Dec. 30, 1930. R. V. L. HARTLEY 1,786,652

ELECTROOPTICAL SYSTEM

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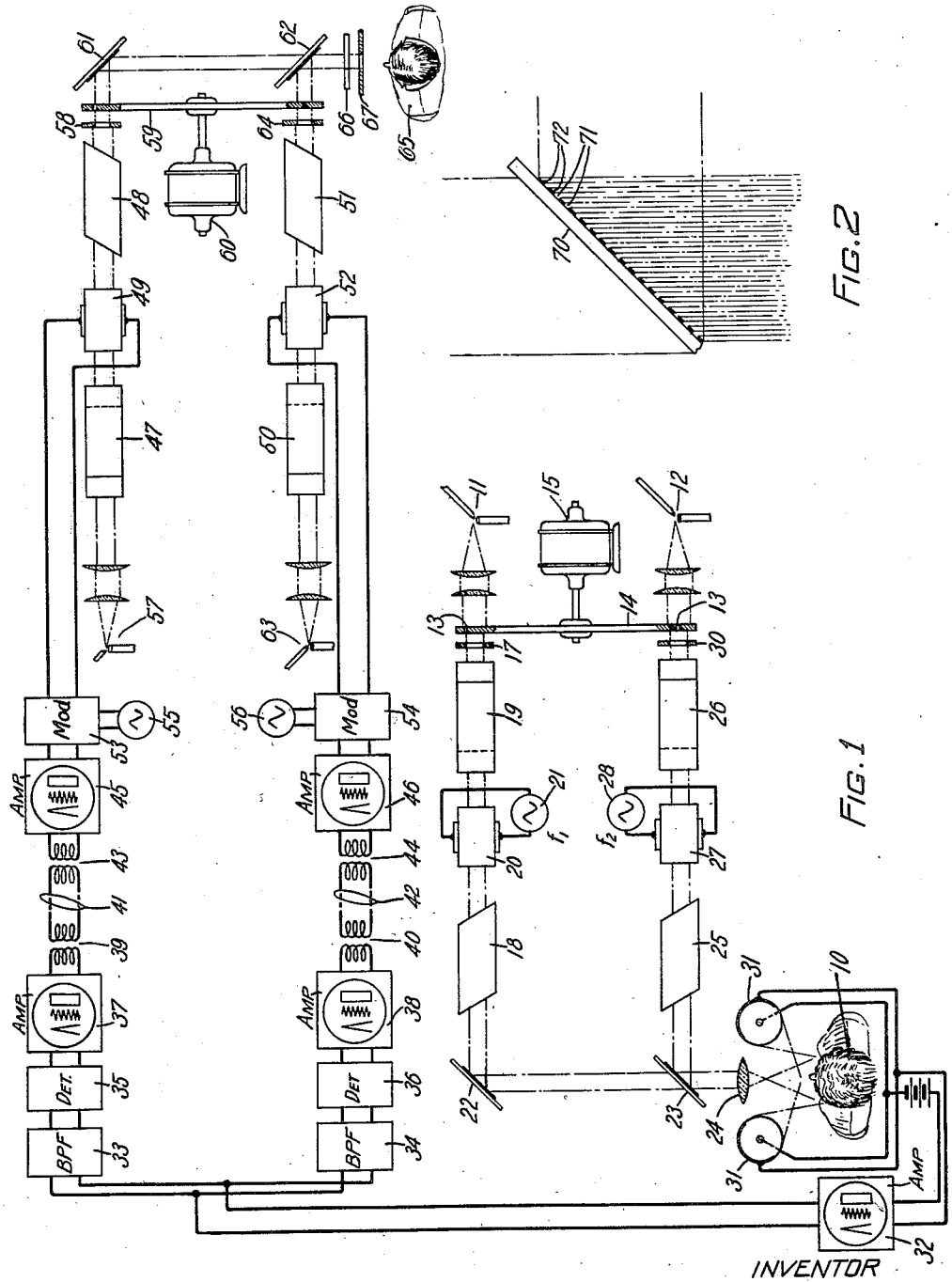


