

Dec. 1, 1942.

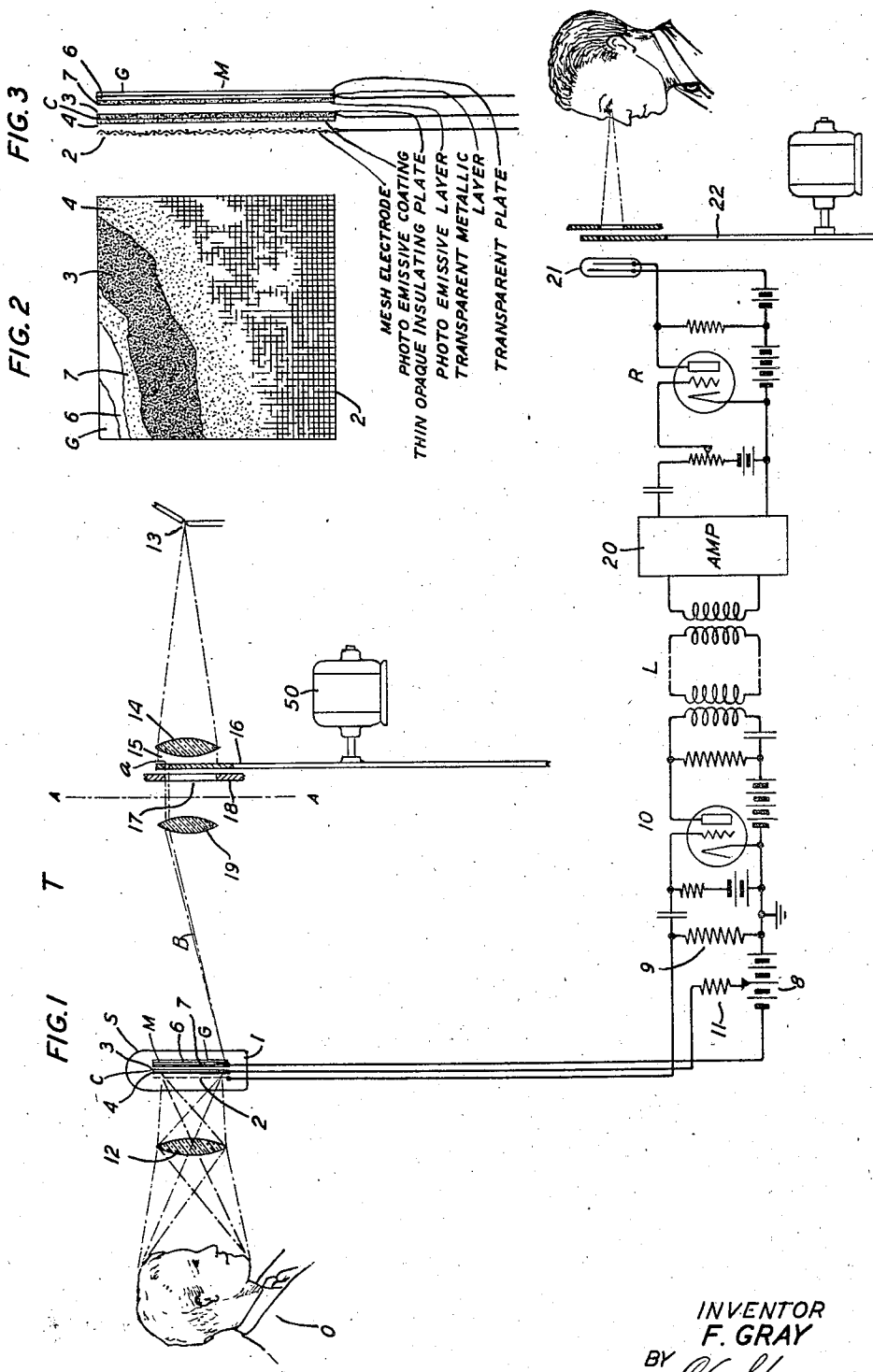
F. GRAY

2,303,930

ELECTRO-OPTICAL SYSTEM

Filed March 4, 1936

3 Sheets-Sheet 1



INVENTOR
F. GRAY
BY *C. Sprague*
ATTORNEY

Dec. 1, 1942.

