

Aug. 25, 1942.

R. E. GRAHAM
ELECTROSTATIC SCANNING

2,294,114

Filed May 31, 1941

3 Sheets-Sheet 1

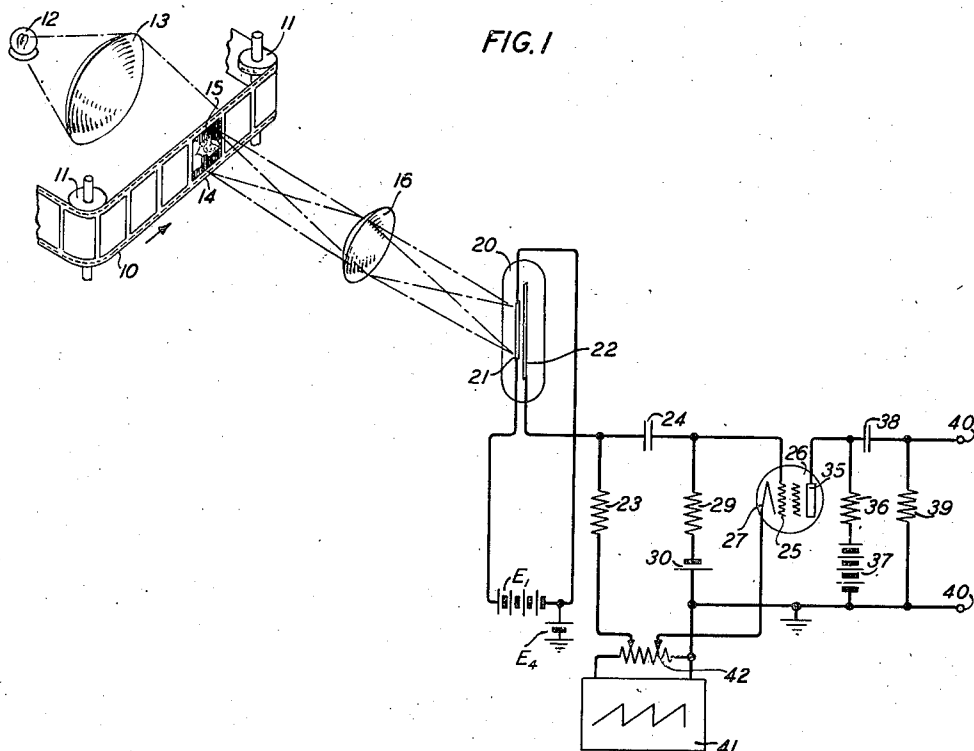


FIG. 2

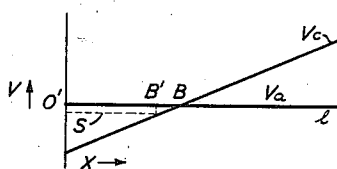
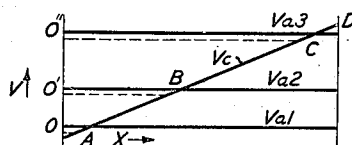


FIG. 3



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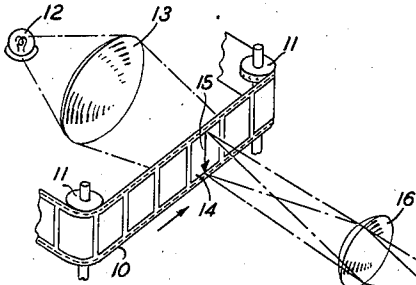


FIG. 4

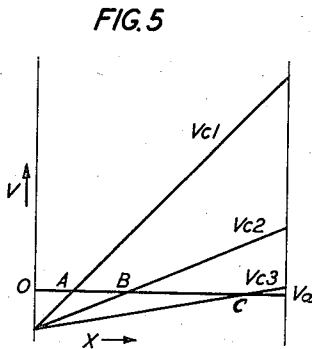


FIG. 5

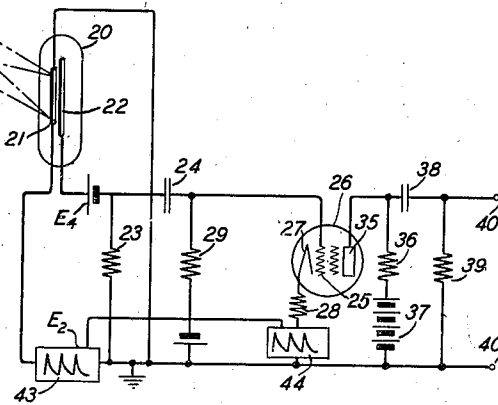
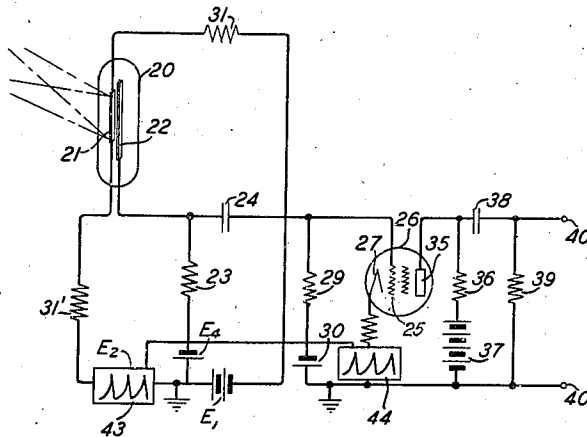


