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A. W. HORTON, JR

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ELECTROOPTICAL SYSTEM

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FIG. 1

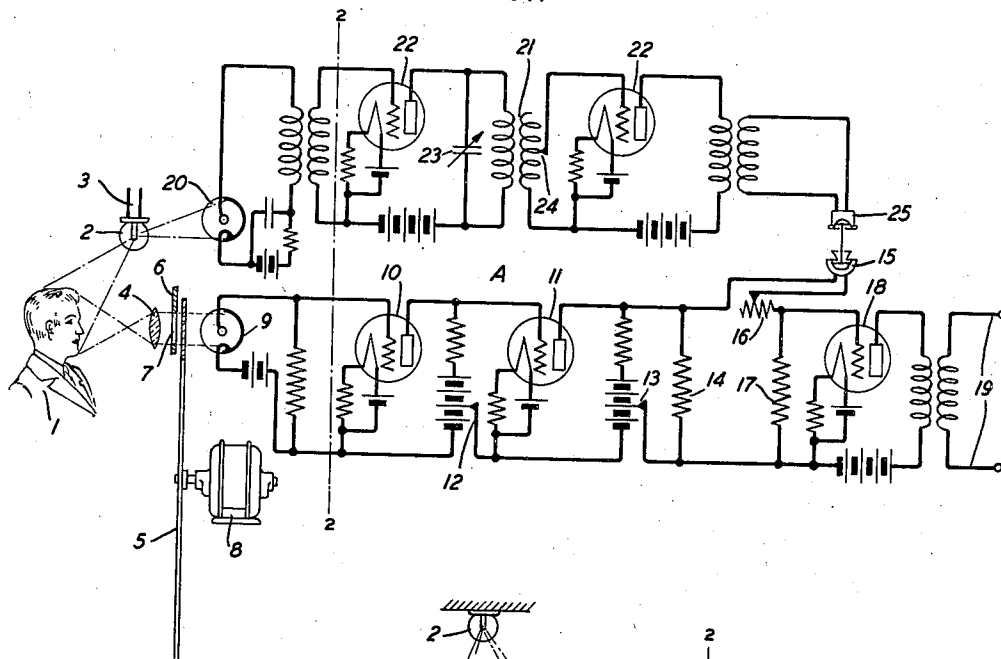
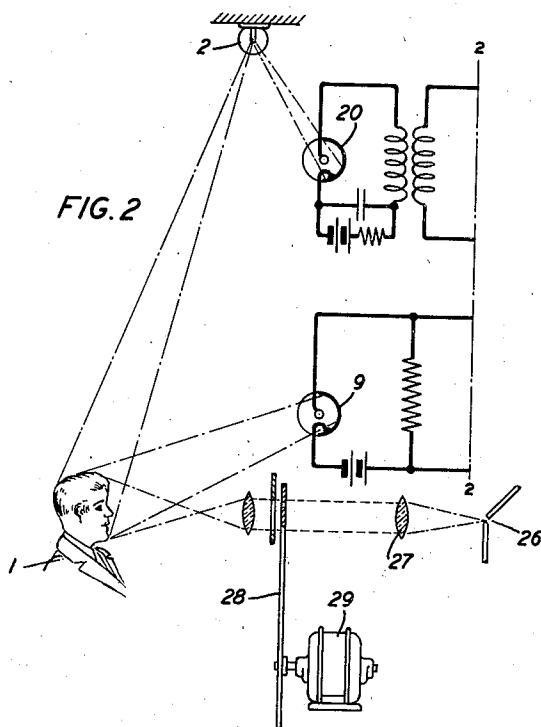


FIG. 2



INVENTOR
A. W. HORTON, JR.
BY *J. H. Neville*

ATTORNEY

UNITED STATES PATENT OFFICE

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ELECTROOPTICAL SYSTEM

Arthur W. Horton, Jr., East Orange, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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6 Claims. (Cl. 178—7.1)

This invention relates to electrooptical systems and more particularly to a method of and means for extending the field of operation of such systems.

