Oct. 27, 1936. R. C. MATHES 2,058,898

ELECTROOPTICAL IMAGE PRODUCTION

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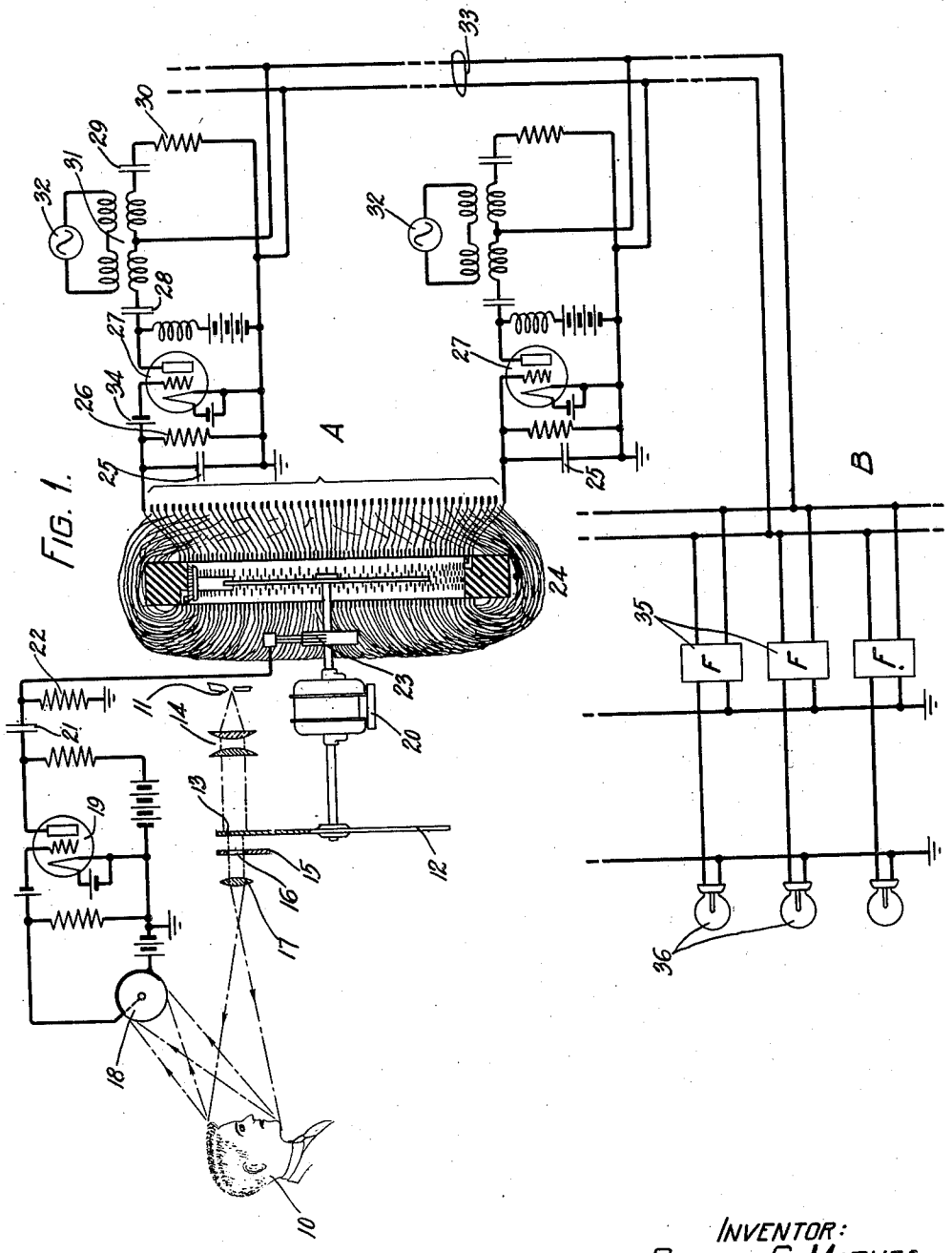

FIG. 1.

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FIG. 3.

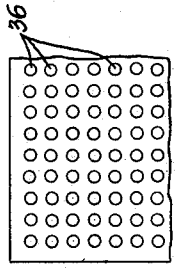

FIG. 2.

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ELECTROOPTICAL IMAGE PRODUCTION

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Application November 12, 1927, Serial No. 232,751

16 Claims. (Cl. 178—6)

This invention relates to electro-optical image production and particularly to a method and means for increasing the brightness of images of the kind produced by television systems.