FIG. 6



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FIG. 6

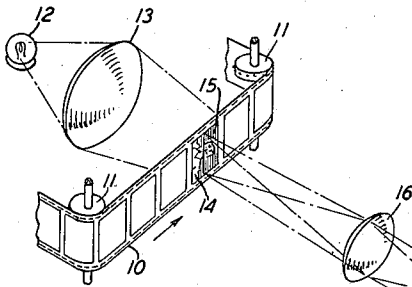
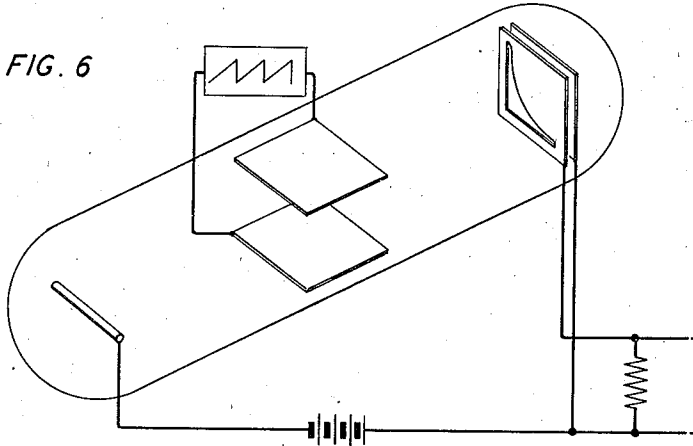


FIG. 8

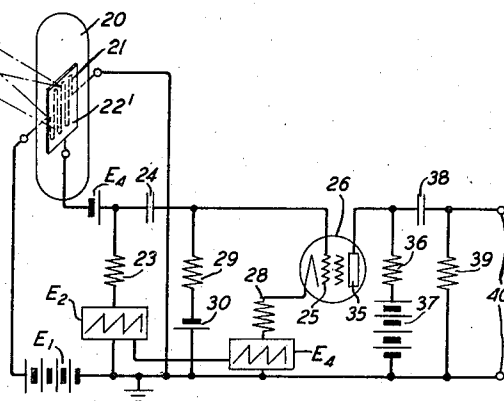
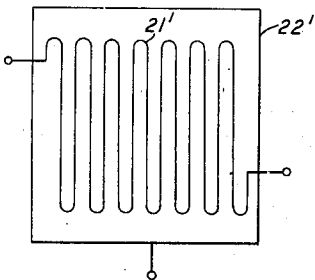


FIG. 9



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UNITED STATES PATENT OFFICE

2,294,114

ELECTROSTATIC SCANNING

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Application May 31, 1941, Serial No. 396,006

14 Claims. (Cl. 178—7.2)

This invention relates to television transmitters and more particularly to a television camera in which the scanning operation is accomplished without the use of any moving material agent such as a focused electron beam.

The now common electronic scanning systems, while they constitute a marked improvement, especially for "instantaneous" image transmission, over the earlier systems employing moving optical elements are nevertheless limited from the practical standpoint by the necessity for the provision of electron-optical systems for sharply focusing a beam or beams of electrons onto a beam receiving target.

In order to escape from the restrictions imposed by the electron-optical system, it has already been suggested to dispense entirely with the electron beam and carry out the scanning operation by the movement along a prescribed path, not of any material agent, but of a point or region which is distinguished electrostatically from neighboring points. For example, it has been proposed to provide two plate-like conductors spaced apart and supply them with different potentials to produce an electrostatic field between them; to provide in this field a third conductor of elongated form and serving as a photocathode on which an image is focused; and by changing the potential of this photocathode to cause a point or line separating parts of it from which photoelectrons are withdrawn from other parts from which they are not withdrawn to progress along the length of the photocathode in such fashion that the resulting current flowing from the photocathode to one of the plate-like conductors is related to the variation of the light values of the image.

A system of the type described is disclosed as to its broadest outlines in British Patent 476,714, complete accepted December 14, 1937. That system, however, is open to the objections that in some forms no less than three electrodes are required, at least one and preferably two of which must be large as compared with the dimensions of the image line scanned, while in other forms certain relations must obtain between the disposition of and coupling between the electrodes, which relations may be difficult to secure in practice.

