

March 4, 1941.

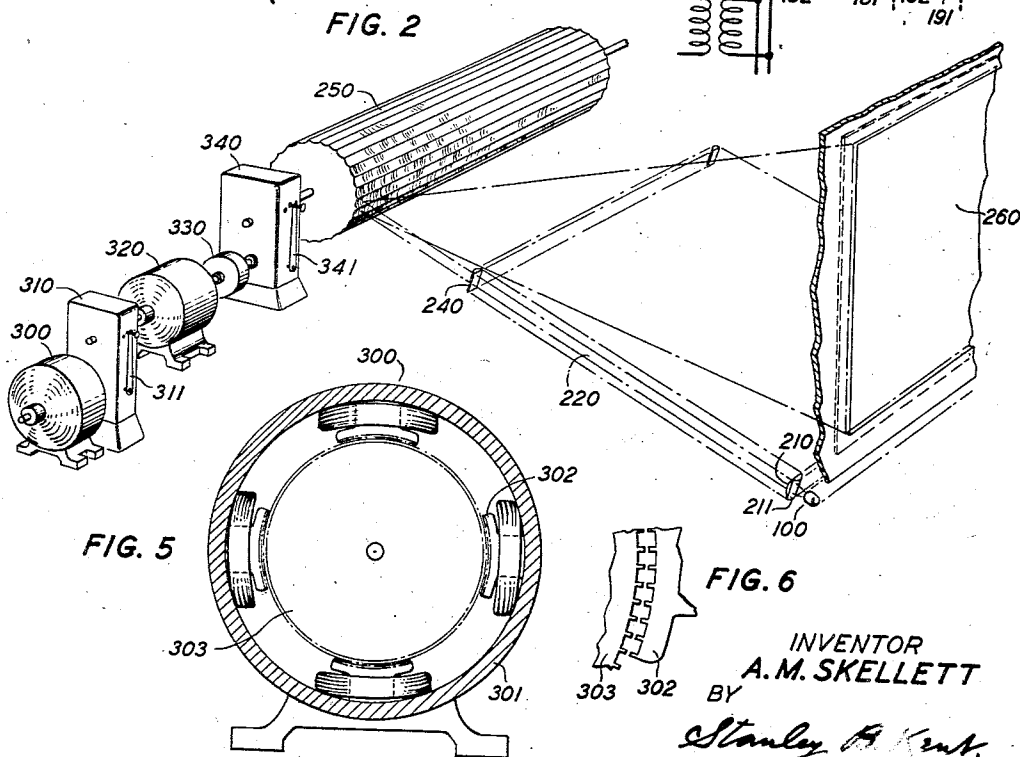
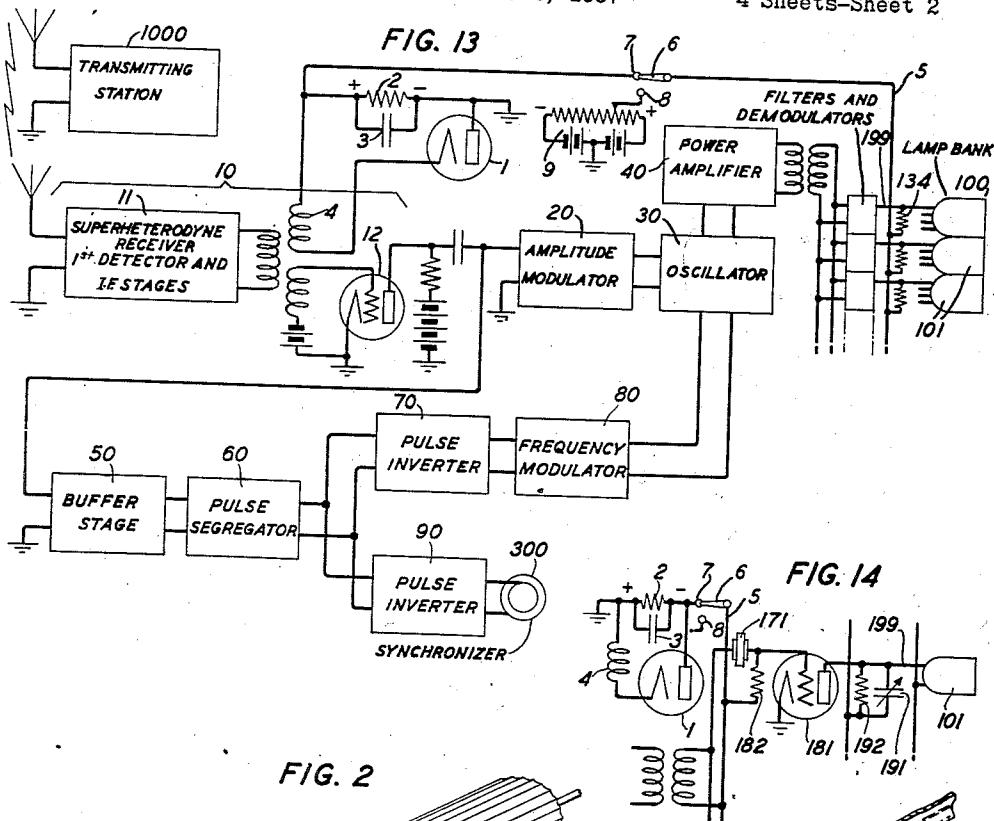
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2,233,876

ELECTROOPTICAL SYSTEM

Filed June 4, 1937

4 Sheets-Sheet 2



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4 Sheets-Sheet 3

FIG. 3

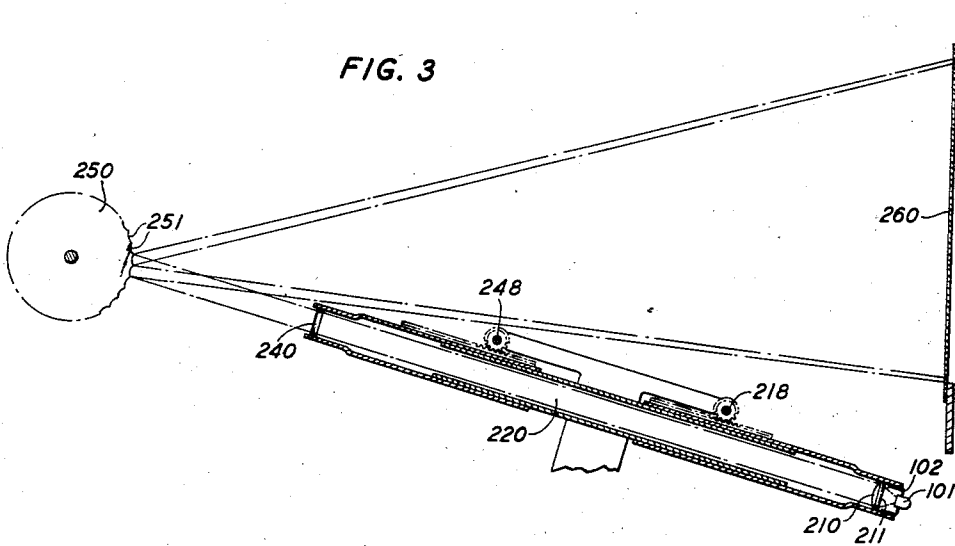
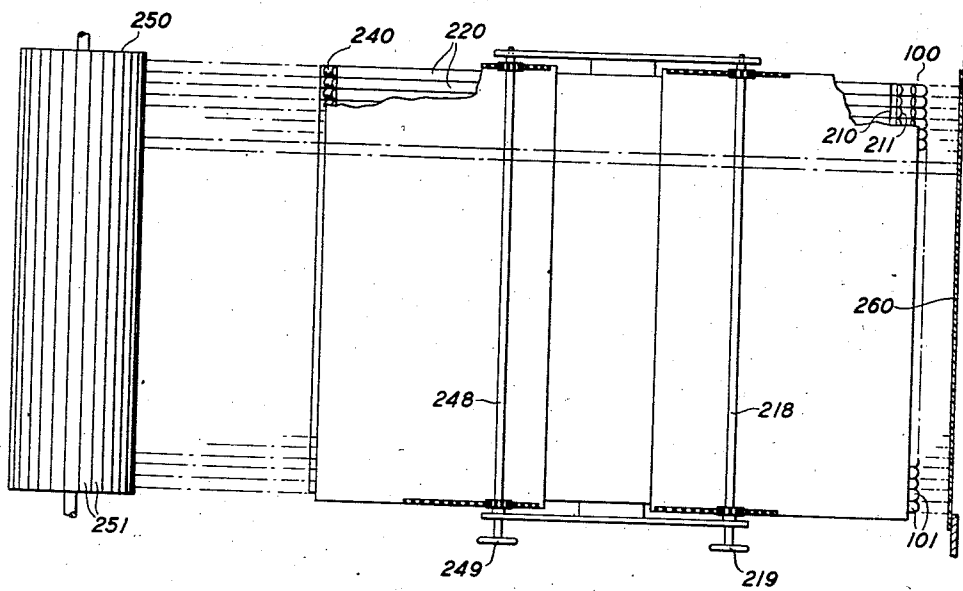