FIG. 1

FIG. 2

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FIG. 5

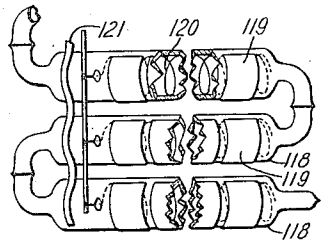


FIG. 3

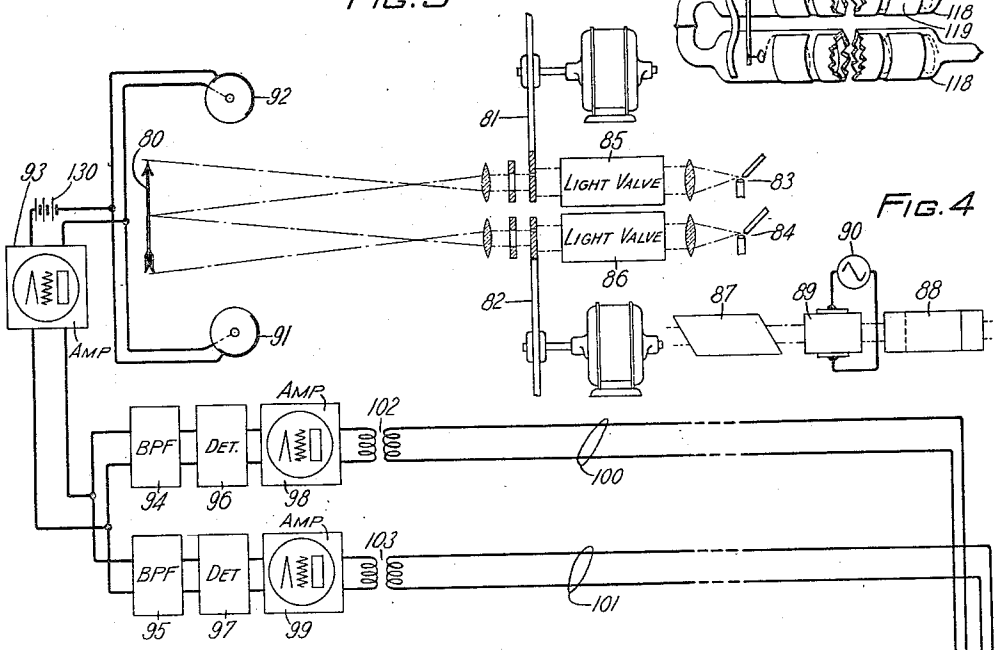
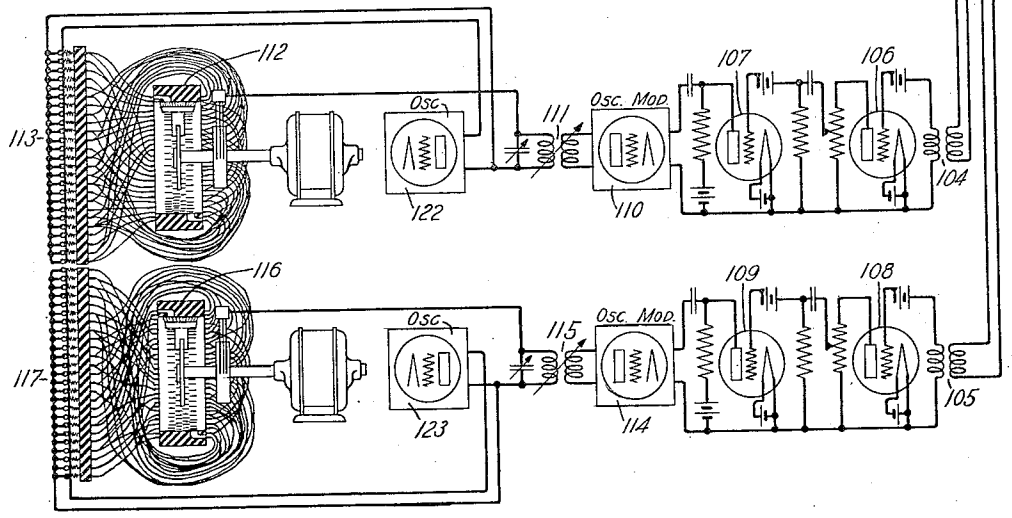


FIG. 4



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ELECTROOPTICAL SYSTEM

Application filed October 16, 1928. Serial No. 312,761.