In a copending application of F. Gray, Serial No. 181,538, filed April 6, 1927, there is disclosed a system which has been used successfully for producing images electro-optically. In this system there is employed at the receiving station a bank of light emitting elements which are actuated periodically in succession by current impulses corresponding to instantaneous aspects of elemental areas of the object or field being scanned at the transmitting station, thereby setting up light impulses of short duration. These light impulses occur in rapid succession in order to give the eye of the observer the impression of seeing a complete image. Because of the short duration of each light impulse the apparent brightness of the image is relatively small.

In accordance with the present invention the light emitting or controlling elements of the image producing apparatus are periodically actuated in succession in accordance with instantaneous aspects of corresponding elemental areas of an object or field being scanned and are maintained actuated in accordance with a given aspect of the corresponding elemental area of the object or field while succeeding actuations of other elements take place, and preferably until the scanning cycle has been completed. The image produced in this manner appears considerably brighter than the image produced by the method in which only one element is in the actuated state at one time.

In one of the specific embodiments of the invention herein shown and described, a commutator driven in phase with the scanning means is employed for connecting condensers one at a time and periodically to a source of potential which varies in accordance with the variations in shade of the elemental areas of the field being scanned. Each condenser is connected to the input circuit of a voltage controlled repeater of the vacuum tube type for varying the amplitude of the current flowing in a transmission channel associated with the output circuit of the repeater. At the receiving station each of the transmission channels is associated with image producing apparatus including one of a bank of light controlling or light producing elements such as an incandescent lamp. It is thus seen that light emitted by each of these elements is of an intensity which corresponds to the charge on one of the condensers, which in turn is in accordance with the tone value of a given aspect of an elemental area of the field of view and this light is sustained for a considerable period in accordance with this aspect.

In another specific embodiment of the invention instead of providing a plurality of transmission channels, one for each of the elemental areas of the field of view, the image currents are transmitted over a single channel which is connected to the commutator at the receiving station. This commutator serves to charge a plurality of condensers in succession and periodically in accordance with instantaneous aspects of elemental areas of the field scanned at the transmitting station, and these condensers control the light produced by the elements of an image producing apparatus in a manner as described above.

In addition to increasing the brightness of the image by sustaining the light produced by each element of the image producing apparatus while other elements are being actuated, the advantage of reducing flicker is realized. In a system in which the actuation of the elements is not sustained a light flash occurs each time that an image impulse corresponding to a given elemental area of the object or field of view is received, while in the system of this invention a light flash occurs only at the element of the image producing apparatus corresponding to the elemental area of the object, the aspect of which is changing.

The invention may be readily understood by referring to the following detailed description and the accompanying drawings in which

Fig. 1 is a diagrammatic view of a television system in accordance with the present invention,

Fig. 2 is a diagrammatic view of a modification of the television system shown in Fig. 1, and

Fig. 3 is a front elevation of a portion of the bank of light producing elements employed in connection with the systems shown in Figs. 1 and 2.

Referring now to Fig. 1 of the drawings the television system shown comprises a transmitting station A and a receiving station B. At the station A the subject 10 comprising the field of view an image of which is to be produced at the receiving station is located in front of a scanning apparatus. This apparatus comprises an arc lamp 11 and an optical system for causing a slender pencil of substantially parallel rays of intense light to sweep across the field in front of the scanning apparatus and scan the subject

10 in a series of successive parallel lines. The optical system includes a scanning disc 12 which has a number of small circular apertures 13 arranged in a spiral extending around the disc near its rim, and which is driven by the motor 20. Light from the arc 11 is directed by a lens system 14 so that an intense beam of light passes through each aperture as it moves across the illuminated area of the disc. An opaque screen 15 in front of the disc is provided with a rectangular opening 16 of such width as to emit light from only one aperture of the scanning disc at a time. Lens 17 bends the slender pencil of parallel rays passing through the aperture 13 and the opening 16 to form an image of the moving aperture on the subject 10. As a result of this arrangement the subject is completely scanned once for each revolution of the disc in a series of successive parallel lines by a small rapidly moving intensely bright spot of light. As the spot of light passes over the subject light is diffusely reflected therefrom and a portion of the reflected light reaches the photo-sensitive surface of a large aperture photo-electric cell 18 which is connected to the input circuit of a vacuum tube amplifier 19. This portion of the television system is shown and described in the copending application of F. Gray referred to above.