5 The prior art contains a disclosure of a picture transmitting system comprising a transmitter including two light sensitive electric devices, one of which is activated by light transmitted through a picture or film from a light source and the
10 other of which is illuminated through a light valve controlled by picture current to compensate the lag due to the inertia of the first light sensitive device. This same result is effected in
15 accordance with a second modification described in the same disclosure by passing the light beam through the picture and applying it to the two light sensitive cells in successive time intervals.

The present invention relates to an electro-optical apparatus of the type described above,
20 in which the added light sensitive electric device is utilized to compensate or neutralize complex distorting current variations which result from the use of the transmitting apparatus in an area supplied with fluctuating light.

25 An object of the invention is to provide improved means for compensating the effect of fluctuating light incident upon a light sensitive electric pick-up means included in electrooptical systems.

30 Another object is to eliminate the disturbing effect of fluctuating light incident on a subject or field of view associated with an electrooptical transmitter.

In one aspect, the invention contemplates the
35 provision of an apparatus including a light sensitive electric device which, because of the incidence of fluctuating light thereon, is activated to control the production of current variations corresponding to the rate of fluctuation of the light
40 source as modified by the varying characteristics of the subject, without causing distortion of the record or image produced at the receiver.

More specifically, the transmitting apparatus is provided with an auxiliary light sensitive electric means which is activated by the fluctuating
45 light to control the operation of means for compensating or neutralizing current variations which result from the activation of the main light sensitive electric pick-up means by fluctuating light directly incident thereon, as well as
50 that indirectly applied thereto over an optical path including the subject. Since such current variations, if supplied to a receiving apparatus, would tend to cause distortion of the record or
55 image produced at a receiving station, the sphere

of satisfactory usefulness of the electrooptical transmitter heretofore disclosed is limited to the case in which the subject is illuminated with light of constant intensity. However, by providing
5 electrooptical transmitters with means for eliminating the distorting current variations resulting from the application of fluctuating light to the subject, for example, that supplied by lamps energized with 60 cycle current commonly used for
10 this purpose in public buildings, offices and the home, this invention serves to extend the field of usefulness of such devices.

According to one embodiment to be hereinafter described in detail, to illustrate the principles of the invention, a field of view is illuminated by
15 lamps energized with alternating current and an image of the field is optically applied to a movable scanning member provided with apertures through which the fluctuating and image modified light, reflected from the field of view,
20 passes to a photoelectric cell or group of such cells.

In a second embodiment, a moving beam of light of constant intensity is used to illuminate
25 successive elemental areas of a field of view which is also illuminated with light radiated by lamps energized with alternating current.

In the first case described above, as the scanning member moves with respect to the optical image, light modulated in accordance with fluctuations
30 of the light source and also by the varying tone values of the field of view is reflected from successive elemental areas of the field and passes through the apertures of the scanning member to the main photoelectric cell or group of cells.
35 In the second case, light of constant intensity passes through the apertures to illuminate successive elemental areas of the field, which is also illuminated with fluctuating light. As a result,
40 fluctuating light may be directly incident on the cell or group of cells and light modulated by the fluctuations and tone value of successive elemental areas of the field is reflected from
45 these areas to the cell or group of cells. In either case, the cell or cells are activated to control the production of a complex current comprising an image current, varying as the tone values of successive elemental areas of the field, a current
50 component corresponding in frequency to the light fluctuations and two side-bands representing image modulations of the light fluctuations.

Associated with the light source is an auxiliary photoelectric cell or group of cells, which are supplied with fluctuating light from the source and
55 are thereby activated to control the production

of a current corresponding in frequency to the light fluctuations. This current, after being amplified and having its phase adjusted, is applied to a member, adapted to control a variable resistance, included in the circuit of the main photoelectric cell, in such manner that the resistance variations are proportional to the fluctuating illumination applied to the main and auxiliary photoelectric cell or group of cells. Under these conditions, if the scanned image is of constant reflecting power, the fluctuating current produced by the main photocell tends to be large when the variable resistance is small, and vice versa, effectively canceling out the fluctuations. As will be shown below, the variable resistance is effective even when the reflecting power of the scanned image varies.