It is an object of the invention to provide improved electrostatic scanning apparatus of compact construction employing a minimum number of electrodes. To this end there is provided a novel electronic device which comprises two special electrodes, i. e., an extended photocathode

on which an image of a part of a field to be transmitted is focused and an anode collector of photoelectrons which may be disposed parallel to and closely adjacent to the photocathode. One of these electrodes, for example the anode, may be at a uniform potential, while the other, for example the photocathode, may be arranged to support a substantial longitudinal voltage drop so that successive points thereof are at successively different potentials with respect to the collector anode, one point or narrow region being at the same or substantially the same potential as the collector anode. This point or region divides the first electrode into two parts over one of which collection of photoelectrons takes place while over the other it does not take place. This dividing point is caused to progress along the length of the photocathode to scan the image focused upon it by the provision of scanning voltages of suitable wave form on and between these electrodes. This results in the flow of a current in an external circuit connected to the collector which is or may readily be converted into a conventional vision signal for amplification and transmission.

It is thus a feature of the invention that the electrode along which the neutral point moves in the scanning operation itself contributes to the configuration and variation of the electrostatic field which produces this movement. A related feature is that the scanning is accomplished with but two principal electrodes. A further feature is that the movement of the scanning point is secured in part by a voltage of suitable wave form impressed across the end terminals of one of the extended electrodes itself. It is a further feature that the photocathode and the collector anode may be interchangeable as regards the potentials impressed on and between them.

While in a broad sense the invention may be useful in the scanning of object fields generally, it is especially applicable to the scanning of images borne by a moving film wherein scanning of successive image lines is carried out in accordance with the novel principles of the invention while frame scanning, that is, scanning in a direction perpendicular to the length of the image line, is accomplished by movement of the film. Accordingly, the following illustrative description is directed in the main to preferred embodiments designed especially for line scanning. It is concluded by a brief description of an embodiment suitable for field scanning.

The description will be more readily understood

by reference to the accompanying drawings, in which:

Fig. 1 shows electrostatic scanning apparatus in which the extended photocathode supports a longitudinal voltage drop derived from a source of direct current impressed thereon, and Figs. 2 and 3 are diagrams illustrating the mode of operation of Fig. 1;

Fig. 4 shows a modification in which the voltage impressed on the photocathode is of a modified saw-tooth wave form, and Fig. 5 is a diagram illustrating the mode of operation of Fig. 4;

Fig. 6 shows in schematic perspective auxiliary apparatus which may be employed to obtain wave forms suitable for use with the apparatus of Figs. 4 and 7;

Fig. 7 shows a circuit arrangement in some respects similar to that of Fig. 4;

Fig. 8 shows an arrangement suitable for field scanning as distinguished from line scanning, the associated circuit arrangement being, for the sake of illustration, the same as that of Fig. 1; and

Fig. 9 shows a portion of the apparatus of Fig. 6 to an enlarged scale.

Referring now to Fig. 1, an elongated flexible member 10 is provided on which are recorded successive images of a field of view to be transmitted. For the sake of definiteness of illustration, this member 10 is shown as a transparent film, for example, a motion picture film. It may be passed around sprocket or guide rollers 11 and any suitable means of a type well known in the art may be employed to maintain a part of it, intermediate the guide rollers, in a definite focal plane. Likewise any suitable means may be employed to advance the film in a direction parallel with its length, for example, with an intermittent line-by-line motion.

Light from any suitable source, for example, an incandescent filament lamp 12, may be directed as by a lens 13 upon an image frame 14 of the film 10 intermediate the guide rollers. The frame 14 is thus evenly flooded with light. A line 15 of the frame 14 extending transversely of the film length may be imaged, for example by a lens 16, on the extended photocathode element of the novel pick-up device of the invention.

The novel pick-up device of the invention may be disposed in a position to be impinged by light from the source 12 passing through the transparent film 10. This device comprises an evacuated envelope 20 containing two principal electrodes. The first electrode is the extended photocathode 21 of the invention and the second is a collector anode 22. The photocathode 21 may be an elongated narrow element, for example, a wire or thin strip of partially conductive material, and, by reason of an appropriate surface treatment or otherwise, having pronounced photoelectric properties. The base material should be one whose unit impedance or resistivity is of an intermediate value, that is to say, it should be neither an insulator nor a good conductor but should offer a resistance or impedance to the passage of electric current such that it can sustain a comparatively large voltage drop even with the passage of a comparatively small current. For example, this element may be a wire of a few mils diameter and an inch or so in length, and made of material such that with these dimensions its resistance as measured between its end terminals is of the order of a megohm. If desired, this element may be constructed in the form of a tight spiral of small diameter in the manner well known in the incandescent filament art. It is important

that the material of which the photocathode element is constructed be uniform both in respect to resistivity or unit impedance and its photoelectric properties so that the voltage drop per unit length and the electron emission per unit of illumination shall be the same throughout its length.

The collector anode 22 which may be an elongated wire or strip of ordinary conducting material such as a metal is preferably disposed close to and parallel with the photocathode within the envelope. The photocathode element and the collector anode may be supported and maintained in correct parallel alignment by any suitable supporting means in a manner well known in the art.

