Sept. 10, 1929. J. W. HORTON 1,728,122

TELEVISION SYSTEM

Filed April 6, 1927 2 Sheets-Sheet 1

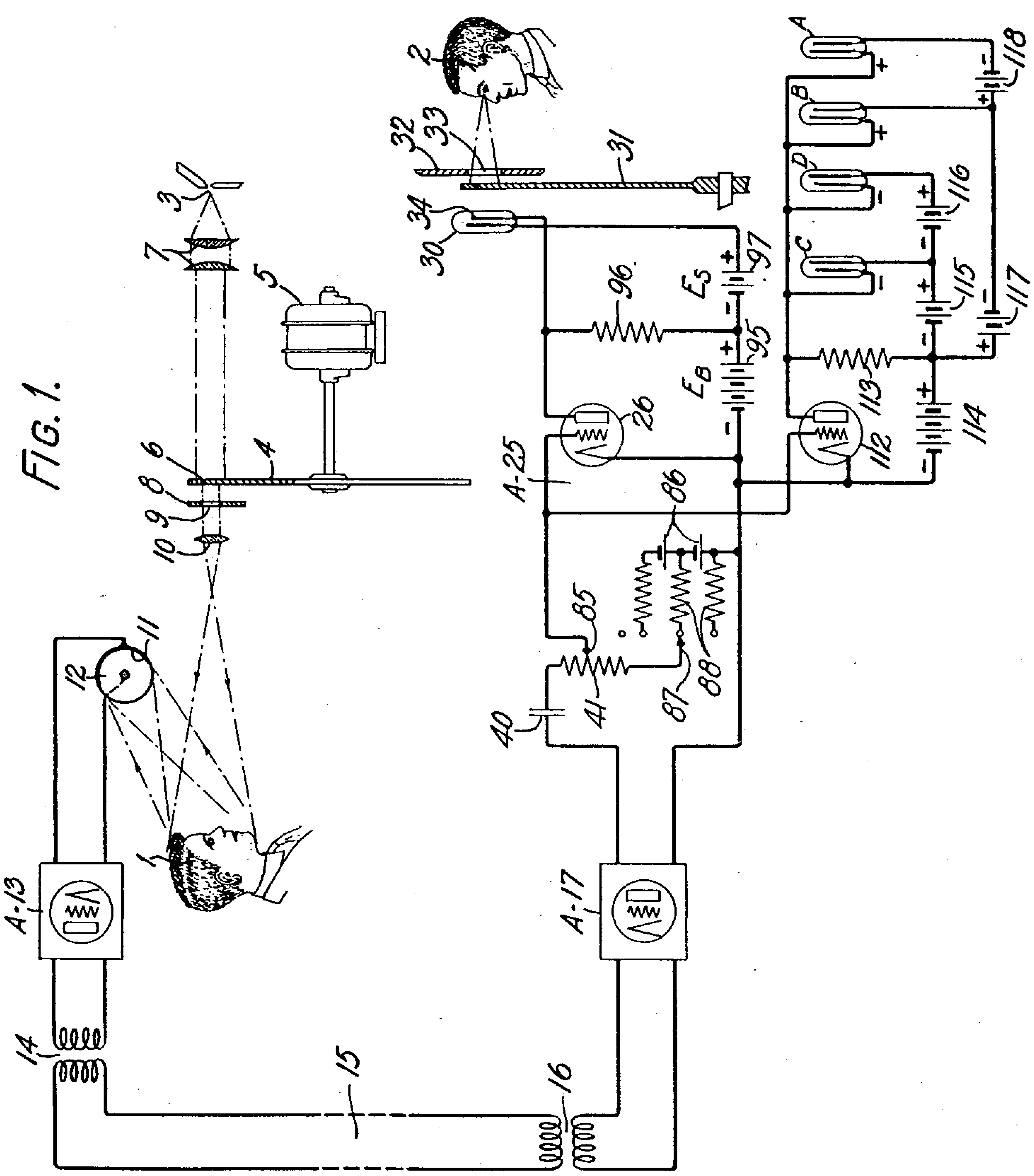

FIG. 1.