The output of the amplifier 19 is connected through condenser 21 of large capacity and resistance 22 to ground. The ungrounded terminal of this resistance is also connected to the brush 23 of the rotary distributor 24 which has as many contacts as the number of elemental areas into which the subject 10 is divided for image producing purposes and which distributor is directly coupled to the motor 20 so that it is driven in synchronism with the scanning disc 12. Each contact of the rotary distributor is connected to a plate of one of a plurality of condensers 25, two of which are shown in the drawings for the purpose of illustration, the remaining plate of each condenser being grounded. Each condenser 25 is shunted by a resistance 26, which may be the leakage resistance of the condenser, and connected to the input terminals of a vacuum tube repeater 27. The output circuit of this repeater is connected to a circuit comprising the condensers 28 and 29, resistance 30 and the secondary winding 31 of a transformer the primary winding of which is connected to an oscillation generator 32. The transmission medium 33 which connects the transmitting and receiving stations is connected between ground and a mid-terminal of the secondary transformer winding 31.

As the subject 10 is scanned, electrical impulses corresponding to the shades of successive elemental areas of the subject are set up by the photo-electrical cell 18. These impulses after being amplified by the amplifier 19 are impressed across the resistance 22 thus causing corresponding potential differences across the terminals thereof. A potential corresponding to the shade of each elemental area of the subject 10 is then impressed upon one of the condensers 25 which is charged accordingly. This potential to which each condenser 25 is charged acts in series with a biasing battery 34 of the vacuum tube repeater 27 and causes the output impedance of the repeater to change in accordance with its magnitude. The circuit comprising the output of the repeater 27, condensers 28 and 29, resistance 30 and the secondary winding of transformer 31 is so adjusted that normally none of the current generated by the oscillator 32 flows through the transmission medium 33. When the output impedance of the repeater 27 is changed however, due to the charging of the condenser 25 this bridge circuit is unbalanced and current from the source 32 of a magnitude determined by the degree of unbalance is caused to flow in the transmission medium 33 to the receiving station B. The oscillators 32 produce currents of different frequency respectively, and each of the band pass filters 35 at the receiving station B are designed to pass current produced by one of these oscillators to one of the bank of light producing elements 36 which may be small incandescent lamps. The value of resistance 22 and the capacity of the condenser 25 should be such that the condenser is charged within the time that a circuit is completed through each of the contacts of the distributor 24. Satisfactory results may be obtained by making the value of the resistance of the order of 5,000 to 10,000 ohms and the capacity of each condenser of the order of 0.001 microfarad. The value of the resistance 26 should be high, for instance, of the order of 100 megohms so that the charge on condenser 25 is not reduced appreciably during the time of a complete scanning of the subject 10. It is thus apparent that the light produced by each of the bank of light producing elements 36 is of an intensity proportional to the shade of a corresponding elemental area of the subject 10 and this light is maintained at a constant value corresponding to a given aspect of the elemental area of the subject 10 until the aspect of this area changes.

The scanning apparatus employed at the transmitting station A of the television system shown in Fig. 2 is the same as that employed in the system shown in Fig. 1 and the parts are correspondingly numbered. The electrical image impulses set up by the photo-electric cell 18 and amplified by the amplifier 19 are transmitted to the receiving station B over the transmission channel 37 which is connected to the transformers 38 and 39 located at the transmitting and receiving stations respectively.

The incoming image impulses are amplified by the vacuum tube amplifier 40 and are then impressed upon the resistance 41 connected in its output circuit through a condenser 51 of large capacity. This resistance is connected successively to one of the condensers 43 through the contacts of the rotary distributor 42 which is driven by the motor 52. The motors 20 and 52 are maintained in synchronism by any suitable means represented by the devices 53 and 54 shown connected by the transmission line 55. A system which has been employed successfully for synchronizing the elements at different stations of a television system is disclosed in Patent 1,763,909, granted June 17, 1930 on an application of H. M. Stoller and E. R. Morton, Serial No. 200,799, filed June 23, 1927. The condensers 43 are charged in succession to a potential corresponding to the potential difference measured between the terminals of resistance 41 and therefor in accordance with the shades of successive elemental areas of the subject 10. These condensers are each connected in the input circuit of one of a plurality of repeater elements of the vacuum tube type having a cathode 44, a grid 45 and an anode 46, and one of a bank of light producing elements 36, such as a small incandescent lamp, is connected in the anode circuit of each repeater in series with a source of anode current 48. The grid 45 of each repeater is normally biased by a battery 49 through a resistance 50 so that at the