Although the construction and arrangement as above described offer certain distinct advantages, an opposite arrangement may be employed, i. e., one in which the photocathode is a highly conductive element which tends to remain at a uniform potential throughout its length while the collector anode offers a comparatively high resistance or impedance to electric current and supports a longitudinal voltage drop. The description will be directed principally to the preferred arrangement though it is to be borne in mind that the invention applies equally to the converse arrangement above briefly alluded to.

In accordance with the invention, the pick-up device 20 may be disposed with the photocathode 21 extending in a direction perpendicular to the length of the film 10 and the line 15 of the film frame 14, extending transversely of the film length and illuminated by the source 12, may be imaged upon the photocathode 21 so that the amount of light falling upon each point of the photocathode 21 is proportional to the translucency of the corresponding point of the illuminated film line 15. Emission of photoelectrons will then take place from each point of the photocathode in proportion to the illumination of the corresponding point of the illuminated film line 15 in well-known manner.

Operating potential may be applied to the electrodes of the novel tube in various ways and may be of various forms. In the modification of Fig. 1 a potential difference is applied to the two ends of the photocathode by connection thereto of a source of steady current such as a battery E₁, the negative terminal of which may be connected through a bias battery E₂ to ground. The collector anode 22 may be connected through a resistor 23 and a portion of a resistor 42 to ground, and also through a condenser 24 to the control element of a discharge device, for example to the control grid 25 of a four-electrode vacuum tube 26 whose cathode 27 is connected through a portion of the resistor 42 to ground, the control grid 25 being returned to ground through a resistor 29 and a biasing battery 30. The output electrode or plate 35 of this tube may be supplied with potential through a load resistor 36 from a suitable source, for example a battery 37, the negative terminal of which is grounded. The signal output from this tube is delivered through a condenser 38 and across an output resistor 39 to output terminals 40.

A generator 41 of line scanning voltage of saw-tooth wave form is provided. The internal construction and arrangement of the elements and connections of this generator form no part of the invention and may be of any desired type well known per se. Its output current may be supplied to the resistor 42, one end terminal of which

is connected to ground. Two points of this resistor are connected, for example, by adjustable contacts through the resistor 23 to the anode 22 and to the cathode 27 of the tube 26 to supply a saw-tooth scanning voltage E_2 to the collector and a neutralizing voltage E_3 to the cathode 27.

The frequency of the saw-tooth generator is adjusted to line scanning frequency, that is, to a frequency at which the period of the saw-tooth wave is equal to the time associated with the movements of the film parallel to its length through a distance equal to the width of a single scanning line.

The operation of the arrangement depicted in Fig. 1 is as follows: The photocathode 21 being illuminated as above described, emission of photoelectrons takes place from the various points thereof in proportion to the light incident thereon. Of these photoelectrons those emitted from points of the photocathode which are at negative potentials with respect to the collector anode 22 are drawn to it and caught by it and return to the photocathode through the external resistor 23 and the battery E_1 to produce a voltage drop across the external resistor 23. On the other hand, photoelectrons emitted from parts of the photocathode which are at positive potentials with respect to the collector anode 22 are repelled by it and fail to reach it and therefore make no contribution to the voltage drop in the resistor 23.

Those parts of the photocathode from which collection takes place are separated from those parts from which it does not take place by a point at which, or a narrow region over which, the photocathode potential is substantially equal to the collector potential or differs from it by a small amount.

The magnitude of the steady photocathode voltage E_1 is preferably set at a comparatively high value so that the voltage drop between the collector and the photocathode rises steeply on each side of this neutral point to a value which insures saturated collection of photoelectrons from all points of the photocathode which lie to the low potential side of this neutral point except for a very narrow region adjacent to the neutral point along which collection increases progressively toward the low potential end of the photocathode. Thus the effective photocathode-collector potential difference is substantially uniform at a complete collection value along one part of the photocathode and substantially uniform at a non-collecting value along the other part, dipping sharply from the one value to the other at the neutral point.

These conditions are illustrated graphically and in exaggerated form in Fig. 2, in which the potentials of the electrodes are plotted against distance along the photocathode. The horizontal line V_a represents the uniform potential of the anode 22 and the sloping line V_c represents the potential of the photocathode 21. Its slope is determined by the gradient supplied by the source E_1 . The point B is the neutral point at which these potentials are alike. The dotted line S represents the potential for saturated collection of electrons. Neglecting the necessity for a small negative gradient to completely suppress collection of photoelectrons, the distance BB' is the neutral region and the distance $O'B$ is the length of the active portion of the photocathode.