FIG. 4



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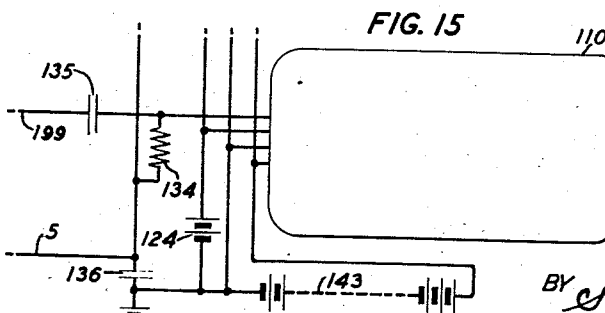
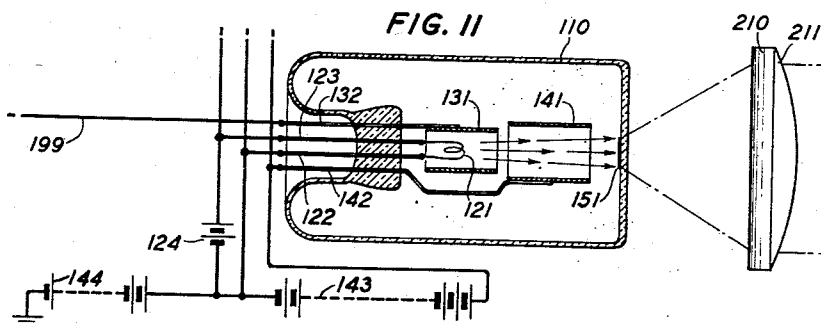
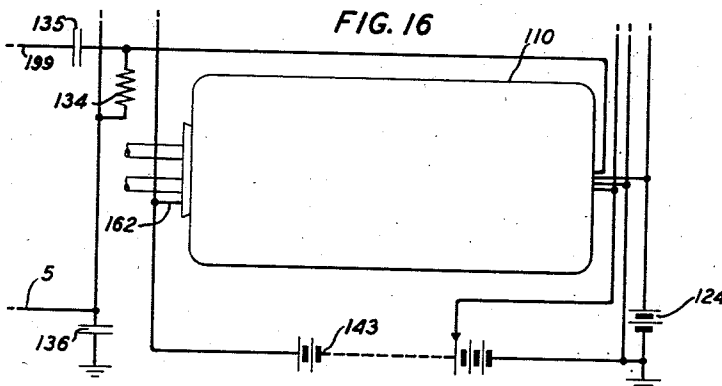
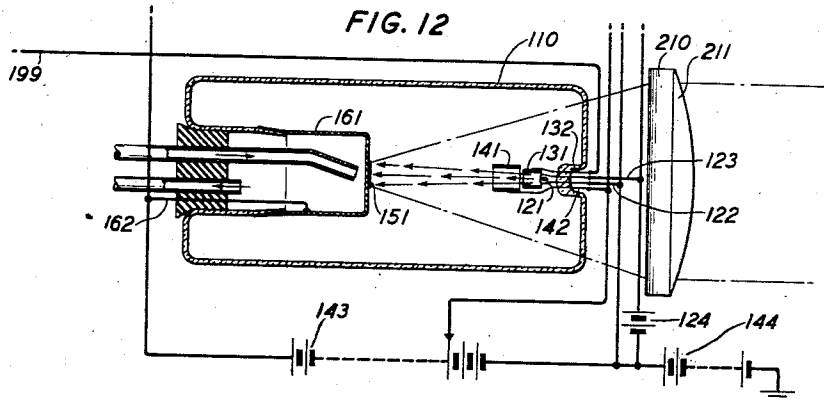
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4 Sheets-Sheet 4



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2,233,876

ELECTROOPTICAL SYSTEM

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13 Claims. (Cl. 178—7.3)

This invention relates to the electro-optical production of images, and more particularly to an arrangement for producing large images on a screen.

An object of the invention is to provide an improved arrangement for producing such images.

In an example of practice illustrative of the invention the scanning at the transmitter is accomplished in well-known manner to produce image currents representative of the light tone values along successive lines of a series of parallel lines of elemental areas of an object or field of view. After transmission to a receiving station either directly or as modulations of a carrier current the received image currents are caused to modulate a local carrier current the frequency of which is continuously varied during the scanning of a line across the field of view, the same cycle of variations being repeated for each line. The modulated local carrier current is impressed upon a plurality of distinctively tuned linearly positioned light sources, preferably, though not necessarily, one for each elemental area of a scanning line, the light from each source being directed to a screen to produce the light tones of the successive elemental areas of the scanning lines. These beams are caused to sweep across the field of view and thereby produce an image of the object being scanned at the transmitter.

A feature of this invention is the production of television images with a high degree of resolution and of sufficient size and brilliancy for viewing by either large or small audiences.

Another feature is the provision of relatively simple scanning means capable of scanning the image field with several hundred lines without excessive speed of operation of any of the physically moving parts.

Another feature is the provision of receiving apparatus capable of being readily changed from receiving an image of a given number of lines to receiving an image of a different number of lines.

A further feature is the provision of cooperative electrical and mechanical controls of the light rays from the light sources for adjusting the size and duration of the scanning spot of light, thereby affecting the width of the scanning lines.

This invention eliminates the fast moving optical element usually employed for sweeping the scanning beam along the scanning lines of the formed image, and requires only a comparatively slow moving optical element for moving or positioning the scanning lines in successive positions on the image field. The fast movement of the scanning beam for causing successive illumination of elemental areas along the scanning lines is electrically achieved by employing a series of linearly positioned light elements or sources

which are tuned to respond to mutually exclusive frequencies and by cyclically impressing upon them a varying frequency carrier current having a band width subtending that of the combined light elements.

In the illustrative arrangements herein described the receiver successively illuminates elemental areas of an elemental line or strip across the field of view by means of a plurality of tuned light sources, preferably one light source for each elemental area in the line though either a smaller or a larger number of light sources may be employed. The incoming signals are caused to modulate a local carrier which is impressed upon the tuned circuits, one for each lamp element, respectively responsive to mutually exclusive frequency bands. The frequency of the local carrier current is varied in synchronism and in phase with the line scanings so as to cause the elemental areas of the scanning lines at the receiver to be illuminated in succession in synchronism and in phase with the elemental areas being scanned successively at the transmitter. For example, the scanning of a square image field with 440 lines at the rate of thirty scanings per second requires the scanning of 5,808,000 elemental areas per second resulting in an elemental frequency of 2,904,000 cycles per second and a line scanning frequency of 440 multiplied by 30 or 13,200 cycles per second. For a 440 line picture, the frequency spectrum or band width of the local carrier current oscillator would be of the order of 6,600,000 cycles assuming a frequency band of 15,000 cycles for each crystal filter circuit and a different frequency band for each of the 440 elements in the linear light source. This band width of the order of 15,000 cycles permits the use of simple crystal filters of one crystal per filter and thus avoids complexity in the filter units. A suitable frequency for the local oscillator may be of the order of 60,000,000 cycles in order to afford sufficient time for about 10 cycles to occur during the period allowable for energizing the circuit of one light element for initiating the illumination of each elemental area in the image field. While the circuit of one light element must be energized in one 5,808,000th of a second, the time of scanning one elemental area, the light source may and preferably should emit light for substantially one 13,200th of a second, the time of scanning one line series of elemental areas across the image field. The time constant of each light element including its respective associated circuit is the time taken for the current passing through the lamp circuit to drop to a value equal to

$$\frac{1}{e} = \frac{1}{2.718}$$

multiplied by the initial value of the current, 60

a value low enough to extinguish the light, e being the base of the Napierian logarithm. The current in each lamp is thus caused to fall within the line scanning period to such a level as to practically extinguish the light element. A gradual, rather than the most rapid possible, fall of the current in each light element is caused and the resulting persistence of light emission increases the picture illumination. The above-mentioned frequency and other figures may obviously be changed and are given only for the purpose of more readily describing the invention.

The foregoing description of a specific example of practice presupposed a square image of as many theoretical elemental areas in a scanning line as there are lines across the image field to give substantially equal resolution in both directions. It is not always essential that this relationship be maintained and as a matter of considerable practical importance the number of such theoretical elemental areas per line may be substantially reduced. In present day television practice it often happens that the image currents from high definition scanning apparatus are transmitted through amplifiers which are incapable of passing the top frequency components. It is of no avail then to use a receiver capable of high line definition with such image currents. The receiver of the present invention can be economically employed, since it can be simplified by merely reducing the number of lamps and associated apparatus individual thereto. In other words, since the top frequency is not transmitted, only that sum of lamps would be needed which corresponds to the highest frequency in the band transmitted. Thus, if it is proposed to receive a 440 line image which has been transmitted through amplifiers whose band width is limited to only 1,500,000 cycles, the highest definition possible would be realized if there were only 220 lamps in the line. The produced image would be scanned with 440 lines, but the definition along the scanning lines would be only that of a 220 line picture or image.