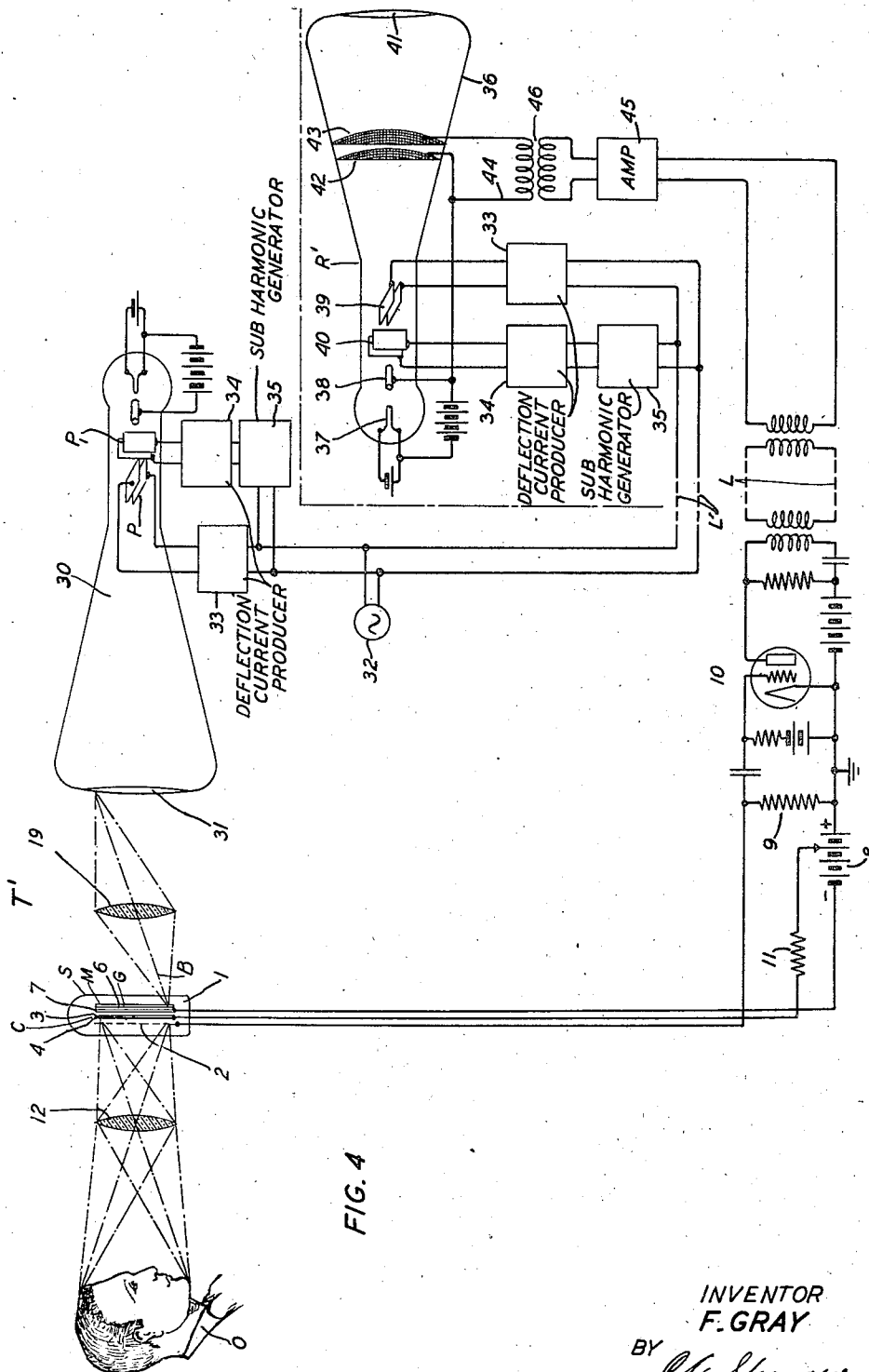
F. GRAY

2,303,930

ELECTRO-OPTICAL SYSTEM

Filed March 4, 1936

3 Sheets-Sheet 2



INVENTOR
F. GRAY

BY *C. Sprague*
ATTORNEY

Dec. 1, 1942.