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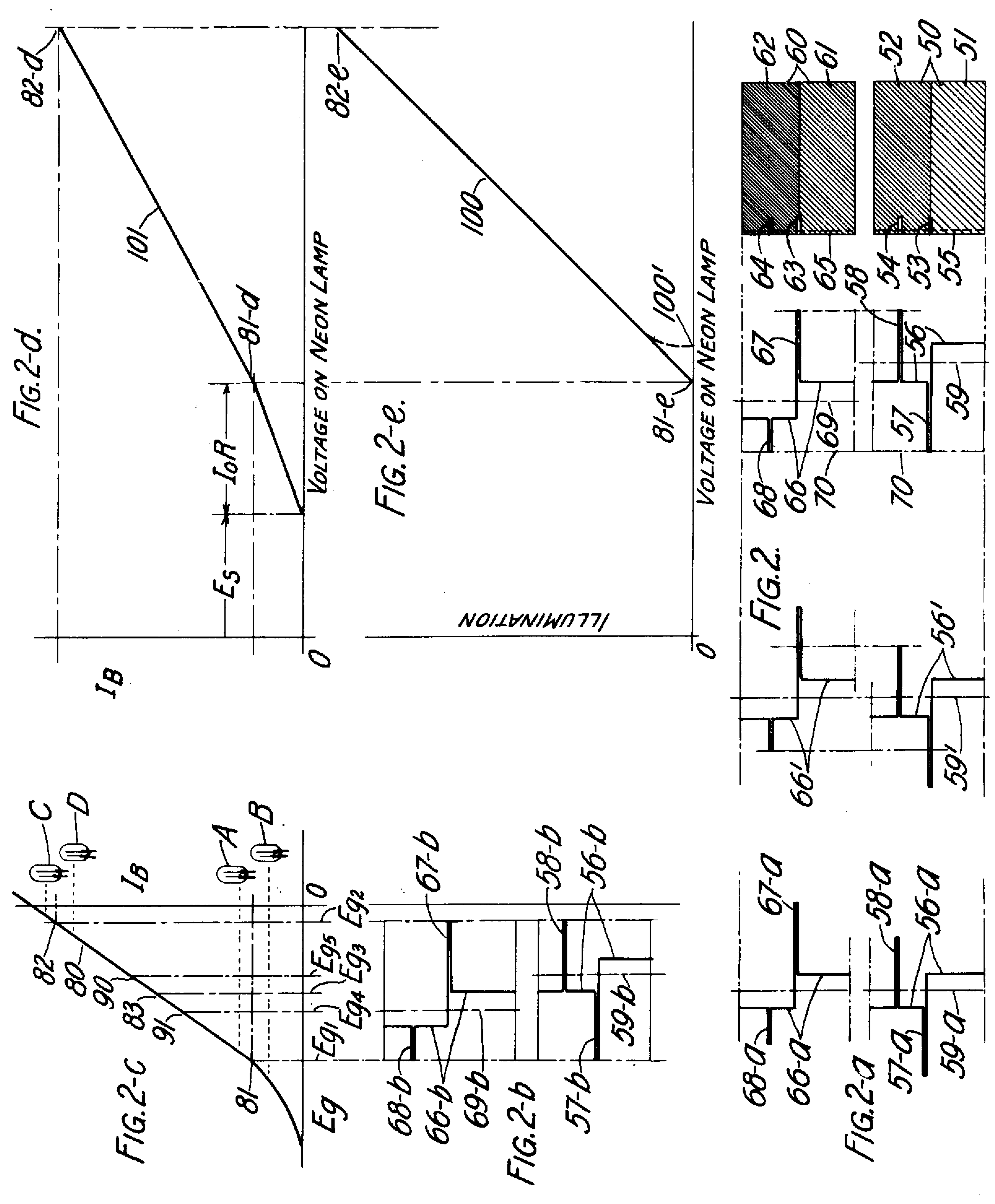


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Patented Sept. 10, 1929. **1,728,122**

# UNITED STATES PATENT OFFICE.

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## TELEVISION SYSTEM.

Application filed April 6, 1927. Serial No. 181,570.

This invention relates to picture transmission and television systems, and especially to electrical wave amplifying systems the field of application of which includes picture transmission and television, the general object of the invention being reduction of distortion.

As a system for transmitting to a distance a pictorial representation of a subject, the embodiment of the invention herein chosen by way of example comprises specifically stated, means at the transmitting end of the system for rapidly scanning the subject point by point and producing by a photo-electric cell an electric current varying in accordance with the light received from the successive elemental areas of the explored subject, and a transmission channel for amplifying and transmitting to the receiving end of the system the variations utilized at the receiver in the production of the image, the direct current component and very low frequency components being suppressed at the transmitter and compensation effected at the receiver. The receiving system includes a thermionic amplifier in the output circuit of which is a glow discharge lamp to emit light of intensity varying in accordance with the initial current. The receiving system also includes means for establishing the region of operation on the characteristic curve of the amplifier and the region of operation on the characteristic curve of the lamp independently, and means for indicating when the proper operating region on the amplifier characteristic is being employed. An attendant at the receiver is thus enabled to reinsert the direct current component of the signal requisite for reproduction of the tone values of the subject with fidelity, by properly polarizing the lamp, and at the same time to adjust the amplifier to give the character of amplification best suited for distortionless overall transmission in the system.

