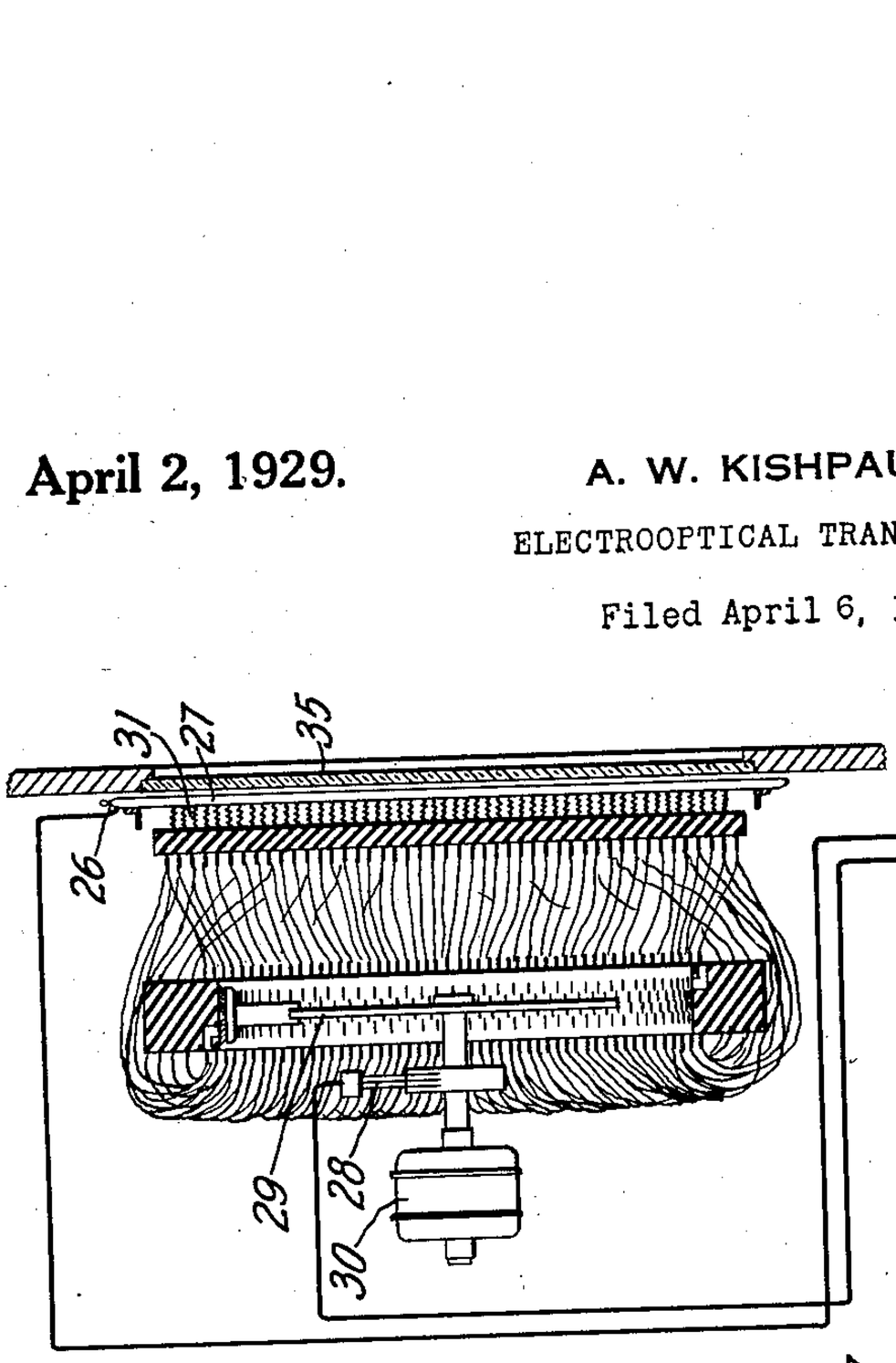
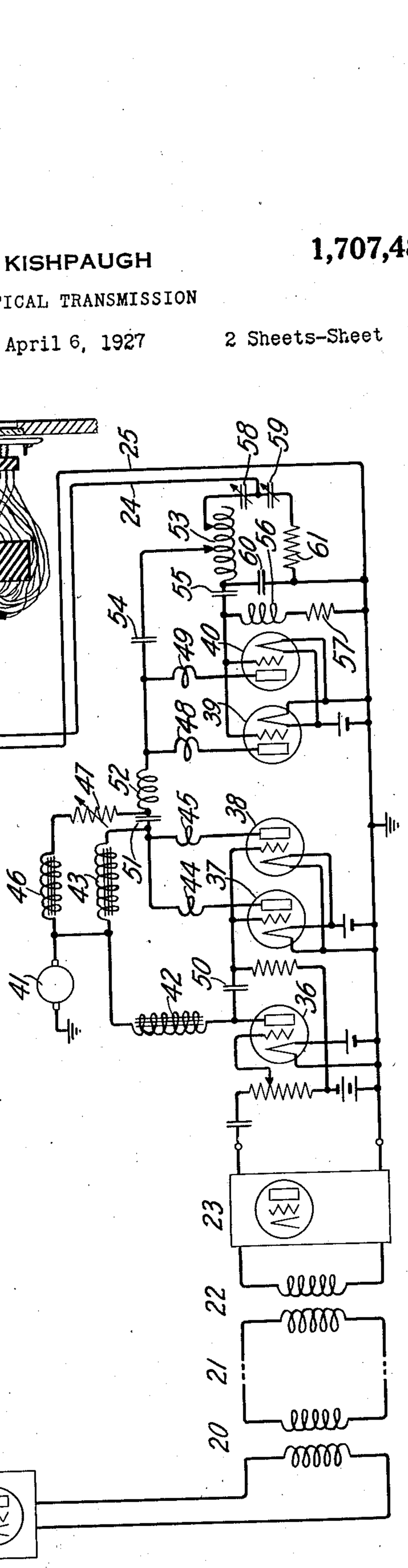
April 2, 1929. A. W. KISHPAUGH 1,707,486