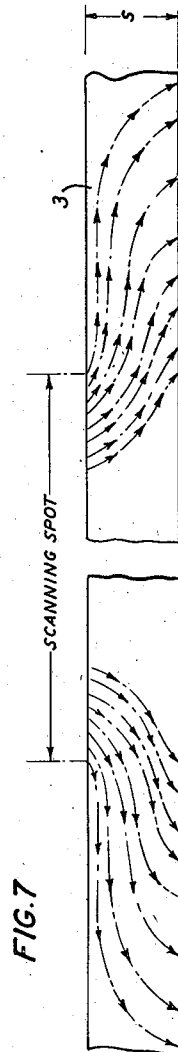
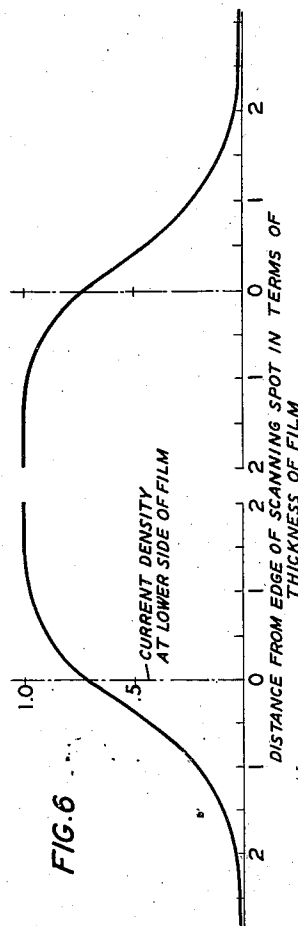
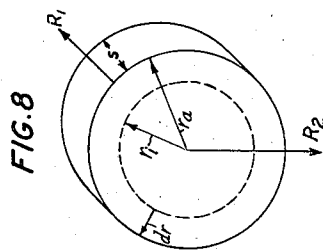
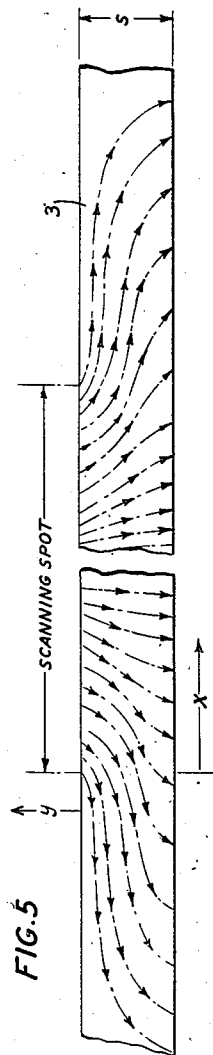
F. GRAY

2,303,930

ELECTRO-OPTICAL SYSTEM

Filed March 4, 1936

3 Sheets-Sheet 3



INVENTOR
F. GRAY
BY *C. Sprague*
ATTORNEY

UNITED STATES PATENT OFFICE

2,303,930

ELECTRO-OPTICAL SYSTEM

Frank Gray, New York, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application March 4, 1936, Serial No. 67,657

12 Claims. (Cl. 178—7.2)

This invention relates to electro-optical systems and more particularly to means for setting up current variations representative of the various light-tone values of an object, as in television scanning.

It has been proposed heretofore, in transmitting an object to a distant station, to scan the object itself with a moving beam of light. Each element of the object, therefore, receives light from the scanning beam for only a very short period of time so that the photoelectric current produced by the light reflected from the object is relatively small. To remedy this situation, it has also been proposed to continuously illuminate the entire image field and reflect the light variations onto one surface of a light sensitive target or screen located in a specially constructed cathode ray tube, the cathode ray of the tube being adapted to scan the surface of the screen with a pencil of electrons. Due to the fact that the light sensitive screen must be placed within the cathode ray tube in order to utilize for scanning purposes the moving pencil of electrons constituting the cathode ray beam, the special cathode ray tube is very expensive and as these tubes must be replaced frequently, this expense is no small item.