Other objects and aspects of the invention will be apparent from the following description and claims:

Fig. 1 of the drawings is a schematic showing of a television system embodying a form of the invention; and

Fig. 2 is a diagram, and Figs $2^a$ to $2^e$ curves, for facilitating explanation of the operation of the system.

In the television system of Fig. 1, the subject 1 whose image is to be viewed at the receiving end of the system by the receiving operator 2 is shown as the face of a man and is located in front of scanning apparatus at the transmitting end of the system. That apparatus comprises an arc or constant intensity light source 3, and an optical system for causing a slender pencil of substantially parallel rays of intense light derived from the arc to sweep across the region in front of the scanning apparatus and scan the subject 1 in a series of successive parallel substantially horizontal lines. The optical system includes an opaque disc 4, which is rotated at a speed of about 18 revolutions per second by a motor 5 and has a number of small circular apertures 6 arranged in a spiral extending around the disc near its rim. Two plano-convex lenses 7 direct light from arc 3 upon disc 4 so that an intense beam of light passes through each aperture as the aperture moves across the illuminated area on the disc. An opaque screen 8 in front of the disc has a substantially rectangular opening 9 of such width as to transmit light from only one aperture at a time. A lens 10 bends the slender pencil of substantially parallel rays passing through the aperture and the opening 9 and forms an image of the moving aperture on the subject 1. As a result of this arrangement, the subject is completely scanned in a series of successive parallel lines by a small, rapidly moving intensely bright spot of light once for each revolution of the disc.

It is not necessary that the subject be at the exact position of the aperture images. The optical system is such that the slender beams of light sweeping across the region in front of the scanning apparatus just barely overlap each other even at a considerable distance from the apparatus. So, in this respect, within wide limits no confusion results as the subject moves toward or away from the apparatus.

As the spot of light passes over the subject, light is diffusely reflected from the subject, and a portion of the reflected light falls on one or more large photo-sensitive surfaces, such as the large photo-sensitive surface 11 of a large aperture photo-electric cell 12, and generates a picture current. The brightness of the image seen by the observer 2 at the receiving end of the system depends upon the distance of the subject 1 from the photo-sensitive surface.

The scanning system described above is disclosed in more detail in the copending application of Frank Gray, Serial No. 227,619, filed Oct. 21, 1927. The large aperture photo-electric cell having the large photo-sensitive surface is disclosed in more detail in the copending application of G. R. Stilwell, Serial No. 181,552, filed April 6, 1927.

The picture current from the photo-electric device is amplified by an alternating current amplifier $A^{13}$, and the amplified current is transmitted through a transformer 14 to a line 15 or other transmission channel connecting the sending end of the system to the receiving end. At the receiving end of the system, the current from line 15 is transmitted through a transformer 16 and an amplifier $A^{17}$ to an amplifier $A^{25}$ including an electric space discharge amplifier tube 26 which feeds a neon glow discharge lamp 30.

In front of the lamp is a disc 31 similar to the disc 4 and rotated synchronously with it by any suitable means (not shown). In front of the disc is an opaque screen 32 having an opening 33 of such size that only one of the apertures of disc 31 at a time is in the field of view of the observer 2. The lamp 30 is preferably of the type, disclosed more in detail in a copending application of Frank Gray, Serial No. 138,831, filed October 1, 1926, with a rectangular cathode 34 slightly larger than the field of view on the disc, the glow discharge covering the entire front surface of the cathode. The television field defined by the opening 33 and illuminated by light coming from lamp 30 through the moving apertures of disc 31, is viewed from in front of the disc without the aid of any optical system. The observer 2 sees at any instant a single aperture in the same relative position as the spot of light on the subject 1 at the transmitting end of the television system, and the brightness of the aperture corresponds to the amount of light reflected from that particular elemental area of the subject. On account of the persistency of vision the observer 2 consequently sees an apparent image of the subject on the front surface of the disc 31.

Complete views of the subject are transmitted at the rate of about 18 per second, so that the subject can be seen in motion. On account of the relatively slow movements of the usual subject, succeeding views in the series will remain about alike over a number of views. Consider, as a function of time, the varying light intensity that falls on the sensitive cell during a period of time covering the transmission of several views, or in other words, during a period approximately equal to several flicker periods. By applying a well-known mathematical principle, discovered by Fourier, to this varying light intensity, it may be approximately considered as a constant intensity plus the sum of a series of sinusoidal components.

The constant component is really the average light intensity of the views, or a luminous field upon which the views occur as variations from the average light intensity. The expression "light-ground" may be used to designate this uniform field of average brightness. The current generated by the photo-electric cells is likewise a fluctuating direct current, which is the sum of a constant current, corresponding to the luminous light-ground, and a series of sinusoidal currents, corresponding to the variations from the light-ground.