A more detailed description of the invention follows and is illustrated in the attached drawing, in which:

Fig. 1 schematically illustrates a television transmitter embodying the invention; and

Fig. 2 an arrangement of apparatus units which may be substituted for that shown at the left of section line 2—2 in Fig. 1.

The television transmitter of Fig. 1 is associated with a subject or field of view 1, which is completely illuminated by light from an electric lamp 2 supplied with alternating current from a supply circuit 3. The subject may be an animate object, a representation or a film from which the fluctuating light is reflected or through it passes.

An image of the subject is projected by an optical system, herein represented by a lens 4, in the plane of a scanning disc 5 having a spiral of apertures, adapted to traverse successive unit lines of the optically produced image. Associated with the disc is a frame or mask 6 provided with an opening 7 which limits the size of the image field to be scanned by the apertures and prevents more than one aperture from being effective in the image field at each instance of time. The apertures traverse contiguous parallel lines of the image field, and the disc is driven by a motor 8 at a rate such that the field is completely scanned within the period of persistence of vision. As the disc rotates, light from the optically produced image field, which varies as the tone values of successive elemental areas of the complete image field and also fluctuates in accordance with the alternating current energizing the source 2, passes through the spiral of apertures to a photoelectric cell 9, having its electrodes connected to a constant potential source 9'.

The light applied to the object is always positive and varies from a maximum to a minimum during each half cycle of the current supplied to the lamp 2, consequently, if this is 60 cycle current, the illumination applied to the object will fluctuate at twice the frequency of the current, i. e. at 120 cycles.

The reflected light applied to the photoelectric cell 9 is the product of the fluctuating light supplied by the source 2 and the variations in the reflecting power of the object or field of view being scanned, consequently, the photoelectric cell will be activated to control the production of a complex electric current including variations corresponding to tone values of successive elemental areas of the field, current variations of 120 cycles due to the fluctuations introduced by the current supplied to the lamp 2, and current variations resulting from the light fluctuations modulated by the variations in tone values of successive elemental areas of the image field.

As the image field is scanned, the reflecting power may be represented as a function of time, for example $I(t)$. This is equivalent to saying that if the image field was illuminated by a light source of constant intensity the photoelectric current will be a similar function of time, for example, $E(t)$, such that

$$E(t) = kI(t)$$

where k is a constant of proportionality.

To simplify the discussion assume that the reflecting power varies sinusoidally, i. e.,

$$I(t) = L(1 + a_0 \cos pt)$$

where a_0 is a constant determined by the difference between the maximum and minimum reflecting power.

If the alternating current supply is 60 cycles, the light produced by the lamp will fluctuate at the rate of 120 cycles. This condition may be represented as:

$$I_1(t) = I(1 + a \cos 2\pi 120t)$$

where a is a constant determined by the difference between maximum and minimum light. The light never goes to zero, because light is proportional to temperature and the thermal lag is too great. The light striking the main photoelectric cell is equal to the product of these two quantities, i. e.,

$$\begin{aligned} I(t) \cdot I_1(t) &= L(1 + a_0 \cos pt) \cdot I(1 + a \cos 2\pi 120t) \\ &= L \cdot I(1 + a_0 \cos pt + a \cos 2\pi 120t + a_0 a \cos pt \cos 2\pi 120t) \\ &= L \cdot I(1 + a_0 \cos pt + a \cos 2\pi 120t + \frac{a_0 a}{2} \cos(p - 2\pi 120)t + \frac{a_0 a}{2} \cos(p + 2\pi 120)t) \end{aligned}$$

In other words, the output current of the photoelectric cell comprises a component of constant value equal to LI , a component varying as the tone values of the field, identified by $LI(a_0 \cos pt)$; a component of 120 cycles, represented by $LI(a \cos 2\pi 120t)$, and two side-bands corresponding to

$$\frac{LI}{2} [a_0 a \cos(p - 2\pi 120)t + a_0 a \cos(p + 2\pi 120)t]$$

The 120-cycle current and its associated sidebands, when supplied to an image producing apparatus at a receiving station, will result in the production of a series of bands extending across the viewing field. For this reason, it is not practical to operate a television transmitter to scan a field of view which is illuminated by lamps supplied with alternating or fluctuating current.