This invention relates to electro-optical systems and more particularly to a method of and apparatus for producing television images.

An object of the invention is to provide a simple method and means for producing a photoelectric current having components which correspond, respectively, to simultaneously scanned elemental areas of a field of view and which can be separated and separately utilized as desired, for example, for multi-transmission line television.

Another object of the invention is to provide a simple method and means for enabling a field of view to be scanned by a plurality of beams of light simultaneously so as to reduce the time of scanning or to increase the fineness of grain of the image or to obtain other advantages which will be obvious to one skilled in the art.

There is disclosed in a copending application of H. E. Ives, Serial No. 291,744, filed July 11, 1928, a scanning disc provided with apertures so arranged that a plurality of elemental areas in different groups are scanned simultaneously, the light from the elements of one group falling upon one light sensitive cell and that from the other upon a second cell. A similar system has been heretofore suggested in which the light reaching the two cells is constantly interrupted at different frequencies, respectively, by means of a scanning disc having two circular rows of apertures, the number of apertures in the two rows being different. The resulting photoelectric variations are impressed on a single transmission line and later separated by means of filters.

In accordance with the present invention, means are provided for producing a photoelectric current having components which correspond, respectively, to simultaneously scanned elemental areas of a field of view. In a preferred embodiment of the invention a scanning disc is employed for projecting two beams of light simultaneously upon the field of view so that the field is scanned by two spots of light moving over different courses. Each of these beams is interrupted or varied in intensity at a distinctive frequency. Light reflected from the field of view may be received upon a single photoelectric cell and the resulting variations impressed upon frequency selective devices for separating the components of different frequency ranges. The light beams are caused to vary in intensity periodically by providing a light valve which is capable of responding to a high frequency actuating electromotive force for acting upon the light beams. For example, there may be employed a piezo-electric crystal having a high frequency source of electromotive force connected thereto and positioned between two light polarizing prisms. A large number of beams may, of course, be employed and any suitable means used to direct and modulate the beams. The image current produced as the result of scanning comprises a plurality of modulated frequency components and these components are preferably separated by means of filters, detected, and transmitted over separate transmission lines, respectively.

Fig. 1 of the accompanying drawings shows, diagrammatically, a television system embodying features of the present invention;

Fig. 2 is a detail showing of apparatus which may be employed in the system shown in Fig. 1;

Fig. 3 shows a modification of the system shown in Fig. 1; and

Figs. 4 and 5 are detail showings of apparatus employed in the system shown in Fig. 3.

Referring now to Figs. 1 and 2 of the drawing, the subject 10 is scanned by light of substantially parallel rays from the light sources 11 and 12 as it passes through apertures 13 of the scanning disc 14 which is driven by the motor 15 at the rate of 16 or more revolutions per second. The apertures of the scanning disc are arranged in the form of a spiral and are so spaced that alternate linear elements of the field of view are scanned by light from the source 11 and the remaining linear elements which are preferably contiguous with or slightly overlap the first mentioned lines are scanned by light from the source 12. With this arrangement, instead of employing a disc such as is ordinarily used for scanning, a disc which is similar except that alternate aper-