The constant component or direct current component representing the light-ground could not be transmitted through amplifiers and transformers of commercial design and over telephone lines even if an amplifier could be designed for properly amplifying it to the requisite degree before putting it on the line 15. Moreover, the signals as generated by the photo-electric cells are very minute, and a direct current amplifier that would amplify them to the requisite degree would not have the requisite stability. Therefore, the amplifier $A^{13}$ (and also the amplifier constituted by amplifiers $A^{17}$ and $A^{25}$) used to produce the requisite amount of amplification of these feeble signals is a vacuum tube amplifier embodying resistance-condenser coupling circuits which prevent zero drift in the amplifier and give it the requisite stability. These coupling circuits are such that the amplifiers have a substantially constant efficiency over a frequency range extending from a frequency below the frame frequency of 18 cycles per second to a frequency above the picture element frequency, say 20,000 cycles per second. Such a coupling circuit, comprising a capacity 40 and a resistance 41, is shown coupling amplifiers $A^{17}$ and $A^{25}$. The values of capacity 40 and resistance 41 respectively, may be, for example, 2 microfarads and 50,000 ohms.

However, pictures or views can not be reproduced with fidelity as regards tone value when the constant direct current representing the light-tone or light-ground of the picture or view is eliminated from the picture current transmitted over the system until a correction which effectively replaces this component is made. For example, imagine that the shaded squares 50 and 60 in Fig. 2 are two types of pictures or views, or represent two aspects of a subject, which are to be transmitted by the system. Substantially half of area 50 is constituted by a block 51, the tone of which is light gray; and substantially half of area 50 is constituted by a block 52, the tone of which is medium gray. A block 61 having the same medium gray tone constitutes substantially half of area 60; and substantially half of area 60 consists of a block 62 dark gray in tone. At the middle of the left hand edges of areas 50 and 60 are rectangles 53 and 63, which are black and white, respectively; and at the middle of the left hand edges of blocks 52 and 62 are rectangles 54 and 64, which are white and black, respectively. Each of these four rectangles is made of small area compared to one of the blocks such as 51, and narrow in the vertical direction, compared to a block such as 51. The relative dimensions, locations and tones of the various portions of areas 50 and 60 have been so chosen that, assuming the scanning spot to move in the vertical direction in Fig. 2, when the spot traces a path on area 50 indicated by dotted line 55 there is generated in the photo-electric cell a current wave 56 which is exactly like a current wave 66 correspondingly generated by a spot scanning along path 65 on area 60 as regards the alternating current components of the two waves, except for the narrow peaks 57, 58, 67 and 68 created in these waves due to rectangles 53, 54, 63 and 64 respectively; and these narrow peaks have but a negligible effect in determining the average value of current for each wave. These waves 56 and 66 are plotted between current and the position or distance of the scanning spot along path 55 or 65 as the case may be. Points on the curves correspond to horizontally aligned points on the paths 55 and 65, as indicated by the horizontal projection lines connecting the curves with the paths. The current values for these waves are plotted toward the right from line 70 as the reference line or line representing zero current value. The average value of current for wave 56 or the magnitude of the direct current component of the wave is indicated by line 59; and the average value of current for wave 66 or the magnitude of the direct current component of the wave is indicated by line 69. Since the area 50 is fairly light in general effect (has a bright light-ground), whereas the area 60 is fairly dark in general effect (has a dark light-ground), the magnitude of the direct current component of wave 56, or the distance between lines 70 and 59, is greater than the magnitude of the direct current component of wave 66 or the distance between lines 70 and 69.

The amplifier $A^{13}$ and also the transformer 14, line 15 and transformer 16 and the condenser 40 in amplifier $A^{25}$ do not pass direct current, and therefore only the alternating current components of the waves 56 and 66 reach the grid of tube 26.

These received alternating signal components are shown in Fig. 2 as voltage waves 56′ and 66′, respectively, with the axis or line of zero voltage indicated at 59′. Waves 56′ and 66′ are drawn each to the same scale as the other, since waves 56 and 66 are drawn each to the same scale as the other.

Fig. $2^c$ shows the grid voltage-plate current characteristic 80 of tube 26. The straight portion, or range over which it will for the present be considered as desirable to operate, is the portion between points 81 and 82. The point 83 corresponds to a voltage just half way between the voltages corresponding to points 81 and 82, respectively, and would be the normal operating point of the tube for an average value of light-ground. Vertically aligned with this normal operating point is line $59^a$ in Fig. $2^a$. This line corresponds to the average value (that is, the zero value) of voltage for waves 56′ and 66′, respectively. If these waves were received by tube 26 when the grid biasing voltage of that tube had the value of the point 83, then the varying voltages on the grid, in the case of the two waves, would be the two voltages indicated by curves $56^a$ and $66^a$, respectively, and the operating region would be that determined by vertical projections from the curves of Fig. $2^a$ on the curve of Fig. $2^c$. With this value of grid bias the apparent images of areas 50 and 60 as seen by observer 2 would be reproduced exactly alike. Areas 51 and 61 would have equal tone values, and areas 52 and 62 would have equal tone values. Furthermore, peak $57^a$ falls below the lower limit 81 of the assigned operating range, and peak $67^a$ falls above the upper limit 82 of the assigned operating range.

