during negative one-half cycles of the alternating current.

11. The method of televising an object in color which comprises, optically producing four images of different color, arranging said images in a

quadrangular field, electronically scanning said field four times with a single electron beam, beginning the first line in the first image in the first scanning, employing an odd number of lines in the field so that in the second scanning the first line begins in the second image, shifting the scanning grating one line after the second scanning so that in the third scanning the first line begins in the third image, maintaining the grating in shifted position during the third and fourth scanings so that in the fourth scanning the first line begins in the fourth image, repeating the series of scanning cyclically, transmitting the signals derived from said scanings, reproducing four images from the transmitted signals, restoring the color to said images, and optically interlacing the color lines of said reproduced images to produce a composite picture in color.

12. In a system employing an electronic scanning device having horizontal and vertical deflecting means, horizontal and vertical deflection generators, a circuit containing the horizontal generator and deflecting means, another circuit containing the vertical generator and deflecting means, and means controlled by an alternating current circuit for electronically connecting said vertical deflection circuit to a direct current source of power at predetermined time intervals to periodically displace the pattern of scanning lines vertically.

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