tures are omitted is employed. The apertures are so arranged that the light beam from one source scans one set of linear elements while the light beam from the other source scans the interposed linear elements. The rays of light from source 11 after passing through the apertures 13 and the opening in screen 17 passes through a light valve comprising the crossed Nicol prisms 18 and 19 and the piezo-electric crystal 20. This light valve arrangement is similar to that disclosed in my Patent No. 1,632,069, granted June 14, 1927. The intensity of the light transmitted by this arrangement varies in accordance with the variations in electromotive force of the source of alternating current 21 which has a frequency f_1, this frequency preferably being made equal to the resonant frequency of the crystal so as to cause it to vibrate at its resonant frequency. If desired, a mechanical interrupter may be employed in place of this light valve. This light of varying intensity transmitted through the light valve is reflected by the mirror 22. The glass plate 23 has a very thin coating of silver so that the light reaching the plate is partly reflected and partly transmitted. This plate is so positioned that the light beam reflected by the mirror 22 is partly transmitted through the plate and the lens 24 and thus reaches the subject 10. In a similar manner, light from source 12, after passing through the apertures in the scanning disc and the opening in screen 30 is transmitted through a light valve comprising the crossed Nicol prisms 25 and 26 and the piezo-electric crystal 27 which is actuated by the electromotive force of the source 28 having a frequency f_2. The light beams from this source impinge upon the plate 23 and the reflected portion of these light beams reaches the subject 10 through the lens 24. It is thus apparent that the subject is scanned in a plurality of lines two at a time by two separate beams of light which are varied in intensity at different frequencies, respectively. Light reflected from the subject 10 reaches the photoelectric cells 31, which are connected in parallel to a common circuit, and produces therein current having two components of different high frequency, respectively, (i. e. $2f_1$ and $2f_2$), each of these components being modulated in accordance with the tone values of successive elemental areas of the subject scanned by one of the scanning light beams. This current is amplified by the amplifier 32 and then impressed on the band pass filters 33 and 34, one of which passes only one of the modulated components and the other of which passes only the other of the modulated components. These current components are then detected by the detectors 35 and 36, respectively, amplified by the amplifiers 37 and 38, respectively, and transmitted through transformers 39 and 40 and over transmission lines 41 and 42, respectively, to the receiving station.

Instead of employing the glass plate 23 having a thin coating of silver for partly transmitting and partly reflecting the light which reaches it, a glass plate 70 shown in Fig. 2 may be employed. This plate has alternate transparent and light reflecting linear portions 71 and 72, respectively, each linear portion being the width of a scanning line or a scanning light beam. This plate is so positioned that the light beam reflected by the mirror 22 passes through the transparent portions and the light from source 12 impinges on the reflecting portions.

At the receiving station currents transmitted over lines 41 and 42 are impressed upon transformers 43 and 44, respectively, and amplified by the amplifiers 45 and 46, respectively. Two light valves similar to those employed at the transmitting station, one comprising the crossed Nicol prisms 47 and 48 and the piezo-electric crystal 49 and the other comprising the crossed Nicol prisms 50 and 51 and the piezo-electric crystal 52, are employed for controlling the intensity of light in accordance with the amplitude variations of the currents transmitted over the lines 41 and 42. These currents after being amplified may be impressed directly on the crystals 49 and 52, respectively, but they are preferably impressed on the modulators 53 and 54, respectively, which are supplied from the sources 55 and 56, respectively, with electromotive forces of a high frequency which are equal to the frequencies at which the crystals are resonant. Parallel beams of light from source 57 after being varied in intensity in accordance with the variations in image current received over line 41, are transmitted through the opening in screen 58 and the apertures in the disc 59 which is similar to the scanning disc 14 at the transmitting station and which is driven in synchronism therewith by the motor 60. Any suitable arrangement may be employed for maintaining the discs 14 and 59 in synchronism and in phase, for example, the system disclosed in Patent No. 1,763,909, granted to H. M. Stoller and E. R. Morton, June 17, 1930, may be employed. Light from source 57 after being transmitted through the apertures of the rotating disc 59 is reflected by the mirror 61 and transmitted through the glass plate 62 which is similar to the plate 23 or 70 employed at the transmitting station. In a similar manner light from source 63, the intensity of which is controlled in accordance with the amplitude variations of the image current transmitted over line 42, is transmitted through the opening in screen 64 and the apertures of the disc 59 and impinges on the plate 62 from which it is reflected. Since the field of view is completely scanned

at the transmitting station 16 or more times per second, which is within the period of the persistence of vision, an image of the field of view is presented to the observer 65 by means of two separate moving light beams, one from source 57 and one from source 63, these light beams varying in intensity in accordance with the tone values of successive elemental areas of the subject 10 scanned by the light beams from sources 11 and 12, respectively, at the transmitting station. It appears to the observer that the image is formed on the ground glass screen 66 positioned back of the opening in the screen 67.