The operating point 81 corresponds to zero signal amplitude at the transmitting end of the system. Therefore, if the direct current component of the initial signal had been transmitted, $Eg_1$ would be the normal operating bias of the tube. Consequently, the operation about operating point 83 which results from the use of grid bias $Eg_3$ is equivalent to the introduction of a unidirectional voltage component of the absolute value $Eg_1-Eg_3$.

The distortions due, as explained above, to the absence of the direct current component from the picture current received by amplifier $A^{25}$ from amplifier $A^{17}$ and the effective reintroduction of a component of improper amplitude may be avoided or compensated for by varying the point about which operation takes place on the characteristic curve 80. To reproduce area 50 the grid bias should be altered as shown by curve $56^b$ of Fig. $2^b$, so that the average value of voltage is moved to the operating point 90. Under these conditions peaks $57^b$ and $58^b$ fall properly upon the limits 81 and 82, respectively, of the operating region of the characteristic. This alteration of the grid bias, to the value $Eg_5$, has affected the reintroduction of the proper unidirectional voltage component of the signal which is the absolute value $Eg_1—Eg_5$.

Similarly, to reproduce the area 60, the grid bias should be altered as shown by curve $66^b$ of Fig. $2^b$, so that the average value of the voltage is moved to the operating point 91. Under these conditions peaks $68^b$ and $67^b$ again fall upon the limits 81 and 82, respectively, of the operating region of the characteristic. This alteration of the grid bias, to value $Eg_4$, has affected the reintroduction of the proper direct current component of the signal which is the absolute value $Eg_1—Eg_4$.

In other words, if the direct current component had not been eliminated from the signal, the normal tube bias would have been $Eg_1$, which locates signal values corresponding to zero illumination at the lower limit 81 of the operating region of the characteristic of the tube. The reintroduction of the proper direct current components has therefore effectively shifted the operating bias with respect to alternating current components to the point $Eg_5$ for the reproduction of area 50 and $Eg_4$ for the reproduction of area 60. The criterion of the proper adjustment is that peaks $57^b$ and $68^b$ fall on operating point 81 and peaks $58^b$ and $67^b$ fall on operating point 82. When alternating current wave 56′ is delivered from amplifier $A^{17}$ to tube 26, the biasing voltage for the grid of tube 26 should be such that the variations of grid voltage which are caused by the wave occur about point 90 on characteristic 80 and the gain of tube 26 should be such that these variations coincide with the range between points 81 and 82. In other words, the wave 56′ and the grid bias combined should appear on the grid as the wave $56^b$ shown in Fig. $2^b$, the average voltage value of wave $56^b$, or the zero alternating voltage line being indicated by line $59^b$ which is vertically aligned with point 90 of characteristic 80 of Fig. $2^c$ as indicated by vertical projection lines extending from each figure toward the other.

Similarly, when alternating current wave 66′ is delivered from amplifier $A^{17}$ to tube 26, the biasing voltage for the grid of tube 26 should be such that the variations of grid voltage which are caused by the wave occur about point 91 on characteristic 80 and the gain of tube 26 should be such that these variations coincide with the range between points 81 and 82. In other words the wave 66′ and the grid bias combined should appear on the grid as the wave $66^b$ shown in Fig. $2^b$, the average voltage value of wave $66^b$ or the zero alternating voltage line, being indicated by line $69^b$ which is vertically aligned with point 91 of characteristic 80 of Fig. $2^c$ as indicated by vertical projection lines extending from Fig. $2^c$ toward Fig. $2^b$.

The desired gain for tube 26 can be obtained by proper adjustment of a gain control device comprising the resistance 41 in the input circuit of the tube and a contact 85 connected to the grid of the tube and movable along the resistance 41. To accomplish the desired variations, mentioned above, of the operating point on characteristic 80, the observer 2 varies the negative grid potential of the tube 26 by means of a contact 87 movable into engagement with resistance taps 88 on a battery 86 which has its positive pole connected to the filament of the tube. The observer 2 can thus choose a light-ground to suit his own fancy by the value of the arbitrary direct current that he puts into the light cell 30, and he sees the original view or picture reproduced except that the luminous light-ground may not be the same as in the original if, in adjusting the grid bias, he must depend merely on his fancy and his general ideas as to the nature of the object being viewed. Means for indicating the proper adjustment will be described presently.