ELECTROOPTICAL TRANSMISSION

Filed April 6, 1927 2 Sheets-Sheet 1



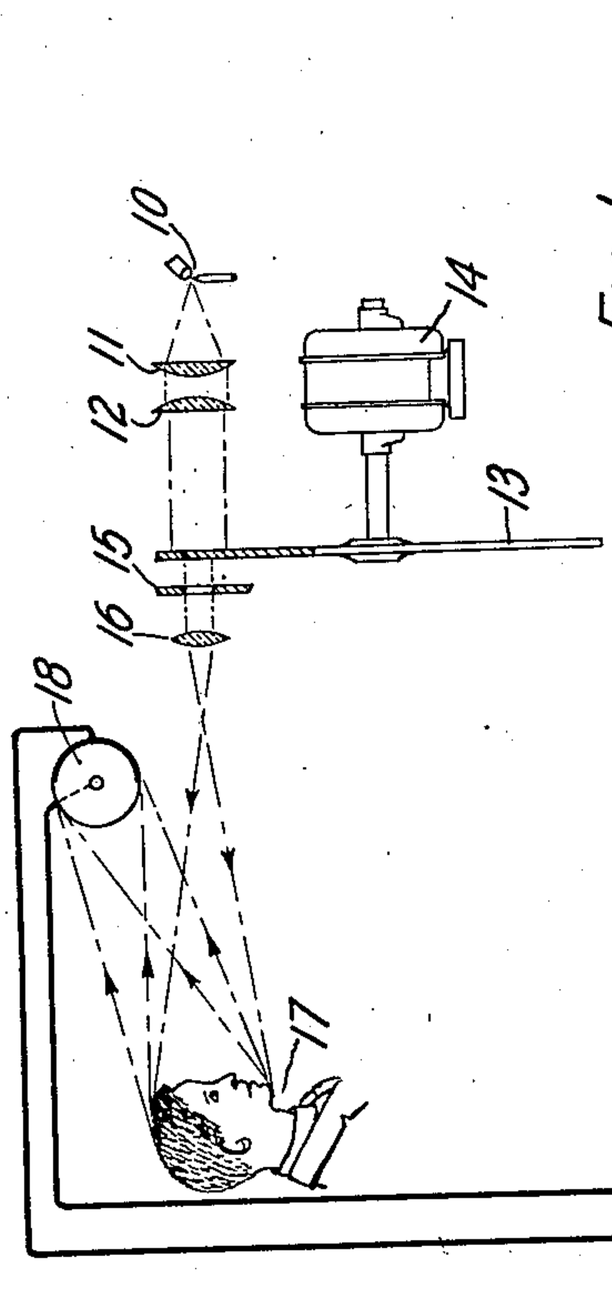




FIG. I.

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