A more detailed description of arrangements chosen for illustrating this invention follows:

Fig. 1 is a general circuit drawing showing the principal electrical equipment of an electro-optical system, especially for receiving television signals and controlling the receiving scanning apparatus for producing television images;

Fig. 2 is a schematic drawing in perspective of the scanning optical system employed for producing television images;

Figs. 3 and 4 show side and plan views respectively of the optical elements and the path of a scanning beam at a given instant;

Figs. 5 and 6 are side views of the synchronizer and of a portion of the stator and rotor of the synchronizer;

Figs. 7 and 8 are diagrams of the operating characteristics of the pulse segregator and the phase inverter stages which govern the cyclically varying line scanning frequencies and which energize the synchronizer;

Fig. 9 is a diagram of the operating characteristics of a vacuum tube associated with the crystal filter in the lamp bank circuit;

Figs. 10, 11 and 12 show different designs of light sources and their respective local circuits which are suitable for use in the arrangement of Fig. 1;

Fig. 13 is a schematic layout of the principal electrical equipment of an electro-optical system, especially the receiving arrangement showing

circuit modifications differing from those shown in Fig. 1;

Fig. 14 shows a modified form of certain of the circuit connections of Fig. 13, wherein a neon lamp is used as the light source;

Figs. 15 and 16 show light sources similar to those shown in Figs. 11 and 12, respectively, but with modified local circuits suitable for use with the arrangement of Fig. 13.

Similar reference characters on the different figures of the drawings refer to like parts.

The received signal may include both the direct and the alternating current components. The circuits of the receiver may be arranged to directly transmit all components through the various circuit elements to the light sources, or in an alternative arrangement to transmit only alternating current components through the regular circuit elements and effect a reinsertion of the direct current and very low frequency components by additional special circuit means connecting with the light sources. Both of these general arrangements are shown, the former in Fig. 1 and the latter in Fig. 13.

Fig. 1 is a general circuit drawing showing the principal electrical equipment of an electro-optical system especially for receiving television signals and controlling the receiving scanning apparatus for producing television images. The television signals may be received from any suitable transmitting source such as the transmitting station 1000. Transmitting stations usually generate a photoelectric current representative of the light tone values of the object or field of view being scanned and in addition a synchronizing current, both of which are transmitted to the receiving station. In the so-called mechanical scanning system employing, for example, a scanning disc the synchronizing impulse may be generated at the end of each picture scanning cycle or at the end of each line scanning cycle. In electron beam scanning systems employing a cathode ray pick-up tube transmitter, synchronizing impulses are generated both at the end of each line and at the end of each picture or frame for operating cathode ray television image producers. In the arrangement shown in this invention only the line scanning synchronizing or control impulse is required for controlling the receiving apparatus and maintaining it in synchronism with any type of transmitter with which it may be operated. Suitable transmitting arrangements have been described in publications from time to time. For such descriptions reference may be had to the paper by R. D. Kell, A. V. Bedford, and M. A. Trainer, entitled "An Experimental Television System" published in the Proceedings of the Institute of Radio Engineers, November 1934, vol. 22, pages 1246 to 1265.

The signal receiving device may be a superheterodyne receiver or other suitable receiving device 10. The received signal current is used for modulating the light tone values produced by the light sources in the receiver, for controlling the cyclic operation of the line of light elements in the receiver, and for synchronizing the operation of the receiver with the operation of a transmitter. The various elements of the superheterodyne receiver up to the second detector are diagrammatically shown in the block 11. The received signal is finally detected by the second detector 12 and the output signal current from this second detector is impressed upon two different circuits, one circuit being capable of transmitting all of the components of the sig-

nal current for controlling the light tone values of the light sources of the scanning elements where the image is produced, and the other circuit carrying current for controlling the synchronization of the television receiver with the transmitter and also the line scanning operation of the light sources. In the latter circuit the direct current and very low frequency components may be suppressed. The signal current received from the transmitting station may not contain the direct current and low frequency components which are necessary to properly govern the background changes of the produced image and adjustable means are provided in the circuits of the receiver for effecting their insertion. This may be accomplished by a number of known means and such an arrangement is illustrated by the potentiometer circuit 9 by which the negative bias of the second detector tube 12 may be varied to cause changes in the intensity of the detected signal. When the direct current with all of the alternating current components are transmitted from the transmitting station, the potentiometer 9 is set to cause a definite biasing and it is unnecessary to make any adjustment of it as all of the current components are continually in the signal. The portion of the signal current controlling the light tone values of the elemental areas of the produced image is transmitted to the light sources by means of a local carrier current. This portion of the signal current including both the direct current and the alternating current components and also the synchronizing pulses is first impressed on the grid of the amplitude modulator 20 which is connected with an oscillator 30 which produces a suitable high frequency carrier current of the order of several tens of millions of cycles per second for an image field being scanned with approximately four hundred lines. The function of the amplitude modulator 20 is to vary the amplitude of the carrier current produced by the oscillator 30 so that the amplitude of the oscillations will be of the correct magnitude at any instant to actuate a light source with a brightness proportional to the light tone value of an elemental area of the image transmitted. The type of amplitude modulator shown here is the so-called Heising modulator although any other, such as a grid modulator, might be used. The carrier current produced by the oscillator 30 is not only modulated as to amplitude by a portion of the full signal current, but it is also cyclically modulated as to frequency, each cycle recurring for each scanning line. For producing this cyclic frequency modulation of the carrier current generated by oscillator 30, a portion of the output signal current preferably with the direct current component suppressed from the superheterodyne receiver is transmitted through a number of vacuum tube elements 50, 60 and 70 to a frequency modulator 80. These intervening vacuum tube elements consist of a buffer stage 50, a pulse segregator stage 60 and a pulse inverter stage 70 for controlling the frequency modulator 80 which in turn cyclically modulates at line scanning rate the frequency of the carrier current produced by the oscillator 30. The buffer stage 50 prevents the pulse segregator 60 whose grid circuit draws current for a part of each pulse cycle from reacting on the output of the second detector and may also be employed to amplify, if necessary, the portion of the signal taken from the second detector so that its value will be suitable for actuating the pulse segre-

gator. The function of the pulse segregator 60 is to separate the synchronizing pulses from the image signal, to discard the image signal, and to impress upon the grid of the pulse inverter 70 only the pulses, which occur at line scanning frequency and between which the current assumes a steady value. The function of the pulse inverter 70 is to change the phase of the pulses so that they will be pulses of positive current in between which the current flowing will be zero or substantially zero, which may be fed to the frequency modulator 80 to actuate it so that it will function in the manner described elsewhere herein. The carrier current produced by the oscillator 30 after being modulated by the signals with respect to amplitude through modulator 20 and with respect to frequency at line scanning frequency through modulator 80, is impressed upon the power amplifier 40 whose output connects through suitable tuned circuits with the light sources 101 in the lamp bank 100 in the television receiver scanning device. For obtaining a synchronizing current of line scanning frequency, connection is made to the output circuit of the pulse segregator 60 for connecting a second pulse inverter 90 to the synchronizing circuit. The output side of the pulse inverter 90 connects with the field of the synchronizer 300 to momentarily actuate it only during the relatively short intervals of the pulses. This synchronizer is thereby maintained in step or in synchronism with the scanning arrangement, whatever it may be, at the transmitter. The output from the pulse inverter 70 may be comparatively small, while the output from the pulse inverter 90 in the synchronizing circuit may be much larger.

The working of the pulse segregator 60 and the pulse inverter 70 may be more clearly explained by referring to Figs. 7 and 8 showing diagrams of the operating characteristics of these elements. The pulse segregator 60 transmits only the synchronizing pulses of line scanning frequency. It is biased positively through resistances 61 and 62 so that for positive grid potentials the grid draws current and the drop due to this current takes place across resistance 62 and it is therefore not effective in changing the plate current. The positive potential on the grid is limited by the very high resistance 62 in series with the circuit. The resistance 62 is made very high with respect to the grid-cathode resistance for positive values of grid potentials. Thus, for all values of positive potential applied from the input circuit across resistance 61, substantially all of the voltage drop appears across the resistance 62 instead of across the internal grid-cathode path of tube 60, while for all values of negative potential applied from the input circuit in excess of the positive biasing potential, the grid is negative with respect to its cathode, and the resistance in the tube from grid to cathode is very high compared with the resistance 62, with the result that the series resistance is negligible. Thus, for signals above a predetermined value the grid swings negative and does not collect electrons so that the resistance 62 becomes ineffective and the vacuum tube of the pulse segregator 60 works over the linear part of its characteristic. A diagram of the operating characteristic showing the action of the pulse segregator 60 is shown in Fig. 7. The signal current, which may have the direct current component eliminated, is shown plotted along the vertical time axis. That part which lies to the right of this axis results from the image portion