Considering a period of time covering the transmission of a series of views comprising a large number of views, or in other words, considering a time period covering a large number of flicker periods, as the subjects move about or change in the particular series of views that is being sent, the average brightness of the field will vary slowly with time, and the receiving operator can vary the grid bias of the last tube at will, to suit his own fancy, or to accord with the indications of the above mentioned means for indicating the proper adjustment.

From the foregoing description it will be seen that the input of the last stage of the amplifier constituted by amplifiers $A^{17}$ and $A^{25}$ in tandem has a gain control device which determines the maximum amplitude of the alternating voltage applied to the grid; that the input also contains means for adjusting the grid bias to determine the operating point on the characteristic curve 80 of the amplifier; and that these two means together enable a region of the curve to be chosen for operation and enable the sweep or extent of variation to be determined.

The output of the tube contains, in addition to a "B" battery or other source 95 of unidirectional voltage of value $E_B$, a resistance 96 in parallel with the neon lamp 30 and a second battery or other source 97 of unidirectional voltage of value $E_s$. The source 97 may be termed the polarizing battery for the lamp. The resistance 96 may be of the order of magnitude of the output impedance of the tube. These elements in the output circuit enable the illumination of the neon lamp to be varied linearly from zero illumination to different degrees of illumination for any amplitude of incoming signals.

The nature and purpose of the various adjustments described above will now be further explained with the assistance of Figs. $2^d$ and $2^e$. The solid line curve 100 of Fig. $2^e$ is the operating characteristic curve of the neon lamp 30 plotted between voltages on the lamp as abscissæ and the intensity of illumination of the lamp or the current through the lamp as ordinates. The voltage corresponding to point 100′ is the striking voltage of the lamp. The curve 101 of Fig. $2^d$ has ordinates corresponding to those of amplifier characteristic 80 of Fig. $2^c$, and has abscissæ corresponding to those of the neon lamp characteristic 100 of Fig. $2^e$. Assume, for simplicity, that the incoming signal wave is the alternating current wave 66′. The amplitude of the alternating current can be controlled by the gain adjusting device to bring it within the desired range. It is desired to operate the amplifier over a linear portion of its characteristic 80 not only as regards the alternating current component of the signal but also to be able to vary the region operated over by the alternating current component on the characteristic curve to take care of different amounts of direct current component which it is desired to introduce into the signal. It is further desired to control the application of voltage to the neon lamp 30 so that the lamp will be dark when the initial signal amplitude is zero and so that the brilliancy will vary linearly with the amplitude of the incoming signal.

Starting out with a given amplitude of signal as indicated at 66′ or 56′ some point on the characteristic 80 is chosen as the lowest suitable operating point from the standpoint of desired quality. The signal 66′ is given a certain amount of direct current bias which is shown by the line $69^b$ in Fig. $2^b$. The negative grid potential is thus chosen in accordance with the criterion given above. If a different direct current component is desired, a different negative bias is chosen for the amplifier. For example, in the case of wave 56, having a large direct current component representing a bright light-ground, such a tube bias is used as will cause operation further up on the characteristic curve 80. It is thus desired that the total range operated over not only by the individual signal variation but between the extremes of the direct current component shall lie within the limits of a fairly linear portion of the characteristic curve 80. The amplifier grid bias is thus determined entirely from the standpoint of the amplifier characteristic 80 without reference to the neon tube.

Turning now to the determination of the neon lamp bias, it is seen from the neon tube characteristic 100 that a certain voltage or bias, as indicated by the abscissa of point $81^e$, is necessary to bring the lamp up to the lowest illuminating voltage. This value of voltage should correspond to point $81^d$ on curve 101, and the circuit constants should be so chosen that this voltage will be just equaled by the algebraic sum of the voltage $E_S$ and the voltage drop in resistance 96 corresponding to the value of amplifier plate current indicated by point 81 at the lower end of the straight portion of characteristic 80. This value of voltage drop across resistance 96 is designated $I_0R$ in Fig. $2^d$.

When the circuit is adjusted in this manner and a signal is received representing blacks and grays, such a grid bias is used that the lower portion of the chosen range of characteristic 100 is used, which changes the illumination of the lamp from dark to dim. If the picture corresponds to gray and white, such a grid bias is used that the upper end of the operating range of characteristic 100 is utilized and the neon lamp is illuminated all the time to a brilliant and less brilliant degree. In this manner the direct current component which was eliminated at the transmitter is reinserted, in effect, at the receiver.