ELECTROOPTICAL TRANSMISSION

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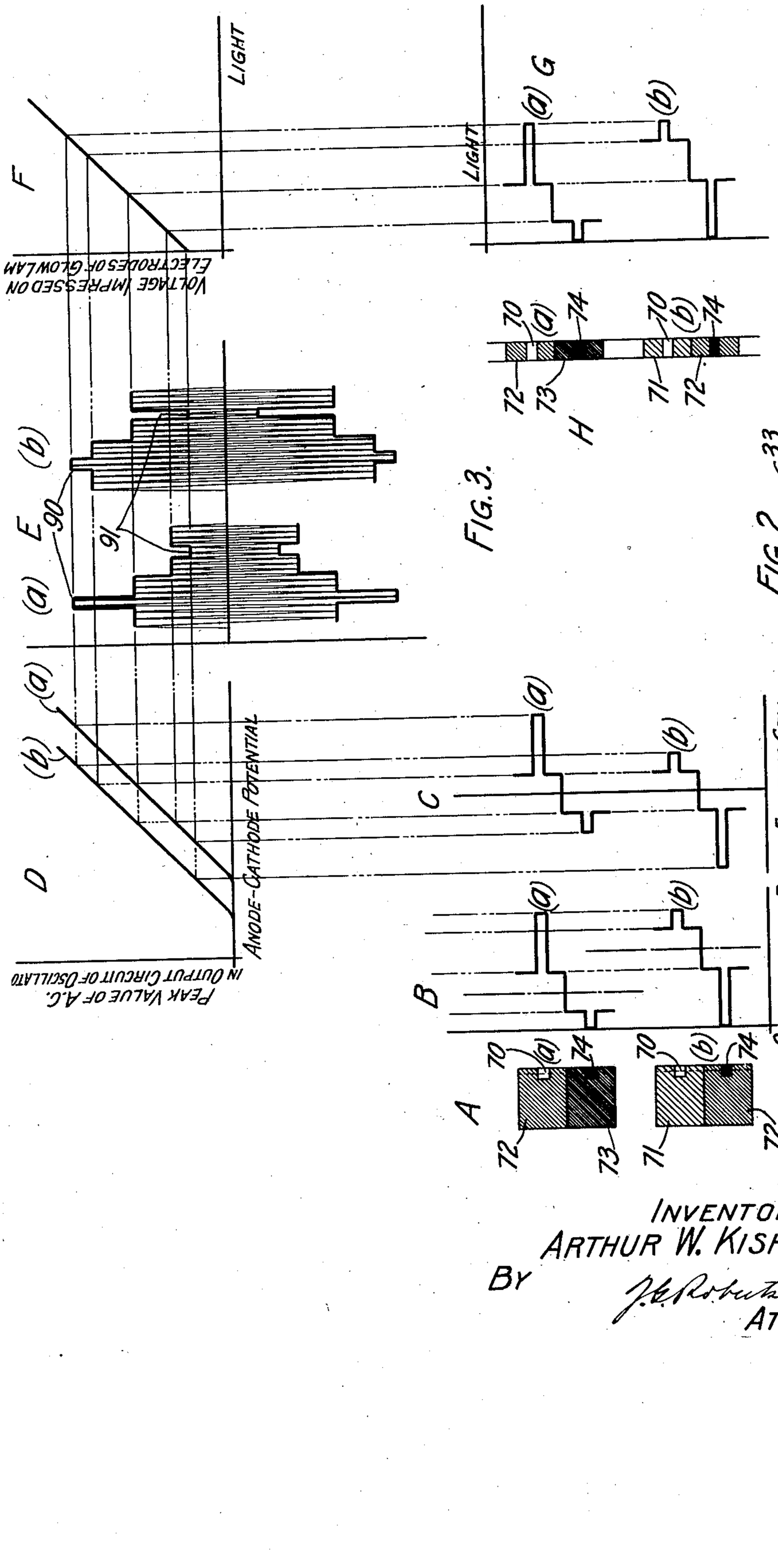