In the system shown in Figs. 3 to 5 of the drawing, the object 80 is scanned by two moving beams of light simultaneously in a manner somewhat similar to that described above in connection with Fig. 1. Two separate scanning discs 81 and 82 each having a row of spirally arranged apertures are employed for scanning separate portions of the object by means of light from the sources 83 and 84, respectively. These discs may be driven by separate motors as shown or by a single motor through a mechanical coupling. The light beams from the sources 83 and 84 are varied in intensity at different frequencies, respectively, by means of suitable light valves or light interrupters 85 and 86, respectively. Each of these light valves may comprise two crossed Nicol prisms 87 and 88 and a piezo-electric crystal 89 which is energized by the electromotive force of a source 90 as shown in Fig. 4. Light reflected from the object 80 impinges on the light sensitive surface of the photoelectric cells 91 and 92 which are connected in parallel to the input circuit of the amplifier 93. A battery 130 is provided for energizing the photoelectric cells. There is thus produced in the circuit of the photoelectric cells a current having two high frequency components each modulated in accordance with the intensity of the light from the sources 83 and 84 reflected from the object 80. This current is amplified by the amplifier 93 and the two frequency components are separated by the band pass filters 94 and 95. These current components are then detected by the detectors 96 and 97, respectively, amplified by the amplifiers 98 and 99, respectively, and impressed on transmission lines 100 and 101 through transformers 102 and 103, respectively.

At the receiving station, two similar sets of apparatus are employed, each for producing one portion of an image of the object 80 which is scanned at the transmitting station by a light beam from one of the light sources 83 and 84. Each of these sets of apparatus is similar to that shown and described in detail in Patent No. 1,759,504 granted to F. Gray, May 20, 1930. Currents transmitted over lines 100 and 101 are impressed through transformers 104 and 105, respectively, upon amplifying circuits, one of which comprises the three electrode vacuum tubes 106 and 107 and the other of which comprises the vacuum tubes 108 and 109, each set of vacuum tubes being coupled through a gain control circuit. The output current of the amplifying circuit comprising the vacuum tubes 106 and 107 is impressed on the oscillator-modulator 110 for modulating the high frequency current produced thereby. The output energy of this oscillator-modulator is impressed through the variable coupling 111 and the distributor 112 upon the multiple electrode glow discharge lamp 113. In a similar manner the current transmitted over line 101 and amplified by the vacuum tubes 108 and 109 is impressed on the oscillator-modulator 114 for modulating the high frequency current produced thereby, and the output energy of this oscillator-modulator is impressed through the variable coupling 115 and the distributor 116 upon the multiple electrode glow discharge lamp 117. The discs 81 and 82 at the transmitting station and the distributors 112 and 116 at the receiving station are driven in synchronism by their respective driving motors. A suitable system for controlling the speed of the driving motors to maintain the driven elements at different stations respectively in synchronism is shown in the patent of H. M. Stoller and E. R. Morton to which reference is made above. Each of the glow discharge lamps 113 and 117 comprises a continuous chamber formed of closely positioned parallel glass tubes 118 (Fig. 5) containing a gas such as neon. The lamp has a large number of small electrodes 119, one for each elemental area of the field of view scanned at the transmitting station, which are connected to the contacts of one of the distributors 112 or 116, and a common grid electrode 120. Each lamp also has a special set of electrodes 121 which is continuously energized by the high frequency output energy of one of the oscillators 122 or 123 for the purpose of preventing lag in the response of the lamp to energy supplied to the individual electrodes. The lamp is described in detail in the patent granted to F. Gray referred to hereinbefore.