anode current is of such a magnitude that the lamps normally appear dark but emit an appreciable amount of light when the anode current is increased slightly. This increase in anode current and the consequent emission of light occurs when one of the condensers 43 becomes charged in accordance with an incoming image impulse corresponding to the shade of an elemental area of the object 10. The electromotive force to which the condenser is charged is impressed across the terminals of the resistance 50 which may represent the leakage resistance of condenser 43, thus placing a positive electromotive force in series with the negative biasing battery 49 and causing the anode current to increase. The charge on each condenser and the resulting illumination produced by the lamp associated therewith is maintained in accordance with the magnitude of a given image impulse and therefore in accordance with a given aspect of an elemental area of the subject until an image impulse of different value corresponding to a different aspect of the elemental area of the subject is received. The value of resistance 41 and the capacity of condenser 43 should preferably be such that the condenser can be charged in accordance with the received image impulse during the time that the distributor completes a circuit through each contact. As explained in connection with the system of Fig. 1, satisfactory results can be obtained by employing a condenser having a capacity of 0.001 microfarad and a resistance of 5,000 to 10,000 ohms. The value of resistance 50 should be sufficiently high that the charge on each condenser 43 is not reduced appreciably during the time of a complete scanning of the object 10. A value of the order of 100 megohms has been found to be satisfactory.

Fig. 3 shows in front elevation a portion of the bank of light producing elements 36 which is employed at the receiving stations B of the systems shown in Figs. 1 and 2 for the production of an image of the subject 10. To obtain an image of good quality a large number of these elements in close space relation should be employed, a bank of 2,500 elements having been found to be satisfactory.

It is to be understood that it is within the scope of the invention to employ a suitable apparatus for recording images of an object or field of view instead of receiving the images directly by the eye. Accordingly, it is also within the scope of the invention to employ instead of the light producing elements other elements which emit energy of a frequency range which extends above or below the visible spectrum.

What is claimed is:

1. In an electro-optical system for producing images of a field of view, a plurality of condenser elements, means for charging said elements in succession periodically in accordance with tone values of elemental areas of said field of view, a plurality of voltage controlled repeaters associated conductively with said condenser elements respectively, and means controlled by said repeaters for producing an image of said field of view.

2. In an electro-optical system for producing images of a field of view, means for scanning elemental areas of said field in succession, a source of potential, means for varying the amplitude of said potential in accordance with the tone values of successively scanned elemental areas, a condenser, means for periodically associating for a short interval said condenser with said source of potential, a voltage controlled repeating device, and means for continuously conductively associating said repeating device with said condenser.

3. In an electro-optical system for producing images of a field of view, means for scanning elemental areas of said field in succession, a source of potential, means for varying the amplitude of said potential in accordance with the tone values of successively scanned elemental areas, a plurality of condensers, means for successively associating said condensers with said source of potential, a plurality of voltage controlled repeating devices, one for each of said condensers, means for conductively associating said repeating devices with said condensers, respectively, image producing apparatus at a distant station, and means for transmitting energy controlled by said repeating devices to said station to control the production of the image.

4. In an electro-optical system for producing images of a field of view, a transmitting station and a receiving station, means at said transmitting station for setting up image current impulses corresponding to the shade of successive elemental areas of a field of view, said shades having a variety of tone values between black and white, a bank of incandescent lamps, one for each elemental area, at said receiving station to be actuated in succession in accordance with the received image current impulses to reproduce said variety of tone values and means for maintaining each lamp actuated in accordance with the characteristics of a given image current impulse for a period greater than the duration of the impulse.

5. In receiving apparatus employed in the art herein described, the combination of a picture plane, means embodying a gaseous lamp for transiently exciting illumination of said picture plane in elementary areas, and means including a condenser and a resistance in circuit with the gaseous lamp for securing persistence of illumination of said elementary areas for a time approximately equal to persistence of vision of the human eye.

6. In receiving apparatus for television systems, the combination of a relay operated by the received signals, an electric lamp arranged to be energized through the said relay in accordance with received signal impulses, and a reactance element electrically connected to the said lamp for storing electric energy to maintain the said lamp illuminated for a longer period than is occupied by the signal impulse.

7. In a receiving apparatus for television systems, the combination of a relay operated by the received signals, an electric lamp, an electric supply circuit for the lamp and operated by the said relay in accordance with received signal impulses, and an electric condenser connected in shunt with the said lamp for maintaining the lamp illuminated over a longer period than is occupied by each signal impulse.