FIG. 3.

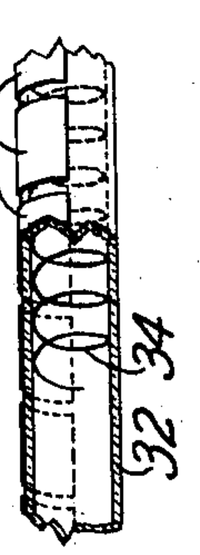


FIG. 2.

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# UNITED STATES PATENT OFFICE.

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## ELECTROOPTICAL TRANSMISSION.

Application filed April 6, 1927. Serial No. 181,568.

This invention relates to electro-optical transmission and more particularly to a television or image producing system having means for controlling the average tone value of a produced image.

The present invention provides an arrangement which is an improvement over the system disclosed in a copending application of Frank Gray, Serial No. 181,537, filed April 6, 1927. In the Gray system there is at the transmitting station a scanning device which comprises means for illuminating in rapid succession small elemental areas of the object, an image of which is to be produced at a receiving station. Light reflected from these elemental areas acts upon a light responsive device, such as a photo-electric cell, which serves to vary the amplitude of the uni-directional current flowing in the circuit in which the cell is connected. For light received by the cell from a certain stationary object, this varying uni-directional current may be analyzed into a steady direct current component and alternating current components of different frequencies. The transmission apparatus which is preferably of the type disclosed in a copending application of H. E. Ives and Frank Gray, Serial No. 181,511, filed April 6, 1927, is not capable of transmitting the steady direct current component and this apparatus also greatly attenuates the components of very low frequency of the order of 10 cycles per second or less, so that currents of these frequencies are also practically lost in transmission. At the receiving station an oscillator is provided for generating high frequency current of the order of one million cycles per second upon which are impressed the currents incoming from the transmitting station, thereby producing a modulated high frequency current. This modulated high frequency current is impressed upon a light emitting device such as a glow discharge lamp having a plurality of spaced electrodes, these electrodes being connected to the source of modulated current through a commutating means which rotates in synchronism with the scanning device at the transmitting station. The position occupied by each electrode of the light emitting device corresponds to the position occupied by a certain elemental area of the object, an image of which is to be produced, so that the position of the light emitted by this device at any time corresponds to the position of the elemental area of the object being scanned at the transmitting station. The intensity of the light emitted depends upon the degree of modulation of the high frequency current generated by the oscillator at the receiving station and upon the amplitude of the unmodulated component. The degree of modulation corresponds to the variations in the uni-directional current in the photo-electric cell and therefore, if the produced image is to faithfully represent the object or picture at the transmitting station, the amplitude of the unmodulated component must correspond to the steady direct current and very low frequency components which were suppressed at the transmitting station. If the amplitude of the unmodulated component does not so correspond the average tone value of the produced image will be either too light or too dark.