of the signal current, whereas the pulse-like parts which fall to the left of this axis are the so-called synchronizing pulses. The resulting output pulses are shown plotted along the horizontal time axis in the upper right portion of the figure. Similarly, the operating characteristic of the pulse inverters 70 and 90 are shown in Fig. 8. The output pulses from the pulse segregator 60 which are impressed on the pulse inverters 70 and 90 are shown plotted along the vertical time axis and the resulting inverted output pulses are shown plotted along the horizontal axis in the upper right portion. The vacuum tubes of these pulse inverters are biased almost to cut-off and the pulses operate the tube over the characteristic to cause the inverting and the amplifying of the pulses. These pulse inverters also amplify the signal. The pulse inverter 70 which feeds the frequency modulator 80 is connected to it through a capacity resistance circuit comprising resistance element 71 and adjustable capacitor 72. The adjustment of this circuit is such that when the vacuum tube momentarily transmits current, condenser 72 is fully charged and during the interval of time between that pulse and the one which follows it, this condenser discharges in an exponential manner through resistance 71. Thus, there is impressed on the grid of the frequency modulator 80 a series of waves somewhat similar in shape to saw-tooth waves and the exponential form of these waves is corrected by opposing it with the parabolic wave shape of the grid frequency modulator. The output impedance of the frequency modulator tube 80 thus varies in an almost linear function. This variation of impedance changes the effective inductance of the winding 31 through the coupling with winding 81 and modulates the frequency of the oscillator 30. The result of this is that the frequency of the oscillator will vary in a substantially linear manner with time over the range of frequencies during the time between the passing of the synchronizing pulses, but when a pulse passes through the system the frequency of the oscillator is changed rather abruptly to a predetermined value when the frequency modulating cycle immediately starts over again. The duration of each such modulating cycle is necessarily substantially equal to that of a line scanning cycle. By adjustment of the timing of the circuit comprising vacuum tube 70, resistance 71 and capacity 72 the frequency range of the oscillator may be matched with that necessary for controlling the cyclic variation of the frequency of oscillator 30 and the apparatus thus may be adjusted for scanning image fields having different numbers of scanning lines. This is an important feature of this invention and it is described further in another part of the specification.

The output of the oscillator 30 the carrier current from which has been modulated as to amplitude by the signal currents in accordance with the light tone values of the elemental areas of the object whose image is produced and modulated as to frequency over recurring cycles at the rate of the line scanning frequency, is fed into the power amplifier 40 and from there fed to a lamp bank or multiple element lamp through a plurality of quartz crystal filters and demodulator tubes. Each lamp or element 101 of the multiple element lamp or lamp bank 100 is connected through leads 199 with its associated quartz crystal filter and demodulator circuit. Each filter 171 is tuned to the frequency which is to operate the corresponding lamp element 101.

Thus, when the correct frequency appears across the line feeding these units, the impedance of the filter is decreased and the associated vacuum tube 181, which normally is biased almost to cut-off, demodulates the signal and charges the condenser 191 in proportion to the amplitudes of the signal current. The grid of the demodulator tube 181 is negatively biased and connection with a source of biasing potential is preferably made through a high resistance 182. A high resistance 192 in shunt with the condenser 191 permits the condenser to discharge before the following signal occurs. Condenser 191 may be made adjustable to more readily adapt the system for operation for any given image resolution and rate of scanning. A distinctively tuned or resonant circuit as above described is employed for each light source and the cyclic frequency variation of the local carrier current impressed upon these resonant circuits has the effect of successively actuating the filter circuits 171, the demodulator circuits 181 and the light sources 101 in the lamp bank 100. The adjustments will, of course, be such that the frequency range through which the carrier current is cyclically varied will cause the total number of light sources to be actuated once during each cycle of the saw-tooth wave. The overall effect will be that each synchronizing pulse causes the actuation of the first light source, followed by the second, third, etc., sources until the final source in the lamp bank 100 has been actuated just before the occurrence of the next synchronizing pulse which restores the frequency to that necessary to actuate the first source. The time during which each synchronizing pulse occurs is lost to the picture, and since these synchronizing pulses are also impressed upon the amplitude modulator 20 they effectively cut down the amplitude of the local carrier current generated by the oscillator 30 to a very low value. This is desirable since during the short interval of time of each synchronizing pulse, the frequency of the oscillator 30, due to the charging of the condenser 72, will pass backward through its entire frequency range, namely, the range of frequencies corresponding to the filter circuits associated with the lamp bank. If the amplitudes of the oscillations of the oscillator 30 were not reduced to a very low value the entire group of light sources in the lamp bank would be actuated and a disturbing flash might result, since during the charging of the condenser 72 by a synchronizing pulse the frequency variation of the oscillator 30 is run backward through its range so that it is ready to again commence the successive actuations of the light sources in the lamp bank. After the condenser 72 has been again charged, the cycle of successively energizing the light sources is repeated. This cycle is repeated for every line of the formed image. As heretofore pointed out, it is a common practice in certain television systems to send a synchronizing pulse following each line scanning and a longer synchronizing pulse at the end of each frame. This longer synchronizing pulse is of no value in the method or arrangement disclosed herein. It may simply charge the condenser 72 to a value where it is ready to start the first light source in the first line position of a new frame or image and also reduce the amplitude of the oscillator during the time of passage of the frame synchronizing pulse so that disturbing flashes of the light sources in the lamp bank which might otherwise occur are prevented while this transition is taking place.

In adjusting the capacity-resistance circuit including the impedance of its input vacuum tube, the time constant is adjusted to a value of less than the duration of the synchronizing pulses so that the condenser 72 is substantially fully charged before the synchronizing pulse has been completed. This allows for small variations in the amplitude of the synchronizing pulses and maintains the constancy of the starting frequency of the frequency modulation cycle. The adjustment of the time constant of the resistance 71 plus the output impedance of the tube 70 and the condenser 72 must be such that when the tube is not operative, namely during the time of the picture signal between synchronizing pulses, the time constant will be correct to enable the frequency modulating cycle to go through its entire range of variation during the time elapsing between successive synchronizing pulses. During this time between successive synchronizing signals the time constant of the circuit is determined by the combination of resistance 71 and the impedance of the tube 70 and the lowered effective resistance must be such that the time constant is reduced by enough so that the condition in the preceding sentence relating to the action of condenser 72 will obtain.

The action of each circuit connecting a lamp or a lamp element may be more clearly understood by referring to Fig. 9 which shows the operating characteristic of the vacuum tube 181 in each circuit. This diagram of the characteristic of the vacuum tube associated with the crystal filter in the lamp bank circuits shows that for a dark signal the amplitude of the oscillations will be small and the vacuum tube will work over its characteristic up to the point B, while for a bright signal the amplitude of the oscillations is larger and the vacuum tube works over its characteristic to the point C. Thus, a dark signal will charge the condenser 191 to a lower potential than a light signal and the lamp elements will not only glow less brightly, but will remain glowing for a shorter space of time for the dark signal. For the brightest signal, the condenser will charge up to a value such that it will just be completely discharged at the end of the time taken to scan one line. While a type of lamp might be employed which would permit the omission of the vacuum tube demodulator in each lamp circuit, as here shown, preferably a demodulator is employed in each lamp circuit. In the subsequent description of the light sources particularly applicable to this system, both the light sources and their local input circuits are shown in detail.

Fig. 2 is a schematic drawing in perspective of the scanning and optical system employed for producing television images. This receiver is particularly adapted for producing television images of high definition or resolution either on a small field or screen for viewing by a few people, or for producing images on a very large screen for viewing by large public audiences. For example, with a resolution of the order of 440 lines at the rate of thirty image scanings per second, this receiver may be arranged to scan an image field having dimensions of the order of 15 to 20 ft., such as employed in moving picture houses or theatres. This receiver is capable or rapidly scanning both large and small image fields with several hundred lines owing to the fact that in scanning a line series of elemental areas across the field, no physical moving parts are required and the line shifting which is relatively slow, may be caused by simple slow moving physical ele-

ments. In achieving this the light scanning beams are successively generated in a long linear light source having individual light elements preferably equal to the number of elemental areas in the scanning lines for full definition, or in an equal number of individual light sources positioned in a line. The latter arrangement is here shown and described in detail. However, as pointed out elsewhere in the specification, the number of light sources need not necessarily be equal in number to the elemental areas in a scanning line as required for full definition in both directions, their number may be either less or greater, depending upon conditions. The arrangement with the number of lamps required for full definition is here shown and described in detail. Each light element, as shown in Fig. 1, is connected to a tuned circuit which is responsive to a distinctive frequency and therefore only one light source is actuated at each instant. The signal current modulates a local carrier current whose frequency is repeatedly cyclically varied over the frequency range to which the light sources are responsive and this causes the light sources to successively and repeatedly light in accordance with the impressed signal with the result that a line series of elemental areas is scanned for each cyclical frequency variation of the local carrier current. The tuning and line scanning arrangements are shown in detail in the electrical circuit drawing of Fig. 1. The vertical shifting of the line scanning light beams may be brought about by any suitable means such as a polyhedral mirror drum. The light scanning beams successively initiated at each instant in the light sources 101 of lamp bank 100 are directed through a suitable optical system so that each light source briefly illuminates a single elemental area on the image screen. The line series of light sources 101 are each equipped with collimating lens elements 210-211 and the path of the rays from each light source may be further channelized by the use of baffle plates or conduits 220. The lens elements 210-211 direct the major portion of the light in approximately parallel rays through distinctive channels, either directly or first to a direction changing element or mirror not shown in the drawings, to the slowly rotating special polyhedral mirror drum 250 from whence the scanning beams are vertically directed from line to line on the screen 260. A line series of image lenses 240 are positioned in the light paths between the collimating lenses and the mirror drum. The mirror drum 250 may have either plane or curved reflecting faces depending upon the other optical elements, and while as here shown the faces are curved or fluted this element will be generally referred to as a polyhedral mirror drum.