It is now known that the width of the frequency band required for producing electro-optically, images of a fair size and good quality, is greater than can be transmitted over a single commercial telephone line. This difficulty is of course obviated by employing a plurality of lines as in the systems just described. In these systems, moreover, the difficulty involved in actuating different photoelectric cells, associated with different transmission lines, respectively, in accordance with the tone values of seperate elemental areas of the field of view, is also avoided by actuating a single photoelectric

cell, or a group of cells associated with a single circuit, in accordance with the tone values of several portions of the field of view simultaneously and later separating the components of the image current each of which varies in accordance with the tone values of one of the portions of the field of view.

What is claimed is:

1. An electro-optical image producing system comprising means for successively scanning groups of elemental areas of a field of view an image of which is to be produced, each group comprising two separate elemental areas which are scanned simultaneously, and light-sensitive means for producing a single photoelectric current having a component corresponding to the tone values of each of said simultaneously scanned elemental areas.

2. An electro-optical system comprising means for simultaneously producing a plurality of separate movable light beams for simultaneously scanning a plurality of elemental areas of a field of view, a plurality of elemental areas being scanned in succession by each beam, and light-sensitive means for producing a single photoelectric current having a component corresponding to the tone values of each of at least two of said simultaneously scanned elemental areas.

3. An electroc-optical image producing system comprising means for simultaneously scanning two elemental areas located in separate portions, respectively, of a field of view an image of which is to be produced, the elemental areas comprising each of said portions of the field of view being scanned successively, and light-sensitive means for producing in a circuit conductively connected to said light-sensitive means a single image current having a component corresponding to the tone values of the elemental areas of each of said portions of the field of view.

4. An electro-optical system comprising means for simultaneously scanning two elemental areas located in separate portions, respectively, of a field of view, the elemental areas comprising each portion of the field of view being scanned successively, light-sensitive means for producing in a circuit conductively connected to said light-sensitive means a single image current having a component corresponding to the tone values of the elemental areas of each of said portions of the field of view, and means for producing a separate current corresponding to each of said components and having a characteristic thereof.

5. An electro-optical image producing system comprising means for simultaneously scanning two elemental areas in different groups, respectively, of a field of view an image of which is to be produced, the elemental areas of each group being scanned in succession, and means including a light-sensitive device for producing in a circuit conductively connected to said light-sensitive device, a single image current comprising components of different frequencies, respectively, each frequency component being modulated in accordance with the tone values of the elemental areas of one of said groups, said tone values extending over a range of values between fixed limits.

6. An electro-optical system comprising means for simultaneously scanning two elemental areas in different groups, respectively, of a field of view, the elemental areas of each group being scanned in succession, means including a light-sensitive device for producing in a circuit associated therewith an image current comprising components of different frequencies, respectively, each frequency component being modulated in accordance with the tone values of the elemental areas of one of said groups, a plurality of transmission lines, and means for transmitting currents corresponding to the amplitude variations of the different modulated frequency components, respectively, over different transmission lines.

7. An electro-optical system comprising means for simultaneously scanning two elemental areas in different groups, respectively, of a field of view, the elemental areas of each group being scanned in succession, for producing a single image current having a component corresponding to the tone values of the elemental areas of each of said groups, respectively, two transmission channels, and means for separating said components and impressing them on separate transmission channels.

8. An electro-optical system comprising means for simultaneously scanning two elemental areas in different groups, respectively, of a field of view, the elemental areas of each group being scanned in succession, means including a light-sensitive device for producing in a circuit associated therewith an image current comprising components of different frequencies, respectively, each frequency component being modulated in accordance with the tone values of the elemental areas of one of said groups, means for separating said modulated frequency components, means for demodulating each of said frequency components, two transmission channels, and means for impressing said frequency components after being demodulated on separate transmission channels.

9. An electro-optical system comprising means for simultaneously producing a plurality of separate movable light beams for simultaneously scanning different elemental areas of the same field of view, and means for modulating said beams at different frequencies, respectively.