Since 60-cycle alternating current is very generally used for lighting purposes, not only in public buildings but also in private homes, and the use of present day television transmitters under conditions whereby the 60-cycle current is incident upon the light sensitive element of the photoelectric cell or the field being scanned, will result in the production of image currents having associated therewith current variations which seriously distort the image produced at a receiving station, it will be apparent that such transmitters cannot be universally used.

The purpose of the present invention is to extend the field of operation of television transmitters, by providing a transmitting apparatus including means for suppressing the distorting current variations, comprising those caused by the fluctuating light and the associated side-bands,

or for at least reducing the amplitudes of these current variations to a value such that they do not cause the distortion of the image. This desirable result may be accomplished by the apparatus to be described below.

The complex current produced by the main photoelectric cell is supplied through a resistance coupling to a direct current amplifier A, which is shown by way of example as a two-stage amplifier comprising thermionic devices 10 and 11. Amplified current is supplied from the amplifier device 10 via the gain control unit 12 to amplifier 11 and through a coupling circuit, comprising a gain control unit 13, a fixed resistance 14, a variable resistance element 15 in series with an adjustable resistance 16 and a fixed resistance 17, to a power amplifier, herein shown as including a thermionic tube 18, for supplying a photoelectric current to a transmission circuit 19. This circuit may be connected to a line extending to a distant station, or to the input of a modulator included in a line carrier channel or a radio link.

An auxiliary photoelectric cell 20, similar to cell 9 and connected to a constant potential source 20', is adapted to be illuminated by light from the source 2 and to be thereby activated to control the production of a current corresponding to the fluctuating light which may be represented by $E(t)(1+a \cos 2\pi 120t)$, i. e., a current having a frequency of 120 cycles.

This auxiliary current is supplied to an amplifier 21 which for convenience is shown as consisting of two stages, each comprising a thermionic tube 22.

Amplifier 21 is provided with a phase shifting element, herein shown as an adjustable condenser 23, included in the output circuit of the first amplifier 22.

The two stages of amplifier 21 are coupled by a transformer having an adjustable secondary winding 24, included in the input circuit of the second stage, and the output circuit of the second stage includes a telephone receiver 25. This receiver is mechanically coupled to the variable resistance element 15, herein shown by way of example as a microphone included in the circuit which couples amplifier A with the power amplifier 18. The phase of the current supplied to the receiver 25 is adjusted so that it operates to vary the pressure applied to the microphone 15, and hence its resistance, proportionally with respect to the 120-cycle current component supplied to the microphone by the amplifier 11.

The resistance of elements 14, 16 and 17 should be small compared with the resistance of the microphone 15 and also with respect to the output impedance of amplifier tube 11. Under these conditions the interference, due to the 120-cycle current variations and the associated side-bands, may be neutralized by adjusting the phase shifting element 23, the gain of the amplifier A, and the value of resistance 16.

The auxiliary current supplied by the photo-cell 20 may be represented

$$I_1(t) = k_1 i_1(t) = k_1 I(1 + a \cos 2\pi 120t)$$

Since no direct current is passed by the amplifiers 22, the current supplied to the receiver 25 is proportional to the fluctuating term of the above expression, i. e.,

$$k_2 \cos 2\pi 120t$$

and the resistance of the microphone is

$$R_0 = R(1 + k_3 \cos 2\pi 120t)$$

The equivalent voltage in series with resistance 17, produced by the current from the main photo-cell, is proportional to $I(t) \cdot I_1(t)$, i. e.,

$$e = k_4(1 + a_0 \cos pt)(1 + a \cos 2\pi 120t)$$

and the current in resistance 17 is

$$\frac{e}{r_1 + r_2 + r_3 + R_0}$$

If $r_1 + r_2 + r_3 = r$, the current in 17 will be,

$$\frac{k_4(1 + a_0 \cos pt)(1 + a \cos 2\pi 120t)}{(r + R)\left(1 + \frac{Rk_3}{r + R} \cos 2\pi 120t\right)}$$