The optical system is further illustrated in Figs. 3 and 4 showing side and plan views respectively of the optical elements and the path of a scanning beam from a single light source at a given instant. The approximate positions of the conjugate foci of the image lenses 240 are at the collimating lenses 210-211 and the image screen 260. The light sources 101, preferably of the crater type or equivalent type to obtain a very intense but small light source, are held in suitable supports 102 and in such relationship with the collimating lenses that their light rays are directed in approximately parallel channels. Since it is practically impossible to obtain point light sources and by means of collimating lenses direct rays of the scanning beam in juxtaposition

separate parallel paths baffle plates or conduits 220 extend from each light source to assist in channelizing the respective beams. With this arrangement the image lenses 240 pick up light from their respective light sources and by themselves operate to produce a narrow vertical strip of scanning light on the screen, but as the mirror or reflecting faces 251 of the special polyhedral mirror drum are properly curved to converge the light beams reflected therefrom, the area of the scanning beam actually reaching the screen is a spot having a vertical dimension substantially equal to the width of a scanning line. The conjugate foci of the curved or fluted reflecting surfaces 251 of the polyhedral mirror drum are approximately at the collimating lens elements 210—211 and at the screen 260. The lens elements 210—211 may be two crossed cylindrical lenses, or they may be formed of long horizontal elements 210 and of short individual elements 211 one for each light source, or strips of the center portion of spherical lenses. A reason for using only the center strip of spherical lenses for the collimating lenses is to reduce their dimension from left to right so as to permit the desired number to be positioned in a line in front of the light sources. These lens elements collect and direct the light rays from their respective light sources 101 in approximately parallel beams having a vertical dimension sufficient to transversely subtend or span two of the special polyhedral curved mirror faces 251. The image lenses 240 limit the longitudinal or left-to-right dimension of the scanning spot on the screen. These lenses 240 may be simple cylindrical elements positioned side by side with their axes in parallel vertical planes and substantially normal to the principal path of the light beams from the collimating lenses. With this optical system the cylindrical image lenses 240 and the curved reflecting surfaces 251 combine to focus the light from one source into a spot on the screen of the correct area for one element. The distance between the mirror drum and the screen and the relative position of the light sources, the lenses, the mirror drum and the screen are adjustable to permit making the scanning beam produce the proper size and shape of spot on the screen. Means for making these adjustments are indicated by the rack and pinion gearing controlled by hand wheels 219 and 249 on the end of shafts 218 and 248 carrying the pinion gears in mesh with gear racks attached to the movable member supporting the collimating lenses 210—211 and their associated light sources 101, and the movable member supporting the image lenses 240, respectively. By manually rotating the pinions, the bank of collimating lenses and their associated light sources and the bank of image lenses may be properly positioned in the optical system. For example, such adjustments are preferably made when the number of scanning lines per image is changed. The angular spacing and width of the curved reflecting surfaces 251 on the mirror drum 250 are such that only one line is scanned at a time. For the condition shown in the drawing, the effective scanning beam is on the bottom line of the image field and an oncoming new effective scanning beam is just above the image field ready to scan the top line of the image field immediately following the scanning of the bottom line of the image field by the beam about to pass off the field. While the image field may be opaque and the audience views it from the side of the scanning drum,

it is here shown as translucent or of such character that the audience views the side of the screen away from the scanning apparatus. The image field on the screen 260 is bounded by an opaque framing which shuts off from the audience any extraneous light and view of the apparatus behind the screen. The polyhedral mirror drum 250 may have any reasonable number of reflecting sides or faces 251 such as a number equal to the images formed per second and with such a number of faces the mirror drum rotates one revolution per second. This slow rate of rotation causes one face to pass through its angle of action during each image scanning cycle, such angle of action causing the scanning beam to sweep the screen in successive parallel transverse lines from the top to the bottom of the image field as above described.

Rotation and synchronization of the operation of the polyhedral mirror drum 250 may be effected by any suitable means such as a synchronizer 300, an adjustable gear ratio coupling 310, a direct current driving motor 320, a suitable mechanical coupling means such as an oil damping member 330 and an adjustable speed reducing gear element 340, all interconnected as shown in the drawings. The driving motor may operate, for example, at 1800 revolutions per minute and the mirror drum at 60, 48 or 40 revolutions per minute so that the speed of the reducing gear unit may have ratios of 30 to 1, 37.5 to 1 or 45 to 1. The arm and indicator 341 indicates means for changing the gear ratios. However, any other suitable speed ratios may be chosen. The speed of rotation of the synchronizer 300 is governed by the frequency of the synchronizing pulses which are proportional to the number of scanning lines per image and the number of images per second, and in order to adjust the apparatus for images of different numbers of scanning lines per image, variable gear ratio coupling 310 connecting the synchronizer and the driving motor is provided. The arm and indicator 311 indicates means for readily adjusting the speed relationship. By adjusting the variable gear ratio couplings 310 and 340, the proper speed of the mirror drum may be attained for different resolutions and rates of scanning. A side view of the synchronizer 300 is shown in Fig. 5. The synchronizer may consist of a synchronous alternating current motor having a stator 301 with toothed poles 302 and suitable windings through which the synchronizing current passes, and a rotor 303 consisting of a toothed element of magnetic material, the teeth on both the stator and the rotor being similarly angularly spaced, as schematically illustrated in Fig. 6 which is a fragmentary showing of the stator and rotor elements. With the synchronizer rotor having as many pole teeth as there are scanning lines in the image field, with the driving mechanism as here described in detail, the gear ratio coupling 310 would be set at a speed ratio of 1 to 1. The synchronizing current, as later explained, having a frequency equal to that of the line scanning frequency, causes the synchronizer having as many teeth in its rotor as there are lines in the image field to make one revolution per image.

As heretofore stated, this system is designed for forming large images with a high degree of resolution and consequently the light sources must respond to very high frequency signal currents. In the optical system here shown, light sources of relatively small size are employed and

several different designs of light sources are shown in Figs. 10, 11, 12, 15 and 16. The type of light source shown in Fig. 10 contains gas at low pressure and while capable of operating at moderately high frequency, it may have the objection of introducing a slight lag when the signal frequency is very high. The types shown in the other figures are of the vacuum cathode ray types and have the advantage of introducing no appreciable lag at very high frequencies. In each of these figures the local circuits for the lamps are shown. The light source shown in Fig. 10 requires that all of the signal components be impressed upon its electrodes. The light sources shown in Figs. 11 and 12 are arranged for having the full signal including the direct current and all other components directly impressed upon their control or modulating element. The light sources shown in Figs. 15 and 16 are arranged for reinserting the direct current component by separately applying a varying biasing potential to the control or modulating element of the lamp.

In Fig. 10 there is shown in cross-section an ordinary crater type light source positioned to direct light through collimating lens 210—211. The center of the crater light source is positioned approximately at the principal focus of the collimating lens 210—211 so that the major portion of the light passing through the lens is directed within a comparatively narrow channel. This lamp consists of a container 110 of glass or other transparent material in which is mounted a cathode 111 having a crater and a ring anode 112. The electrodes are surrounded with gas, such as neon, at low pressure. Lead-in wires 113 and 114 pass through the glass bulb to the electrodes. The positive terminal of the local source of power 143 (also shown in Fig. 1) is connected with the anode 112. The cathode is connected into the circuit of Fig. 1 by conductor 199.

In Fig. 11 there is shown a light source of the cathode ray type employing a hot cathode. The hot cathode 121, the modulating element 131 and an anode 141 are all suitably mounted in alignment within the glass container or housing 110. Lead-in wires 122 and 123 connect with the cathode, and lead-in wires 132 and 142 connect with the modulating and anode elements, respectively. The inside of the transparent front face or window of the lamp, or other suitable support, upon which the cathode rays are directed, is covered with a fluorescent material 151 which upon being bombarded by the cathode rays brightly luminesces. A high vacuum is maintained within the tube. The tube is positioned in alignment with the collimating lens element 210—211 so that the fluorescent material is approximately at the principal focus of the collimating lens. Such a light source is capable of responding to very high frequencies substantially without lag. The local sources of power for the lamp which may be common to a plurality of lamps, comprises a source 124 for heating the cathode and the source 143 of high voltage for the anode. In order that the lamps may be connected to the output circuits of detectors 181 of Fig. 1, which are arranged for transmitting both the direct and alternating current components, a source of potential 144 is employed to positively bias the cathode a proper amount above ground. The signal is directly impressed through lead 199 upon the modulating element of each lamp. The leads or buses extending from the sources of current or potential are shown extending beyond the lamp terminals

of the one connected lamp to provide for connecting a plurality of lamps.