In accordance with this invention, lack of faithfulness in the produced image due to the suppression of low frequency currents by the transmission apparatus is corrected for at the receiving station by varying the amplitude of the unmodulated component of the high frequency oscillations, independently of the degree of modulation which is produced by the incoming picture currents. In the arrangement selected for illustrating the invention a variable resistance is connected in series with the circuit supplying the direct current energy to the space current path of an electron discharge oscillator, the value of this resistance determining the amplitude of the unmodulated component of the high frequency energy.

A detailed description of an electro-optical system embodying this invention and of the theory which enters into its operation is given below, reference being made to the accompanying drawing in which:

Fig. 1 is a diagrammatic view of an electro-optical system showing one embodiment of the present invention.

Fig. 2 is a view partly in section of a portion of a glow discharge lamp employed at the receiving station of this system, and

Fig. 3 is a diagrammatic view illustrating the theory of operation of the system.

Referring now particularly to Fig. 1 of the

drawing, the light source 10 is directed by the lenses 11 and 12 upon a small area on the scanning disc 13 which is revolved by the motor 14. The disc 13 is provided with numerous small apertures spirally arranged so that rays of light sweep over the area of the opening in screen 15 in parallel lines, the whole area being traversed in this manner during one complete revolution of the scanning disc 13. These light rays are bent in passing through the lens 16 and illuminate in rapid succession small elemental areas on the object 17. Good results have been obtained by providing fifty of these apertures in the disc 13 and rotating the disc at about 15 R. P. S. Under these conditions the whole object is completely scanned in about 1/15 second or it is scanned by fifty successive parallel lines of light each requiring about 1/750 second to sweep across the object. Light reflected from the object 17 impinges upon a light sensitive device, such as photo-electric cell 18. As the amount of light impinging upon the cell increases and decreases the voltage impressed upon the amplifier 19 correspondingly increases and decreases. The amplifier is preferably of the type disclosed in the copending application of H. E. Ives and Frank Gray, supra, in which voltage variations produced by the pulsating current in the photo-electric cell are amplified, the steady direct current and low frequency components being suppressed. The alternating current components are impressed by transformer 20 upon the transmission line 21. Both the transformer 20 and line 21 are adapted to transmit waves within a wide band of frequencies from about 10 cycles per second to 20,000 cycles per second. The transmission line 21 extends to the receiving station where it connects to the transformer 22 which in turn is connected to the vacuum tube amplifier 23. The output circuit of this amplifier is connected to an oscillator-modulator, described in detail hereinafter, which generates a high frequency current, preferably of the order of a million cycles per second, and modulates this high frequency current with the picture currents received from the transmitting station. The modulated high frequency current leaves the oscillator-modulator through the conductors 24 and 25. Conductor 25 connects directly to a terminal 26 which connects to a common electrode 34 (shown in Fig. 2) of the light emitting device 27 while the conductor 24 connects to a brush 28 of commutator 29 which is driven by motor 30 in synchronism with the scanning disc 13 at the transmitting station. A suitable synchronizing system is disclosed in a copending application of H. M. Stoller and E. R. Morton, Serial No. 200,799, filed June 23, 1927. Contact points of the commutator 29 are connected to the terminal bank 31, the individual terminals of which are provided with suitable means for making contact with individual electrodes 33 (shown in Fig. 2) of the light emitting device 27.

The light emitting device or glow discharge lamp comprises a plurality of parallel glass tubes equal in number to the number of apertures in the scanning disc 13 at the transmitting station. The ends of these tubes are connected so as to form a single unit which is filled with an inert gas, such as neon, at low pressure. In Fig. 2 is shown a short section of one of these tubes which comprises a glass cylinder 32, individual electrodes 33 of semi-circular cross-section and secured to the outside of the cylinder, and the helical electrode 34 which is common to the whole light emitting device. Light emitted from the light emitting device impinges on a portion of a ground glass viewing screen 35 opposite one of the electrodes 33 to which contact is made with the oscillator-modulator set through the commutator 28. The individual electrode which at a given instant of time is connected to the oscillator-modulator set occupies a position with respect to other individual electrodes which corresponds to the elemental area of the object 17 being scanned. It is thus apparent that an image of the object 17 appears on the viewing screen 35.