The indicating means mentioned above comprises an amplifier tube 112 which has its grid and filament connected directly to the grid and filament respectively of tube 26 and has in its output circuit a resistance 113 and four neon glow discharge lamps A, B, C and D with polarizing batteries 115, 116, 117 and 118. Lamps A and B have their anodes connected to the plate of tube 112, whereas lamps C and D have their cathodes connected to the plate of the tube. Due to persistency of vision, lamps A and D appear lighted when the adjustment of contacts 85 and 87 is correct, that is, when the variations of the space current of tube 112 coincide with the part of curve 80 extending from point 81 to point 82. If the range of the space current variations in tube 112 extends substantially above point 82, lamp C appears lighted. If their range extends substantially below point 81, lamp B appears lighted.

The circuit constants for accomplishing these results may be, for example, as follows. The striking voltage of each of the four neon lamps may be 210 volts. Resistance 113 may be 2000 ohms. The space current of tube 112 corresponding to points 81 and 82 may be 5 milliamperes and 40 milliamperes, respectively, which will mean that the voltage drops in resistance 113 corresponding to these points are 10 volts and 80 volts, respectively. The voltages of batteries 115, 116, 117 and 118 may be 125 volts, 10 volts, 215 volts and 10 volts respectively.

In Fig. $2^c$, the intersection of the dotted lines extending from the lamps A, B, C and D, respectively, with the curve 80 indicate in a qualitative way the points on the curve corresponding to the space currents of tube 112 which cause the voltage drops in resistance 113 to be such as, together with the voltages from the lamp polarizing batteries 115 to 118, will cause the voltages across the respective lamps to equal the striking voltage of the lamps, that is, the voltage at which the lamps begin to glow when their voltage is gradually increased from a value insufficient to cause the lamps to light. The lamp A has as its voltage the drop in resistance 113 and the voltage of the two batteries 117 and 118 in series, these batteries being so poled that their effect upon the lamp is diminished by the voltage drop in resistance 113. The lamp B has a smaller voltage since its voltage is the voltage of battery 117 diminished by the voltage drop in resistance 113. Lamp C has as its voltage the voltage drop in resistance 113 series aided by the voltage of battery 115. The lamp D has as its voltage the voltage drop in resistance 113 series aided by the voltages of the two batteries 115 and 116. Due to this arrangement lamps A and B are illuminated at the values of space current indicated and continue to glow for all lower values. Lamps C and D become illuminated at the values of space current shown and continue to glow for all higher values.

In the operation of this circuit, an attendant, or the observer 2, would need to know that the picture being transmitted, or the field being scanned at the transmitting end of the system, has some portions which vary substantially all the way between the extremes of white and black. He manipulates the gain and bias of the amplifier tube until the lamps A and D are illuminated, and the lamps B and C are dark. This assures that the full operating range of the amplifier characteristic is being covered but not exceeded in either direction. If lamp B, for example, is illuminated, the amplifier bias is too large and a point too far down on the amplifier characteristic is being used. If lamps B and C, for instance, are illuminated, it may be necessary to vary both the grid bias and the gain adjusting potentiometer to bring the maximum variations within the required range.

Since it is of assistance, in making the light-ground of the received image closely approach that of the original if the field scanned at the transmitting end of the system has some portion which is black, as for example, the portion 53 in area 50, or the portion 64 in area 60, and some portion which is white, as for example, the portion 54 in area 50, or the portion 63 in area 60, such portions if not naturally present may be introduced in the subject being scanned or its background.

The copending application of H. E. Ives and Frank Gray Serial No. 181,511, filed April 6, 1927, discloses in more detail the means suppressing the direct current component of picture current at the transmitting end of a picture transmission system, and also discloses means for inserting a direct current component in the signal at the receiving end of the system.

What is claimed is:

1. In a signaling system, a glow discharge lamp of the type which emits light substantially proportional to the potential impressed upon it in excess of the striking voltage, a space discharge amplifier for supplying the lamp with fluctuating uni-directional voltage, and means to impress on said lamp adjustable values of steady potential equal to and greater than said striking voltage.

2. In a signaling system, a space discharge device having an anode, a cathode and a grid or impedance control element, an impedance included in the external space current circuit of said device, a source of space current, adjustable means connected to the grid and cathode for determining the desired operating region on the amplifier characteristic curve, means to impress on the grid circuit signal variations to be amplified, a glow lamp connected to receive variable voltage developed across said impedance in response to variations in space current flow, and means in circuit with said glow lamp for impressing a steady voltage thereon.

3. In a signal receiving circuit for a picture transmission system, a three-electrode space discharge amplifier for the signal variations, a neon glow lamp actuated by the amplified signal variations, means for adjusting the amplifier to operate over a desired region of its space current-grid voltage characteristic and means for applying to said lamp a steady biasing potential equal to and in excess of its striking voltage.