Reference to Fig. 3 reveals how this neutral region is caused to progress along the length of the photocathode by application of the saw-tooth

voltage of the generator 41 to the collector anode 22. In this figure, which shows the potentials of the electrodes as in Fig. 2 but repeated for successive instants, the line V_c represents the photocathode potential which is non-uniform but unchanging in time. The lines V_{a1} , V_{a2} , V_{a3} represent successive values of the uniform potential of the collector anode at three successive instants t_1 , t_2 , t_3 within the rising portion of a single cycle of the saw-tooth line scanning voltage of the generator 41. It will be observed that the neutral point at which the potentials of the two electrodes are alike successively occupies the positions A, B, C during this part of the saw-tooth cycle so that the active parts of the photocathode are OA, O'B, O''C, in succession. In practice, of course, the neutral point travels over the length of the photocathode with a continuous uniform motion and the active portion grows from O to the full length of that part of the photocathode on which the film line 15 is imaged, represented by the point D, in like manner.

The resulting collector current at a given instant and therefore the voltage across the external resistor 23 may then be expressed as

$$e_c = \int_0^x k_1 L(x) dx \quad (1)$$

where $L(x)$ represents the illumination of a point of the photocathode which lies at a distance x from one end and the factor k_1 , which, disregarding the finite width of the neutral region, is a constant, includes both the emission properties of the photocathode and the collecting properties of the system due to the electrode configurations. If this neutral point moves along the photocathode at constant speed v , as it will when the saw-tooth generator voltage rises linearly with time, then

$$x = vt$$

and

$$e_c = \int_0^x k_1 L(x) dx = \int_0^t k_1 v L(vt) dt \quad (2)$$

In accordance with the invention this voltage may be applied to a differentiating circuit, for example the cathode 27 and control grid 25 of a tube of low input capacitance such as a tetrode 26 in whose output circuit are connected a condenser 38 of comparatively small capacitance and a resistor 39 of comparatively high resistance in series. As is well known, if the reactance of the condenser is high as compared with the internal and external plate resistances of the tube, taken both separately and together, the voltage appearing at the terminals 40 across the external resistor 39 will be proportional to the time derivative of the input voltage e_c . Thus

$$e = k_2 \frac{de_c}{dt} = k_2 \frac{d}{dt} \int_0^t k_1 v L(vt) dt \quad (3)$$

$$= k_2 k_1 v L(vt) \quad (4)$$

which is evidently in the form of a conventional vision signal.

After the neutral point has progressed over the full length of the photocathode or that part of it on which the film line 15 is imaged, the saw-tooth voltage drops rapidly to its initial value to commence a new cycle. Meantime the film 10 has advanced by the width of a single line so that as the neutral point starts its progress along the photocathode a slightly different part of the film will be imaged upon it. Successive repetitions of this process result in complete scanning of the film image.

The saw-tooth voltage of the generator 41 is

applied through the resistor 23 to the collector 22. Therefore, the electromotive force of the saw-tooth generator itself, as well as the desired signal e_o is impressed on the input terminals of the tube 26. To prevent its appearance in the output, a neutralizing electromotive force E_3 may be impressed on these input terminals in opposite phase, for example, across the cathode resistor 28. In order to insure equality of frequency and wave form the two voltages E_2 and E_3 may conveniently be derived from the same source, and it is for this reason that they are shown as being tapped at suitable points on the load resistor 42 in the output circuit of the saw-tooth wave generator 41. The taps may be adjusted to give zero output at the terminals 40 when no illumination falls on the photocathode 21.

However, the saw-tooth voltage may be impressed on the collector 22 in any desired manner and likewise its electromotive force may be prevented from affecting the tube 26 in any desired manner, by balancing or otherwise. For example, voltages derived from separate but synchronized sources may be applied to the resistors 23 and 29.

The vision signals derived as above described may be amplified and transmitted by wire or radio, by carrier modulation or otherwise as desired, to a receiver station where they may be reconstituted by suitable apparatus as an image. If preferred, the vision signal integral may be transmitted instead, the conversion to a proper vision signal being effected at the receiver.

Although not essential to the operation of the system, the inclusion of the bias battery E_4 between the collector anode and the photocathode permits correct adjustment of the path followed by the neutral point with respect to the location of the image on the photocathode.

Fig. 4 shows a modification which differs from that of Fig. 1 in the manner in which the potentials are applied to the electrodes. The pick-up device 20 itself, as well as the optical apparatus for illuminating its photocathode 21 and the electrical circuit by means of which signals are withdrawn from the collector anode 22 may be similar to the corresponding portions of the apparatus of Fig. 1. In this figure, instead of a rectilinear saw-tooth voltage applied to the collector, a modified saw-tooth voltage E_2 derived from a generator 43 is applied across the photocathode while a small constant bias E_4 is applied to the collector.

Fig. 5 illustrates the operation of this system. In this figure the single constant voltage line V_a represents the collector anode potential and the lines V_{c1} , V_{c2} , V_{c3} represent the photocathode potential at successive instants t_1 , t_2 , t_3 , at which the neutral point occupies successively the positions A, B, C. Since in the normal course of events it will be desirable that the neutral point travel along the photocathode at constant speed, it is necessary, as appears from Fig. 5, that the voltage of the active portion of each cycle of the saw-tooth wave be a non-linear time function. More particularly, a calculation shows that for uniform motion in one direction of the neutral point over the full length of the photocathode, the saw-tooth generator voltage must theoretically be a simple reciprocal function of time, namely

$$E'(t) = \frac{a}{t} \quad (5)$$

where a is some constant; for uniform motion

in the opposite direction it must be a modified reciprocal time function, namely

$$E'(t) = \frac{a}{b-t} \quad (5a)$$

where a and b are constants.