Fig. 12 shows a modified fluorescent cathode ray lamp employing fluid cooling. In this lamp the cathode rays are caused to bombard the fluorescent material which is supported on a cooled surface thus permitting a very intense bombardment without unduly heating the supporting surface or injuring the fluorescent material and at the same time producing an unusually intense spot of light. This cathode ray lamp employs a hot cathode 121, a modulating element or electrode 131 and two anodes 141 and 161, all positioned within the tube and in alignment with the fluorescent material 151 which is caused to intensely luminesce by being bombarded with the cathode rays. The fluorescent material is preferably supported on a fluid cooled member which is here shown as the second anode 161. Suitable lead-in wires 122, 123, 132 and 142 connect with the respective electrodes within the glass housing the same as in Fig. 11. The anode 161 is sealed to the glass and forms a part of the containing chamber. Electrical connection to this anode 161 may be made in any suitable manner such as by means of lead wire 162. A continuous flow of cooling fluid, such as water, oil or mercury, is directed by any suitable means against the portion of the second anode 161 supporting the fluorescent material to rapidly carry away the excess heat caused by intense electron bombardment. Any suitable well-known means may be employed for circulating the cooling fluid and for insulating the second anode so that it may be properly connected in circuit. A high vacuum is maintained within the lamp. The collimating lens 210—211 is positioned in alignment with the lamp and so that the fluorescent material is approximately at its principal focus. The local sources of power which may be common to a plurality of lamps, comprises a source 124 for heating the cathode and a very high voltage source 143 for supplying a moderately high voltage for anode 141 and a very high voltage for anode 161. The voltage for the anode 161 may be of the order of a few thousand volts up to a few tens of thousands of volts and that for the anode 141 may be much less, but both may be supplied from the same source by suitable taps. In order that the lamp may be connected to the output circuits of Fig. 1 which are arranged for transmitting both the direct and alternating current components, a source of potential 144 is employed to positively bias the cathode the proper amount above ground the same as is employed for the lamp shown in Fig. 11. The leads or buses extending from the sources of current or potential are shown extending beyond the lamp terminals of the one connected lamp to provide for connecting a plurality of lamps to the output circuits shown in Fig. 1 where the bank or plurality of lamps 100 are diagrammatically indicated.

The oscillator-modulator circuit of Fig. 1 may be modified in the manner disclosed in Kishpaugh Patent 1,707,486 patented April 2, 1929, to provide for the reinsertion of the direct current and low frequency components of the image current if such components are not present in the received signals.

Fig. 13 is a modification of the circuit arrangement shown in Fig. 1. This circuit differs from that of Fig. 1 in that only the alternating current components of the image current are directly transmitted from the second detector through the local modulator to the light sources and by special circuit connections the direct cur-

rent component and very low frequency components are reinserted in the circuit immediately connecting with the light sources. Where the direct current and very low frequency components of the signal are not transmitted on a suitable carrier current, coupling transformers or condensers in the circuit prevent the passage of these components. In the circuits of the terminal apparatus, as shown in Fig. 13, such couplings are used, while in the arrangement shown in Fig. 1, they are avoided and, as previously stated, all components are transmitted together directly to the light sources. In Fig. 13 details of the circuit elements are omitted where they are the same as in the circuit of Fig. 1. To effect a reinsertion of the direct current component and very low frequency components which are suppressed in the local receiving circuits of this arrangement a portion of the incoming signal modulated carrier current received by the superheterodyne receiver 10 and containing all signal components is divided after passing through the first detector and the intermediate frequency stages 11 by any suitable means such as a coupling transformer having a second secondary winding 4, one portion of the signal being passed through the second detector 12 and another portion being passed through a rectifier diode tube 1 and resistance 2 which is shunted by a comparatively large capacity 3. The resulting unidirectional current passing through the resistance 2 varies in accordance with the direct and low frequency components of the signal and the potential drop occurring across this resistance is used to bias the lamp elements or their circuits to cause the light emitted to vary in a manner to produce the proper background intensities in the produced images. The bias obtained may be either positive or negative depending upon the terminals of the resistance to which the grounding and biasing connections 5, respectively, are made. The circuit connecting with these two rectifying elements must be such that a proper phase relationship is maintained for taking off the biasing potential from the diode circuit and so that it provides a biasing potential of the right polarity to properly bias the light sources or the connecting circuits of the light sources. Cathode ray light sources are shown in Figs. 15 and 16 which have their local circuits so arranged that the direct current and low frequency components can be reinserted by applying a varying positive biasing potential through respective resistance 134 to the modulating elements of the light sources. For the sake of clearness, the leads supplying current and potential to the cathode ray lamps 101, in Fig. 13, have been omitted, but are shown in detail in Figs. 15 and 16. By this arrangement the background or average light intensity of the produced image correctly follows that of the object whose image is being transmitted. Where the signal from the transmitting station does not contain the direct current and low frequency components, the above described arrangement for automatically causing their reinsertion in the lamp circuits is not effective. A local adjustable biasing source of potential preferably in the form of a potentiometer circuit 9 having the mid-point of the source grounded and its adjustable connection connected to the biasing lead 5, may be employed. The switch 6 in the lead 5 is provided for making connections through contact 7 with the automatic biasing arrangement employing diode tube 1, or through contact 8 with the manual biasing

arrangement employing potentiometer circuit 9.

Fig. 14 shows a modified arrangement for reinserting the direct current and low frequency components ahead of detector 181 when using lamps such as are illustrated in Figs. 1 and 10. This arrangement shows that portion of the circuit connections of Fig. 1 between the output of the power amplifier 40 and the individual light sources of the lamp bank 100, and an arrangement for impressing a negative biasing potential upon the demodulating tubes 181 through respective resistances 182 which is obtained from the rectifier diode tube 1 and resistance 2 of Fig. 13 modified as shown in Fig. 14. Due to the differences in the circuit arrangement of the light sources a negative biasing potential is employed in Fig. 14 while a positive potential is employed in Fig. 13. A switch 6 in the biasing circuit lead 5 of Fig. 14 is used for making connection through contact 7 with the automatic biasing arrangement employing diode tube 1, or through contact 8 with the manual biasing arrangement employing potentiometer circuit 9 shown in Fig. 13. This potentiometer circuit is arranged to provide either a positive or a negative bias depending upon the position of its adjustable connection. In the applications of the varying biasing potentials to the control elements of the light sources, as indicated in Fig. 13, or to the input circuits of the light sources, as indicated in Fig. 14, the action is such as to effect the reinsertion of correcting direct current and low frequency components.

The cathode ray light sources as shown in Figs. 11 and 12 together with their local circuits were shown for connection with a system arranged for transmitting the direct current components along with the alternating current components to the modulating element of the lamp. These light sources, by means of suitable exterior circuit connections, may be readily adapted to systems wherein the direct current component has been suppressed and is later reinserted by suitably varying the bias of the modulating element of the lamp. Such modified circuit arrangements are shown in Figs. 15 and 16, the construction of the lamps in Figs. 15 and 16 being the same as that in Figs. 11 and 12, respectively. For this reason only the exterior circuit modifications are shown in detail. The modification of the local circuit consists in general of eliminating the source of potential 144 between ground and the lamp shown in Figs. 11 and 12 and providing a connection for applying a varying biasing potential to the modulating element. In Fig. 15 the local sources of current and potential for the lamp may be common to a plurality of lamps and comprise a source of current 124 for heating the cathode and a source 143 of high voltage for the anode. A source of varying biasing potential for causing the reinsertion of the direct current component may be obtained as shown in Fig. 13, by passing a part of the signal current through the diode 1 and the resistance 2, and in this figure where the lamp elements 101 are shown diagrammatically, the cathode ray type of lamp having a modulating element is especially applicable. As there described, this varying biasing potential is supplied to the modulating element through suitable resistances 134 connected between the biasing source and the modulating element. This biasing connection 5 is common to the plurality of lamps and a by-pass condenser 136 connects between it and ground. The alternating components of the signal are impressed through a condenser 135 in lead 100 connecting the modu-

lating element of each lamp with a respective tuned circuit connected with the power amplifier 40 of the receiver. The leads or buses extending beyond the lamp terminals of the one connected lamp are provided for connecting a plurality of lamps.