When the constants of the circuits are so chosen that

$$a = \frac{Rk_3}{r + R}$$

and the phase of the current supplied to receiver 25 is properly adjusted, the current in 17 reduces to

$$\frac{k_4(1 + a_0 \cos pt)}{r + R}$$

While in the preceding description it was assumed that the reflecting power of the field varied sinusoidally, it will be apparent that the microphone operates as a demodulator to combine the 120-cycle current variations with the side-bands and thereby produces the image current variations present in the side-bands, and that it may be controlled to compensate or neutralize the distorting components supplied by the photoelectric cell 9, without materially affecting the image current to be transmitted, whether the reflecting power of the field varies sinusoidally or in a more complex manner.

Fig. 2 illustrates a television scanning apparatus comprising an optical system including a source of light of constant intensity 26, a lens 27, a disc 28 provided with a spiral of apertures, and a light sensitive device herein shown as a photoelectric cell 9. This optical system operates as disclosed in Patent 2,113,254, granted to F. Gray, April 5, 1938, to produce a moving beam of light of constant intensity which illuminates successive elemental areas of an object or field of view 1 and the disc is driven by the motor 29 at a rate such that the object is completely scanned within the period of persistence of vision. Light reflected from the object or field is picked up by the photoelectric cell 9, which is thereby activated to control the production of an image current.

For a complete disclosure of the scanning means herein shown, which is designed to replace that shown to the left of section line 2-2 in Fig. 1, reference may be made to the above-mentioned Gray patent.

The object or field of view is also subject to illumination supplied by the lamp 2 energized with alternating current which may be supplied from a commercial distributing system, and hence the photoelectric cell 9 has applied thereto light which fluctuates in accordance with the energizing current. This fluctuating light may reach the photoelectric cell directly from the source 2, partially by direct incidence and partly by reflection from the object, or wholly by reflection from the object.

As described in connection with Fig. 1, the photoelectric cell 9 will be operated to control the production of a complex current wave including an image current per se, and, in addition, current variations corresponding to the frequency of the energizing current supplied to the lamp 2

and two side-bands. These additional current variations would cause distortion of the image produced at a receiving station.

The complex wave is adapted to be amplified by amplifiers A and 18 and, associated with the light source 2, is an auxiliary circuit including the photoelectric cell 20. The amplifier and auxiliary circuits are identical with those included in Fig. 1 and cooperate in the same manner to compensate or neutralize the distorting current variations without materially affecting the image current supplied to the transmission circuit 19.

While in the preceding description certain specific details have been described for the purpose of disclosing the principles involved in the operation of the apparatus devised by applicant, it will be apparent that the invention is not dependent upon the use of the specific means herein set forth. For example, the fluctuating illumination may consist of light comprising wavelengths wholly within the visible range, partly within and partly outside the visible range or wholly outside the visible range; in Fig. 2 the scanning beam may be supplied by a light source energized with alternating current, any type of distortionless amplifier may be used in both the main and auxiliary circuits and the number of stages may be varied to suit different operating conditions, any suitable form of gain control means may be used, for example, a potentiometer of the type shown in the circuit of amplifier A may be associated with the secondary winding of the transformer included in the input circuit of the second stage of amplification of the auxiliary amplifier, and any suitable phase adjusting networks may be substituted for that shown. As a matter of fact, the units which control the neutralization or compensation of the distorting current variations may differ materially from the telephone receiver and microphone construction herein shown. In accordance with this invention, the essential requirements for effecting compensation are, that the apparatus produce an auxiliary current fluctuating in accordance with that supplied by the light source, and that this current be used to proportionally vary the resistance of a device included in the circuit for supplying the complex wave to the transmission circuit, without materially affecting the image current to be transmitted.