The oscillator-modulator set comprises the amplifier vacuum tube 36, the modulator vacuum tubes 37 and 38 the control electrodes of which are connected in parallel and the oscillator vacuum tubes 39 and 40, the control electrodes of which are also connected in parallel. The cathodes of these tubes are connected to ground and the grounded generator 41 supplies space current to the tube 36 through choke coil 42, to tubes 37 and 38 through low frequency choke coil 43 and parasitic oscillation preventing choke coils 44 and 45, respectively, and to tubes 39 and 40 through low frequency choke coil 46, variable resistance 47, high frequency choke coil 52, and the parasitic oscillation preventing choke coils 48 and 49, respectively. The anode of amplifier tube 36 is coupled to the control electrodes of the modulator tubes 37 and 38 through the coupling condenser 50, and the anodes of the modulator tubes 37 and 38 are coupled to the anodes of the oscillator tubes 39 and 40 through choke coils 44 and 45, respectively, coupling condenser 51, high frequency choke coil 52 and the choke coils 48 and 49, respectively. The parasitic oscillation preventing choke coils 44, 45, 48 and 49 are designed to offer appreciable impedance only to frequencies above that generated by the oscillator tubes 39 and 40, while the high frequency choke coil 52 offers a high impedance to this generated high frequency. The choke coils 42, 43 and 46 offer a high impedance to all of the frequency components of the picture current received from the transmitting station. The anodes of the oscillator

tubes 39 and 40 are connected to the tuning coil 53 through the choke coils 48 and 49, respectively, and stopping condenser 54, and the control electrodes of these tubes are connected to the tuning coil through the grid condenser 55. The choke coil 56 and the high resistance 57 serve as a leak for the control electrodes of the oscillator tubes. The oscillator circuit is completed through the variable condenser 58 and 59, fixed condenser 60 and the resistance 61 which latter serves to broaden the tuning of this oscillatory circuit. It is apparent that the operation of the oscillator-modulator is based upon the principle that the anode-cathode impedance of tubes 37 and 38 is varied in accordance with the incoming picture currents and these impedance changes serve to vary the shunt impedance between the anodes and cathodes of the oscillator tubes 39 and 40 or, in other words, these impedance changes vary the anode-cathode potential of tubes 39 and 40 which impedance variations, in turn, cause the oscillator output current to be modulated in accordance with the incoming picture currents. The general type of oscillator-modulator is disclosed in Heising Patent No. 1,559,870, issued November 3, 1925.

The variable resistance 47 which controls the direct current anode-cathode potential difference of the oscillator tubes 39 and 40 and therefore the value of the unmodulated component of the high frequency energy, serves to correct for the distortion in the image produced by the light emitting tube 27, because of changes in the average tone value due to the suppression by the transmission apparatus of the zero and very low frequency components of the varying unidirectional current set up by the photoelectric cell 18. This will be made apparent by tracing the operation of the system with reference to the illustration given in Fig. 3. At A of this figure are represented two objects (*a*) and (*b*), the transmission and image production of which are to be compared. The tone values of different portions of these objects are designated by numerals 70 to 74 as follows: 70, white; 71, light gray; 72, medium gray; 73, dark gray; and 74, black. At B, curves (*a*) and (*b*) respectively, represent the varying unidirectional current which flows in the circuit in which the photoelectric cell 18 is connected in response to the light reflected from the objects (*a*) and (*b*), respectively, as the scanning beam traces one path across the objects in A, the paths being represented by the dotted traces. It will be noted that the current in the circuit is substantially zero when the black portions 74 are being scanned, and a maximum current flows in the circuit when the white portions 70 are being scanned. Since steady current components of these current waves are suppressed by the transmission apparatus as explained above, the wave forms (*a*) and (*b*) at C having a zero steady current component are impressed upon the oscillator-modulator at the receiving station.