In the practical application the voltage need not become infinite as these equations indicate that it must, when t is equal to zero or b , respectively. This difficulty is most simply avoided by merely providing a photocathode of somewhat greater length than the line image focused on it so that the "tag end" provides a marginal resistance. If preferred, separate marginal resistors may be connected to the ends of the photocathode, either inside or outside of the envelope 20. It may easily be shown that inclusion of a marginal resistor or tag end of the photocathode as a part of the circuit gives rise to a modified inverse time function, i. e., to the equation

$$E''(t) = \frac{Z_1 + Z_c}{Z_1 + KtZ_c} E_o'' \quad (6)$$

where

Z_c = total photocathode impedance;

Z_1 = impedance of marginal resistor or tag end;

E_o = minimum value of the saw-tooth voltage;

and

K is a constant.

Any desired means may be employed to secure a voltage which varies inversely with time in the required manner. For example, an arrangement such as that disclosed in copending application Serial No. 342,601, filed June 27, 1940, or in that disclosed in Strobel Patent 1,757,345, May 6, 1930, may be adapted to the present purpose as shown in Fig. 6. Currents having various desired wave forms may be generated by the use of a cathode beam tube in which a broad electron beam is projected on a suitably shaped target or on a target disposed behind a suitably shaped aperture and swept over the target or aperture in accordance with a signal whose wave form it is desired to modify. For the present purposes, if the aperture has the form of a reciprocal curve, a current varying inversely with the time will flow in the target circuit when the beam is deflected past the aperture at a uniform speed. This inverse current may be translated into a voltage of like wave form in any desired manner, for example by allowing it to flow through a resistor across which are connected the input terminals of a high impedance tube. The voltage appearing in the output circuit of this tube may then serve as the generator 43 of Fig. 4 and be applied to the photocathode 21 to produce progressive movement of the neutral point as above described.

Inspection of Fig. 5 will reveal that with this arrangement the rate of change of the potential difference between photocathode and collector is greater when the neutral point is near one end of the photocathode than when it is near the other end. As a result, the region of saturated collection of photoelectrons extends closer to the neutral point at one end of the photocathode, where the neutral region is very narrow, than at the other where the neutral region is comparatively broad. In other words, the "aperture effect" varies along the length of the photocathode and the received image will have higher definition at one side than at the other. In some applications this may be of advantage.

In the arrangement of Fig. 4 collection of photoelectrons takes place from all points of the photocathode which lie to the low potential side of the neutral point. The current output and therefore the voltage appearing across the resistor 23 will thus be a vision current integral, just as in the case of Fig. 1. By impressing this signal on a differentiating circuit similar to that of Fig. 1 its derivative, a true vision signal, may be obtained at the output terminals 40.

Circuit arrangements of still other forms may be employed for impressing the actuating potentials on the photocathode and collector anode, respectively. One such other form is illustrated in Fig. 7, in which a steady voltage as of a battery E_1 and a modified saw-tooth wave E_2 of a generator 43 are both applied in series through marginal resistors 31, 31', to the photocathode terminals, their common point being grounded while the anode is returned to ground through a resistor 23 and a bias battery E_4 . For constant speed movement of the neutral point in this case the wave form of E_2 may be calculated as follows.

If E_1 =voltage of battery,

E_2 =voltage of modified saw-tooth generator,

Z_c =photocathode impedance,

Z_1, Z_2 =marginal impedances 31 and 31',

then, measuring from one end of the extended photocathode toward the other, the neutral point will appear at KZ_c , where

$$0 < K < 1$$

and K is determined by

$$E_1 \frac{(1-K)Z_c + Z_2}{Z_1 + Z_2 + Z_c} = E_2 \frac{KZ_c + Z_1}{Z_1 + Z_2 + Z_c} \quad (7)$$

or

$$E_2 = \frac{(1-K)Z_c + Z_2}{KZ_c + Z_1} E_1 \quad (8)$$

In this expression the factor K is to be obtained by modification of a saw-tooth voltage and is increased linearly with time over each saw-tooth cycle. Putting $K = K_1 t$, where K_1 is a constant factor,

$$E_2 = \frac{(1-K_1 t)Z_c + Z_2}{K_1 Z_c t + Z_1} E_1 \quad (9)$$

In particular, taking $Z_c = 10Z_1 = 10Z_2$,

$$E_2 = \frac{11 - 10K_1 t}{1 + 10K_1 t} E_1 \quad (10)$$

Any desired means, for example an arrangement similar to that heretofore described in connection with Fig. 4, may be employed to secure a voltage which varies with time in the required manner.