By providing a switch in the auxiliary circuit, the auxiliary apparatus may be cut out, thus providing a transmitter for scanning a field of view supplied with illumination of constant intensity.

The invention herein described can be used to compensate or neutralize the effect of undesired light fluctuations of any desired frequency, and it may be utilized to advantage in other types of electrooptical systems in which it is essential to suppress, or reduce to an innocuous value, complex current variations corresponding to light fluctuations which interfere with the proper operation of the system.

What is claimed is:

1. An electrooptical system comprising means for illuminating a field of view with periodically fluctuating light to cause said fluctuating light to vary in accordance with the tone values of elemental areas of said field, light sensitive electric means activated by said periodically fluctuating and varying light to control the production of a complex electric wave comprising an image current which varies as the tone values of elemental areas of said field of view and modulation prod-

ucts including components which vary as the tone values of elemental areas of said field of view, and means controlled by said periodically fluctuating light for substantially neutralizing the variable components of said modulation products.

2. A source of periodically fluctuating light for illuminating an object, means for scanning said object to set up an image current which varies as the tone values of the elemental areas of said object, and modulation products having components which vary as the tone values of elemental areas of said object, means for producing a separate current under control of the periodically fluctuating light supplied by said source, and demodulating means supplied with said modulation products and controlled by said separate current for partly or wholly neutralizing each of the varying components of said modulation products.

3. Means for electrooptically scanning an object including means for illuminating said object with light from a source of periodically fluctuating light and light sensitive means receiving light from the object to set up an image current varying in accordance with the varying tone values of successive elemental areas of said object and unwanted modulation products including components which vary as the tone values of said object, and means for neutralizing or reducing said unwanted modulation components, said last mentioned means comprising demodulating means upon which said variable components are impressed, means for producing a separate current having the same periodic fluctuations as said source of illumination, and means under control of said separate current for controlling said demodulating means.

4. Means for repeatedly scanning an object within the period of persistence of vision to set up television image currents, means for illuminating said object with light which periodically fluctuates at a frequency within the frequency range of said image currents, means activated by fluctuating light received from said object for controlling the production of said image currents and unwanted modulation products including components which vary in accordance with the varying tone values of successive elemental areas of said object and means for neutralizing or reducing said unwanted modulation components, said last mentioned means comprising demodulating means upon which said image currents and said unwanted modulation products are impressed, means for producing a separate current having the same periodic fluctuations as said illumination, and means under control of said separate current for controlling said demodulating means.

5. Means for electrooptically scanning an object including means for illuminating said object with light from a source of periodically fluctuating light and light sensitive means receiving light from the object to set up an image current and unwanted modulation products including components which vary as the tone values of successive elemental areas of said object, and means for neutralizing or reducing said unwanted modulation components, said last mentioned means comprising a circuit in which said image current and said modulation components are caused to flow, an element having impedance in said circuit through which said image current and said modulation components flow, means for producing a separate current having the same periodic fluctuations as said source of illumina-

tion, and means under control of said separate current for varying said impedance.

5 6. An electrooptical system in which an object is illuminated from a source of light energized with alternating current, means activated by
10 light received from said object to cause the production of a composite wave comprising an image current and a modulated current having components varying as the tone values of successive elemental areas of said object, a circuit comprising a fixed resistance in series with a variable
15 resistance element, means for causing said composite wave to flow serially through said fixed

resistance and said variable resistance element, means for neutralizing or reducing the components of said modulated current, said last-mentioned means comprising means for setting up an auxiliary current which varies as the illumination
5 supplied by said light source, means for controlling the phase relation of said auxiliary current with respect to said composite wave, and means under control of said phase adjusted auxiliary current for controlling said variable re-
10 sistance element to cause it to demodulate the said modulated current.

ARTHUR W. HORTON, JR.