The modification of the lamp circuit for adapting the fluid cooled cathode ray lamp for use in circuits where the direct current component is reinserted, is shown in Fig. 16 and the modified portion is substantially the same as shown for Fig. 15. The circuits here shown are arranged for connecting this lamp in the arrangement shown in Fig. 13,

While the generation of a local carrier current and its cyclical frequency modulation at line scanning rate is described and shown in detail as produced by vacuum tube elements and electrical networks which have the advantage of avoiding the use of rapidly moving physical members, this carrier current can be frequency modulated by any of several methods of frequency modulation. For example, the condenser which tunes the oscillator may be paralleled by another condenser having a rapidly rotating element of a plurality of properly shaped and displaced sectors. The rotor of this condenser may be driven by any suitable synchronized driving unit or it may be connected directly with the synchronizer and driving motor rotating the polyhedral mirror element. A somewhat similar device arranged to inductively cyclically vary the frequency might also be used. Such arrangements become more and more advantageous as the number of lines per image is decreased, since the cyclical variations of the frequency of this carrier current must be produced at a rate proportional to the line scanning rate, but it may introduce difficulties in readily changing the apparatus from scanning an image field of a given number of scanning lines to that of a different number of scanning lines.

This invention has been described in detail more particularly as an electro-optical receiver, but as electro-optical devices with slight modifications are generally reversible, the mechanism can readily be adapted for scanning and generating a photoelectric current for the transmission of the light tone values of an object or picture. A modification required to convert the receiving apparatus into electro-optical transmitting apparatus comprises primarily equally energizing the linear light sources or light elements so that each successively emits substantially the same light intensity. The field of view or object is then spot scanned with a rapidly moving spot of light of uniform intensity produced by these light sources and the reflected light from the screen or object may be caused to generate photoelectric currents by positioning photoelectric cells in such relation to the screen that the reflected light impinges on the photoelectric cells, as is done in the usual systems employing spot scanning. This arrangement for transmitting and generating photoelectric currents representative of the light tone values of an object or picture has the advantage of being able to scan an unusually large field of view such as the stage of a moving picture house. Substantially the same apparatus is employed in the scanning operation for either transmitting or receiving excepting that for transmitting the addition of photoelectric pick-up apparatus is required at the transmitter.

The scanning apparatus is readily adaptable

to either plain or interlaced scanning. In plain scanning the entire image field is scanned with juxtapositioned lines while in interlaced scanning the field is alternately scanned on its odd and on its even numbered lines, respectively. The plain scanning with successively juxtapositioned lines across the field may be achieved by causing the scanning beams for each line scanning operation to be successively deflected the width of a scanning line for each line scanning; and the interlaced scanning may be achieved by causing the scanning beam for each line scanning operation to be successively deflected twice the width of a scanning line and in alternate scanings to respectively scan the odd and the even numbered lines of the field, and thus in one scanning of the field to scan an odd number of lines and in the succeeding scanning to scan an even number of lines, such for example, as 221 and 220, respectively, in a 441 line image. In the scanning apparatus here shown the polyhedral mirror drum is rotated twice as fast for interlaced scanning as for plain scanning so that as each reflecting face moves through its angle for deflecting the scanning beam, the beams are spaced apart approximately the width of one line. This change of speed of rotation of the scanning drum may be readily made by well-known methods of changing the speed reduction ratio in the speed reducing gear element 340.

Another important feature of this electro-optical system is that if the receiver is constructed for producing a 440 line image, this same receiver may with very simple changes be adjusted for producing 72, 180, 220 or 1000 line images, or in fact an image of any reasonable definition of this order. The essential changes necessary where the same number of images per second are produced is the small adjustment of the frequency modulator to provide that in the interval of time between the synchronizing pulses at line scanning rate the frequency of the master oscillator changes over its entire range, namely, the full range of frequency covered by the total number of filter sections in the lamp bank, and adjustment of the synchronizer or the coupling gearing between it and the mirror drum so that the drum rotates at the same speed whatever the number of scanning lines per image. Also, in changing from one number to another number of lines per image, the optical system may be refocused by simple adjustment of certain optical elements to obtain the proper dimensions of the scanning spot on the screen, as heretofore explained. In other words, the receiving apparatus may be constructed with a definite number of lamps in the lamp bank, determined possibly by practical considerations, and with but minor adjustments, it may be employed to produce images of different definitions. This flexibility is a great practical advantage. Further, as the art advances and it becomes practical to build amplifiers to pass the entire frequency band width so that the highest definition possible is transmitted for an image of any specified number of lines in the image, the receiving apparatus as disclosed herein, even though it has been built with a fewer number of lamp elements in the line than needed for the production of the full definition transmitted, may with additional lamp elements including their filters and demodulator units and associated lenses added to the line and with the

minor adjustments stated above be adapted for the higher definition.

Even where the image is produced by using a fewer number of lamps in the line than the theoretical number of elemental areas in the line very good image quality and definition may be obtained. As an example, a 440 line image produced thirty times per second requires the amplifier to have a band width of approximately 3,000,000 cycles in order that the highest essential frequency may be passed, this frequency being determined by the width of the smallest spot which may be transmitted without distortion. If the band width is cut in half and in the case of this apparatus the number of lamps is reduced by one-half, the dimension of this spot is doubled along the scanning lines. Any difference would be noticeable only where very fine details were transmitted and where areas have very sharp edges perpendicular to the line of scanning. For many images the difference between the two could not be detected. In this example the image is scanned by 440 lines whether the frequency band width is unchanged or reduced by one-half. It is for this reason that the practice has generally been to increase the number of lines more or less out of proportion to the band width of the amplifiers since increasing their number results in less apparent line structure. Stated in another way, to increase the over-all quality of the image, it is more profitable to increase the number of lines within reasonable limits than to increase the band width of the signal.

Another feature of this invention is the two means for determining the width of the scanning lines produced at the receiving station by means of adjusting the optical elements in the optical system. The size or width of the scanning spot may be varied for scanning an image field of different numbers of scanning lines and for adjusting the size of a spot to produce no overlap or a desired amount of overlap of the scanning lines. A further means provided by this system for adjusting the width of a scanning line resides in the electrical system employed whereby the length of the persistence of illumination from the light elements determines to a large degree the effective width of a scanning line. In ordinary systems where the spot or the beam is directed on a given elemental area or spot of the image field for only a period of very short duration, the width of the scanning line is controlled practically entirely by the optical system. In this system where the beam for each light element of the line comes from corresponding fixed sources of light and the light persists for a time even equal to the length of time of scanning a line and the optical element causing the line shift is continuously moving, the effective width of the scanning beam illuminating each element in a scanning line may be varied in one dimension by means of the electrical system determining the time of the persistence of the illumination from each light source, as well as by the optical elements used for focussing the spot or spots. As heretofore stated this system is applicable with very few adjustments for scanning image fields with different numbers of lines and at different image rates. The size of the scanning spot may be changed by adjustment of the optical elements to adapt the system to scanning image fields having different numbers of scanning lines. Also, without changing the optical elements or their adjustment, the effective width of the scanning

lines may be changed by adjusting the electrical elements connected with the light sources to vary the persistence of illumination of each light source. When the number of lines in the image field is decreased, the width of the scanning lines are increased and the area of the scanning spots are correspondingly increased. This may be accomplished by adjusting the electrical system to increase the time of the persistence of illumination of the light sources. If the number of scanning lines is increased, the opposite electrical adjustment may be made, namely that of shortening the time of the persistence of illumination of the light sources. It is thus seen that either the optical or the electrical system may be employed to change the width of the scanning line, or both may be jointly used. In either case they are properly coordinated in their action, particularly with the optical elements continuously moving the scanning lines from line to line.

While this invention has been described in the foregoing as producing the image at the receiver by illuminating line series of elemental areas from left to right across the image field, and parallel with the scanning lines at the transmitter generating the photoelectric signal currents, the arrangement may be considered as scanning the image field from top to bottom with as many scanning lines as there are elemental light sources in the line of light sources. The beams of light radiated from these light sources are repeatedly moving from top to bottom of the image field while there is no actual movement of the light beams from left to right, this apparent cross-wise scanning action being effected by successive energization of the light sources as heretofore explained. Thus the scanning lines or structure may be considered as running vertically along the image rather than as running horizontally. By means of the optical system, the scanning beams may be rectangular in shape and may be accurately positioned adjacent to one another with respect to their left and right edges on the image field and it is thus possible to reduce the vertical line structure to a minimum. Also since the beams are repeatedly moving from top to bottom of the image field any horizontal line structure is also substantially eliminated. This system may therefore be considered as having the novel feature of the scanning at the transmitter taking place in one direction and the scanning at the receiver taking place in a direction at right-angles to that at the transmitter. Further the scanning at the transmitter at each instant is concerned with one elemental area, while the scanning at the receiver is concerned with a plurality of elemental areas at each instant which may reach a number equal to the number of elemental areas in a line across the image field. The relationship of the scanning at the transmitter with that at the receiver may be considered as taking place on diverse bases and the two properly coordinated in producing an image of the object scanned at the transmitter.

What is claimed is:

1. In combination, means at a television receiving station for receiving and detecting a constant frequency carrier current the amplitude of which is representative of the light tone values of an object field at a distant transmitting station, a generator at said receiving station for generating a current of such high frequencies that selection of a portion of these frequencies can be effected with crystal filters, said generator including means for continuously and cyclically

varying the frequency generated, means for modulating said varying frequency with said detected television current, a plurality of light sources in linear array equal in number to the elemental areas in an elemental line of the image to be produced, crystal filters associated respectively with said light sources each tuned to a different frequency or band of frequencies within the range of frequencies generated by said generator, means for simultaneously impressing said varying frequency modulated current upon said filters whereby said light sources are activated cyclically in succession and in accordance with the modulation of said varying frequency modulated current, and means cooperating with and utilizing said light sources to form successive lines of the image during succeeding respective cycles of illumination of said light sources.