As in the case of Fig. 1, the saw-tooth electromotive force of the generator 43 of Figs. 4 and 7 by which movement of the neutral point is obtained is impressed, through the parasitic capacity between the photocathode 21 and the anode 22, as an electromotive force on the control grid of the tube 26 so that, where it not somehow neutralized it would appear as an undesired component at the output terminals 40. It may be neutralized by an arrangement similar to that described above in connection with Fig. 1, and schematically indicated in Fig. 4 by the inclusion in the cathode circuit of the tube 26 of a generator 44 of a wave form related to that of the generator E_2 and coupled therewith to

maintain synchronism. Unlike the arrangement of Fig. 1, however, the electromotive force of the generator 43 is not impressed on the grid of the tube 26 directly, but only through the comparatively high impedance of the parasitic capacity between the photocathode 21 and the anode 22. Therefore, the amplitude of the compensating generator 44 may be greatly reduced as compared with that of the scanning generator 43.

Fig. 8 shows an arrangement by which the neutral point scanning of the invention may be applied to the scanning of a whole field or surface image as distinguished from a line image. As more clearly shown in Fig. 9, the photocathode is a continuous filament or strip 21, bent back and forth to form a field net on which the image as a whole may be focused. The collector 22 is a plate mounted behind the photocathode net. The scanning action, which may be secured in accordance with any of the circuit arrangements hereinabove described, the arrangement of Fig. 4 being shown merely by way of example, moves the neutral point along the continuous photocathode strip, effecting both horizontal and vertical scanning together without the necessity for separate means for effecting line-by-line movement of the image across the photocathode strip. The resulting signal is a vision integral signal as before, but the integration is now carried out over the full length of the net, or from one end of the image frame to the other. Care must, of course, be exercised in the design of the differentiating circuit to insure that it shall be able correctly to restore this integral signal to a conventional vision signal.

As stated above, the photocathode and the collector anode may be interchanged from the potential standpoint; that is to say, the former may be at uniform potential and the latter may sustain the voltage gradient. This interchange may be made in the apparatus of Fig. 1 and Fig. 4 without further structural change. In Fig. 8 it is necessary that the collector have the form of a net, in which case the photocathode may be a plate. In any case, care must be exercised to assure that the impedance of the collector be not excessive, otherwise spurious voltage drops due to the collected electron current will appear on it and modify its potential in such a way as to produce distortion of the signal.

In addition to the means described above for producing the voltage drop along the gradient-supporting electrode, the potential difference between it and the other electrode, and the progressive movement of the neutral region, various other means are possible. For example, the battery E_1 and the saw-tooth voltage E_2 of the generator 4 of Fig. 1 may be replaced by an unmodulated carrier frequency generator and a carrier frequency generator modulated with a saw-tooth scanning voltage, respectively. Corresponding modifications are possible with the arrangements of other figures. Such modifications form parts of the subject-matter of copending application Serial No. 396,521, filed June 4, 1941.

Again, movement of the neutral point may be effected without directly impressing any electromotive forces as such on the scanning electrodes. For example, one or other of these electrodes may form an element of a bridge network which balances at the neutral point, while the latter is caused to move along the electrode by variation of some other bridge element. Modifications of this type form parts of the subject-matter of another

application, namely Serial No. 396,522, filed June 4, 1941. Further modifications within the scope of the appended claims will occur to those skilled in the art.

What is claimed is:

1. Image signal translating apparatus which comprises an envelope, an extended photocathode element within said envelope, a collector anode element within said envelope in position to intercept photoelectrons emitted by said photocathode, at least one of said elements being capable of supporting a substantial uniform longitudinal voltage gradient, the other of said elements being constructed to remain substantially at a uniform potential despite the flow of current therein, said photocathode element being disposed to have a line of a field of view imaged upon it to cause electron emission from the various points thereof in accordance with the light tone values of corresponding points of said line image, means for producing a voltage gradient along the length of said first-named element, which gradient is substantially uniform throughout said length, means for causing said uniform potential element to successively adopt the potentials of successive points of said gradient-supporting element, which potentials are intermediate the potentials of the extremities of said gradient-supporting element, and means for utilizing current drawn from one of said elements.

2. An image signal translating device which comprises an evacuated envelope, an extended photocathode element mounted within said envelope and an extended collector anode element mounted within said envelope in parallel disposition to said photocathode element, at least one of said elements offering a comparatively high resistance to the flow of electric currents along its length, means for causing a direct current to flow lengthwise of said resistance element to produce therealong a uniform gradient of substantial magnitude, and means for causing the other of said elements to successively adopt potentials intermediate the potentials of the extremities of said gradient-supporting element.