It is an important object of this invention to provide a novel, compact and relatively inexpensive light sensitive electric unit toward which an image of the entire object is directed and which is scanned by a moving beam of radiant energy from a source without the container enclosing the unit.

A further object is to provide a novel means for translating light variations into electric current variations, as for example in the production of image currents in television systems, making use of a relatively thin plate-like element of photo-emissive material for generating a moving beam of electrons for scanning another photo-emissive element upon which the light variations are impressed.

A further object of this invention is to provide a novel supporting member for a light sensitive electric element which permits a flow of current therethrough with negligible lateral spreading.

These objects are accomplished in the preferred embodiment of the invention, which is herein-after described in detail, by providing a scanning device comprising a gas-tight container enclosing a mesh electrode, a screen or target comprising a thin, high resistance supporting plate having its face adjacent the grid coated with a layer of photo-emissive material, and a

scanning control member comprising a transparent plate closely adjacent the supporting plate and carrying on its face adjacent this plate a transparent metallic layer or film carrying a layer of photo-emissive material. Associated with this device and in front thereof is an optical system for directing radiations from a complete field of view through the interstices of the mesh electrode onto the photo-emissive coating of the high resistance supporting plate, whereby the elemental areas of this coating are activated in accordance with the light-tone values of corresponding elemental areas of the field of view. On the opposite side of the device, that is, beyond the rear face of the transparent plate and outside the container, there is provided means for producing a moving beam of radiations which beam traverses in succession elemental areas of the photo-emissive layer carried by the transparent plate, whereby this layer is activated to cause the production of an intense moving beam of electrons which scans in succession the corresponding elemental areas of the photo-emissive coating carried by the high resistance supporting plate. The transparent metallic conducting film is connected to the fine mesh electrode by an external circuit including in series a direct current source and a resistance. The electronic scanning beam operates to cause small areas of the photo-emissive coating to emit, in succession, electrons corresponding to the intensity of the radiations received from the respective elemental areas of the object or field of view, whereby there is caused to flow, through the external circuit and the resistance included therein, an image current which is representative of the light-tone values of the various elemental areas of the field of view. The resistance may be connected to the input circuit of an amplifier having its output circuit connected to a transmission circuit or radio system. The moving beam of radiations for controlling the production of the electron scanning beam may be produced by an optical means including an apertured scanning disc associated with a suitable light source. A cathode ray tube may be used for this purpose, in which case such tube may be, and is preferably, a separate entity from the apparatus including the target or screen, its associated electrode and the photo-emissive scanning member.

The invention will be more readily understood by referring to the following description taken in connection with the accompanying drawings forming a part thereof, in which:

Fig. 1 is a diagrammatic representation of a television system involving this invention;

Fig. 2 is a detail view of the assembly within the scanning tube;

Fig. 3 is a side view of the assembly of Fig. 2;

Fig. 4 diagrammatically illustrates a second television system involving the invention;

Fig. 5 diagrammatically illustrates the lateral spreading of current in the case where the current admitted to a thin film is free to emerge over the entire opposite side of the film;

Fig. 6 shows the relation between current density and distance from the edge of the scanning spot for the situation of Fig. 5;

Fig. 7 diagrammatically illustrates the lateral spreading of current in the case where the current admitted to a thin film cannot emerge over the area directly opposite, but can emerge over the entire remaining portion of the opposite side of the film; and

Fig. 8 represents a portion of the thin film covered by the scanning spot at any instant.

Referring more specifically to the drawings, the system of Fig. 1 comprises a television transmitter T, suitable connecting means L, and a receiving station R.

The transmitting station T includes a scanning device S, an optical system for forming an image of an object or field of view O on a coating of photo-emissive material forming an element of a target or screen C in the scanning device S, and optical means for producing a moving beam of radiations for scanning a photo-emissive layer I of a composite plate or scanning control member designated as M, the scanning control member M being also located in the scanning device S.