2. In combination, means at a television receiving station for receiving and detecting a constant frequency carrier current the amplitude of which is representative of the light tone values of an object field at a distant transmitting station, a generator at said receiving station for generating a current of such high frequencies that selection of a portion of these frequencies can be effected with crystal filters, said generator including means for continuously and cyclically varying the frequency generated, means for modulating said varying frequency with said detected television current, a plurality of light sources in linear array equal in number to the elemental areas in an elemental line of the image to be produced, crystal filters associated respectively with said light sources each tuned to a different frequency or band of frequencies within the range of frequencies generated by said generator, means for simultaneously impressing said varying frequency modulated current upon said filters whereby said light sources are activated cyclically in succession and in accordance with the modulation of said varying frequency modulated current, and a rotatable light directing member for directing light from said light sources to a screen.

3. In combination, means at a television receiving station for receiving and detecting a constant frequency carrier current the amplitude of which is representative of the light tone values of an object field at a distant transmitting station, a generator at said receiving station for generating a current of such high frequencies that selection of a portion of these frequencies can be effected with crystal filters, said generator including means for continuously and cyclically varying the frequency generated, means for modulating said varying frequency with said detected television current, a plurality of light sources in linear array equal in number to the elemental areas in an elemental line of the image to be produced, crystal filters associated respectively with said light sources each tuned to a different frequency or band of frequencies within the range of frequencies generated by said generator, means for simultaneously impressing said varying frequency modulated current upon said filters whereby said light sources are activated cyclically in succession and in accordance with the modulation of said varying frequency modulated current, and a rotatable polyhedral mirror for directing light from said light sources to a screen.

4. The method of receiving and utilizing in a television receiving station image modulated carrier current of a constant frequency modulated

in accordance with the light tone values of successively scanned lines of an object field whose image is to be produced at the receiving station which comprises detecting said carrier current to produce an image current having amplitude variations corresponding to the light tone values of the object field, generating a carrier current the frequency of which repeatedly varies progressively over the same range at the periodicity at which the successive lines are scanned at the transmitter, continuously modulating the amplitude of said carrier current of varying frequency in accordance with said detected signal current, projecting light beams in succession under control of said carrier current of varying frequency and also controlling thereby the intensity of the projected light beams.

5. The method of receiving and utilizing at a television receiving station carrier current of constant frequency the amplitude of which is modulated in accordance with the light tone values of successively scanned lines of a field of view at a transmitting station, the amplitude of which carrier current is also distinctively modulated at intervals separating the modulations representative of the separately scanned lines at the transmitting station, which method comprises detecting said modulations to form a current whose amplitude corresponds to the tone values of the successively scanned portions at the transmitting station and also to said distinctive amplitude modulations, generating a carrier current the frequency of which repeatedly varies progressively over the same range at a periodicity corresponding to that at which the successive lines are scanned at the transmitting station, utilizing said distinctive modulations of said detected current to control the frequency of said carrier current of varying frequency, varying the amplitude of said carrier current of varying frequency in accordance with said detected signal current, projecting light beams in succession under the selective control of said carrier current of varying frequency and controlling the intensity of the light beam projected at each instant under control of said carrier current of varying frequency.

6. The method of receiving and utilizing at a television receiving station carrier current of constant frequency the amplitude of which is modulated in accordance with the light tone values of successively scanned lines of a field of view at a transmitting station, the amplitude of which carrier current is also distinctively modulated at intervals separating the modulations representative of the separately scanned lines at the transmitting station, which method comprises detecting said modulations to form a current whose amplitude corresponds to the tone values of the successively scanned portions at the transmitting station and also to said distinctive amplitude modulations, generating a carrier current which repeatedly varies progressively over the same range at a periodicity corresponding to that at which the successive lines are scanned at the transmitting station, utilizing the frequency variations of said carrier current of varying frequency to control the projection in succession of light beams and the amplitude variations of said carrier current of varying frequency to control the intensity of said light beams, and deflecting each of said light beams under control of said distinctive amplitude modulations.

7. In an electro-optical image producing system an array of a large number of cathode ray light sources, an optical means individual to said sources for forming the light therefrom into beams the central axes of which lie in the same plane, a screen, a rotatable polyhedral mirror with its axis parallel to said array of light sources and positioned to receive said beams and sweep them simultaneously across said screen as said mirror rotates, said optical means imaging said light sources on said screen, said optical means comprising light converging means positioned very close to its associated light source and a lens positioned between said light source and said mirror, all of said light converging means being aligned, with adjacent ones close to each other, and said lenses likewise being aligned and having adjacent ones close to each other, and light baffles, each of which extends from a region between two adjacent light sources to a region between two adjacent lenses which respectively cooperate with said two light sources, said baffles being arranged to prevent light from any light source from reaching any lens except the one cooperating therewith.

8. The combination of claim 7 in which each of said light sources is a cathode ray tube comprising a container, a cathode ray gun adjacent one wall of said container, and a fluorescent target in the path of the beam from said gun, and each of said light converging elements is an optical lens element in a position outside said container near the portion of the wall which is adjacent said gun for receiving light emitted from said target opposite in direction to that in which said beam impinges thereon, said lens element having its axis coinciding with a line connecting said gun and the center of said target and having a large diameter compared with the dimension of said gun in a direction transverse to said line, the area of said target being small compared with the area of said lens, and the distance between said gun and said target being less than the diameter of said lens, whereby the solid angle through which said lens collects light from said target is relatively great.

9. The combination with a generator of saw-tooth wave voltage, each wave of which has a portion varying slowly and another portion varying relatively abruptly, a generator for generating oscillations at a frequency very large compared with the saw-tooth wave frequency, means under control of said saw-tooth waves for varying the frequency of the waves generated by said second generator substantially at a linear rate, a plurality of selective circuits simultaneously connected in energy receiving relationship to said variable frequency generator, each circuit being selective of a discrete band of frequencies within the range of frequencies generated by said variable frequency generator and different from the bands of every other selective circuit, means for building up an optical image element by element, and means for utilizing the high frequency waves passed by said selective circuits to control the rate at which the elements of said image are built up.

10. In an image producing system, means to produce image current corresponding to the light tone values of successively scanned lines of an object field an image of which is to be produced, means to produce synchronizing impulses occurring at intervals between portions of the image current representative of successively scanned lines, a generator of carrier oscillations having a

frequency several times higher than the elemental frequency of scanning, means to control said generator of carrier oscillations by said synchronizing impulses to vary the frequency of the generated oscillations over a fixed range of frequency during the period corresponding to the portions of the image current representative of line scanings, means to effect amplitude modulation of said generator of carrier oscillations by said image current, and means for projecting light beams under control of said amplitude modulated carrier current of varying frequency, said light beams being projected in succession under control of said varying frequency and the intensity of the individual beams being controlled by the amplitude of said carrier frequency.

11. In an image producing system a vacuum tube oscillator having inductance coils in the input and output circuits inductively coupled together, a tuning condenser connected to said coils, a source of saw-tooth waves of line scanning frequency, a vacuum tube repeater including an inductance coil in the output circuit inductively coupled to the coupled coils of said oscillator for varying the frequency of said oscillator over a given range of frequencies under control of said saw-tooth waves, a vacuum tube modulator having image currents of varying amplitude impressed on its input circuit and its output circuit associated with said oscillator to effect amplitude modulation of the generated oscillations, and an image producing means controlled by the amplitude modulated varying frequency produced by said oscillator.

12. In an image producing system a vacuum tube oscillator having inductance coils in the input and output circuits inductively coupled together, a tuning condenser connected to said coils, a source of saw-tooth waves of line scanning frequency, a vacuum tube repeater including an inductance coil in the output circuit inductively coupled to the coupled coils of said oscillator for varying the frequency of said oscillator over a given range of frequencies under control of said saw-tooth waves, a vacuum tube modulator having image currents of varying amplitude impressed on its input circuit and its output circuit associated with said oscillator to effect amplitude modulation of the generated oscillations, a circuit associated with said oscillator transmitting the amplitude modulated varying frequencies produced by said oscillator, a plurality of band-pass filters each tuned to a different band of the frequencies produced by said oscillator and connected to said circuit, and a corresponding plurality of light sources associated with respective filters and controlled by the currents passed by said filters.

13. The combination with a generator of saw-tooth wave voltage, each wave of which has a portion varying relatively slowly and another portion varying abruptly, a generator for generating oscillations of substantially sine wave form at a frequency very large compared with the saw-tooth wave frequency, means under control of said saw-tooth waves for varying the fundamental frequency of the generated waves of sine wave form substantially at a linear rate, means for building up an optical image element by element, and means for utilizing said high frequency wave of varying frequency to control the rate at which the elements of said image are built up.

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