8. In receiving apparatus for television the combination of a plurality of illuminating elements one for each unit area of a receiving screen, means for distributing electric energy in accordance with received impulses to each said illuminating element in turn and a reactance unit for each illuminating element electrically connected thereto to store energy when the element is receiving energy due to the signal and to subsequently electrostatically control an electric current to maintain the illumination of the element after it is disconnected from the electric energy.

9. In receiving apparatus for television the

combination of a plurality of illuminating elements one for each unit area of a receiving screen, means for distributing electric energy in accordance with received impulses to each said illuminating element in turn, and a condenser for each illuminating element electrically connected in shunt therewith to store energy when the element is receiving energy due to the signal to maintain the illumination of the element after it is disconnected from the electric energy.

10. A television system comprising an image producing device having a plurality of elements one for each elemental area of a field of view, a source of energy for energizing the elements of said image producing device to cause light to be emitted therefrom, means for generating electrical impulses corresponding to the tone values of elemental areas of a field of view for controlling said energization of each element of the image producing device to control the intensity of the light emitted therefrom over a range of intensities between a minimum and a maximum value, thereby producing an image of said field of view in a variety of tone values between black and white, and means for causing said energization of an element to persist for a period after the controlling electrical impulse for that element is interrupted.

11. In receiving apparatus employed in the art herein described, the combination of a picture plane divided into elementary areas, each area having its own source of illumination embodying a gaseous lamp, means for transiently exciting said sources, and means including a condenser and a resistance in circuit with the gaseous lamp for securing persistence of said illumination after the exciting means has passed on.

12. In receiving apparatus employed in the art herein described, the combination of a picture plane divided into elementary areas, separate means for illuminating each of said areas, including a gaseous lamp, a resistance and a condenser in circuit with the gaseous lamp, and means for switching an exciting current successively to a plurality of said illuminating means, whereby said elementary areas are successively illuminated and the illumination thereof caused to persist for a time approximately equal to the persistence of vision of the human eye.

13. An electro-optical image producing system comprising a transmitting station and a receiving station, a transmission medium connecting said stations, means including a scanning device at said transmitting station for causing electrical impulses corresponding to the tone values of elemental areas of the field of view having a variety of tone values between black and white to be impressed on said transmission medium, a bank of electric light elements at said receiving station, one for each elemental area of a field of view, adapted to produce light when current flows therethrough, a source of current at said receiving station for energizing said elements to cause light to be emitted therefrom, means for controlling said energization of the light producing elements in accordance with the electrical impulses received over said transmission medium, thereby controlling the intensity of the light produced by each element and causing an image to be produced having a variety of tone values between black and white, and means for causing the energization of an element to be maintained for a period after the controlling electrical impulse for that element is interrupted, said period being a large part of the period required to scan said field of view.

14. In an electro-optical image producing system, a bank of light emitting elements each corresponding to an elemental area of a field of view, means for energizing said elements by energy from a local source to cause light to be generated and emitted thereby, means for controlling the energization of said elements in succession and repeatedly one at a time, and means the elemental portions of which are energized under control of said control means in accordance with the instantaneous aspects of corresponding elemental areas of said field of view for maintaining each light emitting element energized during a cycle of energization of the remaining elements, said control means being capable of causing a decrease in the energization of an elemental portion within an elemental control period if the light tone value of the corresponding elemental area in said field of view has decreased since the preceding energization readjustment for that elemental portion, or an increase in the energization if the tone value has increased.

15. A television system comprising an image producing device having a bank of electric lamps, a source of energy for exciting said lamps to cause light to be emitted therefrom, means for receiving electrical impulses corresponding to the tone value of elemental areas of the field of view, means under control of said last-mentioned means for controlling the energization of said lamps in succession and repeatedly one at a time, and means the elemental portions of which are energized under control of said control means for maintaining each lamp energized during a cycle of energization of the remaining lamps, said control means being capable of causing a decrease in the energization of an elemental portion within an elemental control period if the light tone value of the corresponding elemental area of said field of view has decreased since the proceding energization readjustment for that elemental portion, or an increase in the energization if the light tone value has increased.

16. In electro-optical image producing apparatus the combination with an array of electric storage elements, one for each elemental area of an object field and at least 2500 in all, of means for cyclically charging said storage elements in succession, the period of a complete storage cycle being of the order of that of persistence of vision, means for causing a slow, desired leakage of each charge to take place during at least a large part of the period required to charge all of said elements, and means for setting up an image current under control of said storage elements.

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