10. A method of scanning a field of view which comprises simultaneously producing

two separate moving beams of light for scanning different lines of elemental areas of the field, respectively, and modulating said beams at different frequencies, respectively.

11. An electro-optical system comprising means for simultaneously producing a plurality of separate moving beams of light for scanning different lines of elemental areas of a field of view, respectively, means for modulating said beams at different frequencies, respectively, and light-sensitive electric means for receiving light reflected from said field of view and for setting up an electric current having components, respectively, constantly varying at said frequencies, the amplitude of variation corresponding to the tone values of elemental areas of said field scanned by a beam of corresponding frequency.

12. In combination, a light-sensitive electric element, a source of direct current in circuit therewith, a source of light for controlling a characteristic of said light-sensitive element, means for controlling the intensity of the light reaching said light-sensitive element for causing the current in said circuit to vary periodically in accordance with at least two different frequencies, and a plurality of electric filters for selecting current components having said two different frequencies, respectively, from said first mentioned current.

13. An electro-optical image producing system comprising means for sucessively scanning groups of elemental areas of a field of view, each group comprising two separate elemental areas which are scanned simultaneously, light-sensitive means for producing a single photoelectric current having a component corresponding to the tone values of each of said simultaneously scanned elemental areas, means for transmitting energy corresponding to the components of said photoelectric current and means responsive to said energy for causing light to be emitted from a plurality of elemental areas, simultaneously, of an image field corresponding to the scanning of the elemental areas of the field of view, to produce an image of said field of view.

14. An electro-optical image producing system comprising means for simultaneously producing a purality of separate movable light beams for simultaneously scanning a plurality of elemental areas of a field of view, a plurality of elemental areas being scanned in succession by each beam, light-sensitive means for producing a single photoelectric current having a component corresponding to the tone values of each of at least two of said simultaneously scanned elemental areas means for separately transmitting energy corresponding to each component of said photoelectric current and means responsive to said energy for controlling the production of an image of said field of view.

15. An electro-optical image producing system comprising means for simultaneously producing a plurality of separate moving beams of light for scanning different lines of elemental areas of a field of view, respectively, means for modulating said beams at different frequencies, respectively, light-sensitive electric means for receiving light reflected from said field of view and for setting up an electric current having components, respectively, constantly varying at said frequencies, the amplitude of variation corresponding to the tone values of the elemental areas of said field scanned by a beam of corresponding frequency, frequency discriminating means for impressing currents corresponding to said components on separate circuits, respectively, means for demodulating said currents, a plurality of transmission lines for separately transmitting said demodulated currents, means at the receiving end of said lines for producing a plurality of moving beams of light, the movement of said beams corresponding to the movement of said scanning beams of light, and means controlled by said separately transmitted currents for controlling said beams respectively at the receiving end to produce an image of said field of view.

16. In an image producing system, means for producing a movable light beam for scanning portions of a field of view, means for producing a second movable light beam for scanning portions of a field of view lying between portions of the field of view scanned by the first mentioned light beam, and means for causing both said means to operate simultaneously.

17. In an image producing system, means for producing a movable light beam for scanning non-adjacent line series of elemental areas of a field of view, means for producing a second movable light beam for scanning line series of elemental areas of said field of view lying between the lines scanned by the first mentioned light beam, and means for causing both said means to operate simultaneously.

18. In an image producing system, a movable light beam for scanning portions of a field of view, means for producing a second movable light beam for scanning portions of said field of view lying between portions of the field of view scanned by the first mentioned light beam, means for causing both said means to operate simultaneously, and means for giving each light beam a distinctive characteristic before it is utilized for scanning.

19. In an electro-optical image producing system, means for producing a movable light beam for scanning portions of an object, means for producing a second movable light

beam for scanning portions of the object lying between portions scanned by the first mentioned light beam, means for causing both said means to operate simultaneously, means for giving said light beams a distinctive characteristic, and photoelectric means having a large photo-sensitive surface for receiving light reflected from said object.

In witness whereof, I hereunto subscribe my name this 29th day of September, 1928.

RALPH V. L. HARTLEY.