At D of Fig. 3, curves (*a*) and (*b*) show the relation between anode-cathode potential of the oscillator tubes and the peak value of output current of these tubes for high and low value settings, respectively, of variable resistance 47. If this resistance is varied so that current variations corresponding to objects (*a*) and (*b*) operate on curves (*a*) and (*b*), respectively, at D, then the modulated high frequency output current of the oscillator-modulator or the E. M. F. impressed on the light emitting tube 27 will be represented by (*a*) and (*b*), respectively, at E of this figure. The high frequency modulated current is impressed on the electrodes 33 and 34 of the light emitting device 27. The curve at F shows the relation between the voltage which is impressed across the electrodes of the light emitting device and the intensity of the light emitted therefrom. At G of Fig. 3 curves (*a*) and (*b*) represent the intensity of the light emitted by the elemental areas of tube 27 as the high frequency modulated waves (*a*) and (*b*), represented at E of Fig. 3, are impressed across the electrodes of the tube 27. If the numerals used at A of Fig. 3 are used to represent the tone values of the image formed by these light variations, it is apparent that the images (*a*) and (*b*) at H of Fig. 3 correspond to the objects (*a*) and (*b*), respectively, shown at A of this figure. It should be noted, if the current variations represented by (*a*) and (*b*) at C of Fig. 3 were employed to modulate the high frequency output current of the oscillator directly, that is, without changing the setting of resistance 47, that, in this case, the maximum and minimum values 90 and 91, respectively, of the modulated high frequency current as represented at E would be different for waves (*a*) and (*b*), respectively. This would cause a difference between the maximum and minimum values of light as represented by (*a*) and (*b*), respectively, at G of Fig. 3. Since these peak values of light intensity correspond to white and black, respectively, of the objects (*a*) and (*b*) at A, it is obvious that, if these peak values are not equal, the portion 70 of the image (*a*) at H will have a tone value different from that of portion 70 or image (*b*) at H. So also there will be a difference between the tone value corresponding to the black portions 74 and other portions of these objects. It is apparent, therefore, that the resistance 47 may be varied in accordance with changes in the substantially steady component of the unidirectional varying current set up by the photoelectric cell 18 and thereby correct the distortion of the average tone value of the produced image due to the suppression by the transmission medium of

the zero and very low frequency components of the varying unidirectional current just referred to. It is apparent, moreover, that a battery having a variable connection thereto or other means may be substituted for the variable resistance 47 in order to increase or decrease the amplitude of the high frequency current output of the oscillator.

What is claimed is:

1. The combination with an energy responsive element actuated by oscillatory energy, of an oscillator for actuating said element, means to modulate the oscillations applied from said oscillator to said element, and means to vary the unmodulated component of the applied oscillations independently of the modulated component to control the character of the response of said element.

2. A lamp having a glow discharge chamber, an oscillator to supply variable ionizing voltage thereto in accordance with received signal variations, and means to control the mean amplitude of the oscillatory energy applied to said lamp, independently of the amplitude variations thereof, to determine the average tone of a produced image.

3. In a television or image producing system, a source of energy having variations characteristic of an image to be produced, translating means for producing an image under the control of energy from said source, an electric discharge device having a cathode and an anode included in said translating means, and means to change the direct current potential impressed on said anode and cathode to control the average tone value of the produced image.

4. In a television or image producing system, a source of energy having variations characteristic of an image to be produced, translating means for producing an image under the control of energy from said source, a plurality of electric discharge devices included in said translating device each having an anode, a cathode and an impedance controlling element, means connected between the anode and cathode of one of said devices to control the average tone value of the produced image, and means connected between the impedance controlling element and the cathode of another of said devices for controlling the difference between the maximum and minimum tone values of elemental areas of said image.