4. In a signaling system, an electric lamp having a light producing characteristic substantially proportional to impressed voltage over a range of voltages the lowest of

which is of a value substantially above zero, and means to impress upon said lamp voltages within said range, the voltages within said range being alone representative of the transmitted signals, said means comprising a source of voltage, a path for current from said source, and means connecting said lamp to said path and applying to said lamp a voltage different from that across said path.

5. In a signaling system, a receiving circuit comprising an electron discharge amplifier having an anode circuit, a source of current for said anode circuit, a glow discharge lamp in said anode circuit, and a current path for by-passing current around said lamp and a portion of said source, the light emission from said lamp being substantially proportional to the voltage impressed thereon above the striking voltage.

6. The combination with an electric lamp which produces light only when the impressed voltage has a value substantially above zero, means for impressing a varying voltage upon said lamp, and a shunt circuit for said lamp and a portion of said means in series.

7. The combination with an electric lamp which produces light only when the impressed voltage has a value substantially above zero, a source of voltage for impressing a varying voltage upon said lamp, a path comprising said lamp and a portion only of said source, and a shunt circuit for said path.

8. The combination with an electric lamp which produces light only when the impressed voltage has a value substantially above zero, a source of voltage for impressing a varying voltage upon said lamp, a path comprising said lamp and a portion only of said source, and a shunt circuit for said path, said shunt path having substantially constant impedance for varying impressed voltages above said light emitting voltage.

9. In a signaling system, a source of current comprising an amplifier having an anode circuit, a source of light and a voltage changing device connected in series with said anode circuit, light being produced only when the voltage impressed upon said light source has a value substantially above zero, and a path for shunting current around said lamp and said voltage changing device.

10. In an image transmission system, a source of current comprising an electron discharge amplifier in which the currents in the output circuit corresponding to the various light values of the object an image of which is to be produced have a range of amplitudes the lowermost of which has a value substantially above zero, a glow discharge lamp having a striking voltage corresponding to said lowermost current value, a voltage changing device connected to said lamp, and a shunt path for said lamp and said device.

11. In an image receiver including a vacuum tube terminal amplifier, a receiving lamp, a source of voltage, and a current path, said current path being connected in parallel with said receiving lamp and said source of voltage across the output of said terminal amplifier.

12. A source of voltage, a plurality of circuits supplied with voltage in parallel from said source, a glow discharge lamp in one of said circuits, and an auxiliary source of voltage in one only of said circuits.

13. A source of voltage, a plurality of circuits supplied in parallel with voltage from said source, a glow discharge lamp in one of said circuits, and means for maintaining the voltage across said glow lamp different from the voltage across said other circuit.

14. A source of unidirectional voltage having alternating components, a plurality of circuits supplied in parallel with voltage from said source, a glow discharge lamp in one of said circuits, and a source of voltage for maintaining different unidirectional voltages across said lamp and said other circuit.

15. The method of operating a glow lamp from an electric space discharge device, which comprises, supplying the lamp with fluctuating unidirectional voltage from the device and rendering the voltage across the lamp different from that supplied to the lamp from the device.

16. A receiving system comprising a glow discharge device, an amplifier for amplifying received picture currents and transmitting them to said device, and means for indicating variations in the range of the amplifier characteristic over which operation takes place.

17. A system for transmitting visual aspects of objects to a distance, comprising means for generating a fluctuating unidirectional current representing the visual aspect of the object to be viewed at a distance, means for deriving alternating current from said unidirectional current, amplifying said alternating current and transmitting it to a distance, a receiving amplifier for amplifying said transmitted current and combining therewith a unidirectional current, and means for indicating the value of the combining unidirectional current relative to the value of the direct current component of the first mentioned fluctuating unidirectional current.

18. In combination, a plurality of glow discharge lamps, a source for supplying voltage to said lamps, and means for causing the voltage across said lamps to so differ for the different lamps as to indicate the range of variation of the voltage of said source.

19. A system for transmitting and ampli-

fying a signal having a direct current component, said system comprising means for eliminating that component and amplifying another of the components of the signal, and means included in said system for combining with the amplified other component direct current for restoring the original proportion between the direct component and the other component.

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

JOSEPH W. HORTON.

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

JOSEPH W. HORTON.

## CERTIFICATE OF CORRECTION.

Patent No. 1,728,122. September 10, 1929.

JOSEPH W. HORTON.

It is hereby certified that error appears in the printed specifications of the above numbered patent requiring correction as follows: Page 7, beginning with line 130, strike out all to and including line 9, page 8, comprising claim 19, and insert the following as claim 19:

19. In a picture transmission system, means for generating picture currents having a direct current component, means for eliminating the direct current component from the picture current at a portion of the system, means for restoring the direct component at another portion of the system, and means for indicating the amount of the direct component restored.

And that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 14th day of November, A. D. 1933.

F. M. Hopkins
Acting Commissioner of Patents.

(Seal)