3. An image signal translating device which comprises an envelope, an extended photocathode element mounted within said envelope, an extended collector anode element mounted within said envelope in parallel disposition to said photocathode element, one of said elements being constructed to support a substantial longitudinal voltage gradient when traversed by unvarying electric currents, the other of said elements being constructed to remain substantially at uniform potential despite the flow of electric currents therein, means for causing a direct current to flow lengthwise of said gradient-supporting element to produce therealong a uniform potential gradient of substantial magnitude, and means for causing the other of said elements to successively adopt potentials intermediate the potentials of the extremities of said gradient-supporting element.

4. Image signal translating apparatus which comprises an extended photocathode element, means for illuminating different portions of said photocathode element to cause electron emission therefrom in accordance with the illumination thereof, an extended anode disposed to intercept electrons emitted from said photocathode, at least one of said elements being capable of supporting a substantial uniform longitudinal voltage gradient, means for applying a voltage to the terminals of said last-named element to produce said longitudinal voltage gradient, means for ap-

plying another voltage between said two elements such that some parts of said first-named element are at potentials higher than said second-named element while other parts are at lower potentials than said second-named element, means for varying one of said voltages to sweep a region at which the potentials of said elements are alike along the length of said gradient-supporting element, and means for utilizing currents drawn from one of said elements.

5. Apparatus of the type defined in claim 4 wherein said photocathode element is constructed to support a uniform voltage gradient along its length and said collector anode element is constructed to remain substantially at a uniform potential despite the flow of electric currents therein.

6. Apparatus of the type defined in claim 4 wherein the first-named voltage is a steady voltage and the second-named voltage is of sawtooth wave form.

7. Apparatus of the type defined in claim 4 wherein the first-named voltage is of a sawtooth wave form so modified that the voltage rise during each cycle is inversely proportional to time, and the second-named voltage is a steady bias.

8. Image signal translating apparatus which comprises an extended photocathode element, means for illuminating different portions of said photocathode element to cause electron emission therefrom in accordance with the illumination thereof, an anode element disposed to intercept photoelectrons emitted from said photocathode element, means for causing said photocathode element to sustain a uniform longitudinal voltage gradient, means for causing said anode to successively adopt the potentials of successive points of said photocathode element, which potentials are intermediate the potentials of the extremities of said photocathode element, and means for utilizing currents drawn from said anode.

9. Image signal translating apparatus which comprises an extended photocathode element, means for illuminating different portions of said photocathode element to cause electron emission therefrom in accordance with the illumination thereof, an extended anode element disposed to intercept electrons emitted from said photocathode element, means for biasing said anode below a collection threshold, means for applying a uniform voltage to the extremities of one of said elements to provide a voltage gradient along its length, means for applying another voltage between said anode and said photocathode to overcome said bias at points of said cathode other than a boundary point, said other voltage having a wave form such that said boundary point moves along said photocathode under control of said last-named voltage, and means for utilizing currents drawn from said anode.

10. Apparatus of the type defined in claim 9 wherein said points at which said bias is overcome are all points between one end of said photocathode and said boundary point.

11. Apparatus of the type defined in claim 9 wherein the wave form of the last-named voltage is such that the boundary point moves along the photocathode at constant speed.

12. Image signal translating apparatus which comprises an extended photocathode element disposed to have a line of a field of view imaged upon it to cause electron emission from various points thereof in accordance with the light tone values of corresponding points of said line image,

an extended anode element disposed to intercept electrons emitted from said photocathode, means for applying a voltage to the terminals of one of said elements to produce a uniform voltage gradient along its length, means for applying 5 another voltage between said two elements, means for varying one of said voltages to sweep a region at which the potentials of said elements are alike along the length of said gradient-supporting element, and means for utilizing currents 10 drawn from one of said elements.

13. Image signal translating apparatus which comprises an extended photocathode element, an extended anode element disposed to intercept 15 electrons emitted from said photocathode, one of said elements being constructed of uniform voltage-gradient-supporting material and arranged in the form of a net extended in two dimensions, the other of said elements being 20 plate-like in form and constructed to remain substantially at a uniform potential, said net-like element being disposed to have a line of a field of view imaged upon it to cause electron emission from various points thereof in accordance with the light tone values of corresponding 25 points of said image, means for producing a voltage gradient along the length of said gradient-supporting element, which gradient is substantially uniform throughout said length,

means for causing said uniform potential element to successively adopt the potentials of successive points of said gradient-supporting element, which potentials are intermediate the potentials of the extremities of said gradient-supporting element, and means for utilizing currents drawn from said anode.

14. Electrostatic scanning apparatus comprising a first electrode, a second electrode disposed substantially parallel to said first electrode, a source of periodically varying potential, circuit connections from the terminals of said source to said electrodes, respectively, one of said electrodes being photoemissive and one of said electrodes being linearly extended and offering a high resistance to the flow of current there-through in the direction of said linear extent, and means for causing current to flow in said direction through said high resistance electrode to produce a longitudinal voltage gradient therein, the magnitudes of said high resistance and of said current and of the voltage gradient resulting therefrom being such as to cause a portion of said photoemissive electrode from which electrons are collected by the other electrode to increase progressively in extent as the potential of said source is varied.

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