5. In an electro-optical transmission system, a source of current having variations characteristic of tone changes of elemental areas of an object, an image of which is to be produced, means to modulate an alternating current in accordance with varying current from said source, a translating device for translating said modulated current into light of varying intensity, and means to change the amplitude of the unmodulated component of the alternating current without affecting the modulated component.

6. In combination, a source of varying uni-directional current, a source of high frequency alternating current, means for utilizing said high frequency current and responsive to amplitude variations thereof, means for modulating said high frequency alternating current with an alternating current component of said varying uni-directional current, and means for changing the amplitude of the unmodulated component of said modulated high frequency alternating current independently of the modulated component to compensate for changes in the substantially steady current component of said varying uni-directional current.

7. In combination, a source of varying uni-directional current, a vacuum tube oscillator for generating a high frequency alternating current, said oscillator comprising a vacuum tube having an anode, a cathode and a control electrode, means for utilizing said high frequency current and responsive to amplitude variations thereof, means for modulating said high frequency alternating current by varying the anode-cathode potential of said vacuum tube in accordance with an alternating current component of said varying uni-directional current, and means for varying the amplitude of the unmodulated component of said modulated alternating current independently of the modulated component to compensate for changes in the substantially steady current component of said varying uni-directional current.

8. In an electro-optical transmission system, a source of light of varying intensity, means for converting said light variations into current of varying amplitude, a source of high frequency current, a device utilizing said high frequency current for emitting light which varies in intensity in accordance with the amplitude variations of said high frequency current, means for modulating said high frequency current with the varying current which corresponds to the light intensity variations of said source, and means for increasing or decreasing the amplitude of the unmodulated component of said modulated high frequency current independently of the modulated component as the average intensity of the light from said source increases or decreases, respectively.

9. In an electro-optical transmission system, a source of light of varying intensity, means for converting light variations from said source into uni-directional current of varying amplitude, means for generating a high frequency alternating current, means for modulating said high frequency current with alternating current components of said varying uni-directional current, means upon

which said modulated high frequency current is impressed for emitting light which varies in intensity in accordance with the amplitude variations of said high frequency modulated current, and means for varying the amplitude of the unmodulated component of said modulated high frequency current independently of the modulated component to compensate for changes in the substantially steady current component of said uni-directional current, thereby causing changes in the average intensity of the light given off by said light emitting means to correspond with changes in the average intensity of the light given off by said light source.

10. An electro-optical transmission system, comprising a transmitting station and a receiving station, a circuit including a light sensitive device at said transmitting station for setting up varying uni-directional current in said circuit in accordance with the intensity variations of the light reflected from an object an image of which is to be produced at said receiving station, a transmission medium, capable of transmitting alternating current only, connecting said transmitting and receiving stations, an oscillator-modulator set at said receiving station connected to said transmission medium for producing a high frequency current modulated with said incoming alternating current, a source of energizing potential for said oscillator, modulator set, a light emitting device connected to said oscillator-modulator set for producing an image of said object, and means for varying the energizing potential supplied to the oscillator of said oscillator-modulator set in order to correct the average tone value of said image for the distortion due to the suppression by said transmission medium of the steady component of the varying uni-directional current set up at said transmitting station.

11. In a television or image producing system, a source of current having variations characteristic of an image to be produced, an oscillator including an electric discharge device having a cathode, an anode and a control electrode for generating a high frequency current, a second electric discharge device having an input and an output circuit connected, respectively, to said source of current and to the anode-cathode circuit of said first mentioned electric discharge device for varying the anode-cathode potential of said first mentioned electric discharge device and for modulating said high frequency current with current from said source, a light emitting device actuated by said high frequency modulated current for producing said image, a source of steady potential connected in the anode-cathode circuit of the first mentioned electric discharge device, and means connected in said anode-cathode circuit for varying said steady potential and thereby vary the average tone value of the image produced.

In witness whereof, I hereunto subscribe my name this 6th day of April A. D., 1927.

ARTHUR W. KISHPAUGH.