The scanning tube S comprises a gas-tight container 1 enclosing, as shown in greater detail in Figs. 2 and 3, an assembly including a fine mesh or other light transmitting anode 2 of nickel gauze or other suitable material, a composite screen or target C, and a scanning control member M. The electrode 2 and members C and M are of substantially the same size and are mounted parallel to each other with a very small space between the members C and M. The distance between these members is preferably of the order of the dimensions of an elemental area defined by the size of the scanning spot. The composite target or screen C, upon which an image of an object or field of view O is formed, preferably comprises a high resistance insulating plate and supporting member 3 having a coating 4 of photo-emissive material, which coating is adjacent the mesh electrode 2. The supporting plate 3 is quite thin and comprises a material of very low conductivity, practically an insulator, so that the lateral conductivity (along the plate from elemental area to elemental area) is low compared to the conductivity through the plate over an elemental area. This property will be discussed more fully below. This plate 3 may consist of conducting glass, that is, glass which is slightly conducting, or ordinary glass impregnated with metallic particles, or other suitable high resistance material such as an alloy of mica and copper. The photo-emissive coating 4 may consist of a thin layer or film of atomic thickness consisting of any suitable photo-emissive material, such, for example, as is employed in commercial caesium, potassium, or sodium photo-electric cells. The plate 3, which is opaque, may be cross-hatched with closely spaced lines or otherwise treated to decrease its lateral conductivity from elemental area to elemental area.

However, if this plate is sufficiently thin, no special precautions need be taken to thus decrease its lateral conductivity.

In order to fully understand how lateral conductivity may be made negligible by making the film 3 very thin, two cases of current flow through a thin film will be considered.

The first case or example illustrates the situation where current is admitted over only an elemental area on one side of the film and is free to emerge over the entire opposite side of the film, as shown in Fig. 5. The lateral spreading of current in the film thus causes an effective diffusion of the elemental area. If the film is thin compared to the diameter of the elemental area, the spreading is approximately the same as if the perimeter were a straight line. Let it be assumed that s is the thickness of the film and that x and y are coordinates measured from the edge of the elemental area along the film and transverse to the film, respectively, as shown in Fig. 5. There are two conjugate potentials ϕ and ψ which define the flow of current in the film and which obey the equations

$$e^{ax} \cos ay = \sin b\phi \cosh b\psi \quad (1)$$

$$e^{ax} \sin ay = \cos b\phi \sinh b\psi$$

where

$$a = \frac{\pi}{2s}, \quad b = \frac{\pi}{2v}$$

v is the potential drop across the film, the curves ϕ constant are equipotential lines, and the curves ψ constant are lines of current.

It thus follows that the current density at the lower side of the film (the side adjacent the photoelectric film 4) is given by

$$D = \frac{kv}{s} \frac{e^{ax}}{\cosh(\sinh^{-1} e^{ax})} \quad (2)$$

where D is the current density and k is the conductivity of the material.

In Fig. 6, this current density is plotted for various distances from the edge of the elemental area, the distance being given in terms of the film thickness s . It is seen by examining the curve shown in Fig. 6 that the flow of current is substantially confined within a region extending about twice the film thickness beyond the edge of the elemental area. The diffusion of a spot due to lateral conductivity will, in the case under consideration, be about equal to twice the film thickness. For a film whose thickness is, for example, one-tenth the diameter of an elemental area, this will not be a serious amount of spreading.

For the case under consideration, the shape of the lines of current flow is independent of the conductivity of the material, for the Equations 1 do not contain the conductivity k of the material. The spreading is thus independent of the material and depends only on the thickness of the film.

The second and more critical case arises when current is admitted over only an elemental area on one side of the film and cannot emerge over the area directly opposite (as this area corresponds to a dark spot on the object), but can emerge over the entire remaining portion of the latter side of the film, as shown in Fig. 7. In this case, it is important that the current be small, for, under ideal conditions, there would be no flow of current.

An idea of the required constants of the film may be obtained in the following manner. With

reference to Fig. 8, let r_1 be the radius of the elemental area over which current is admitted and let r_2 be the radius of a portion of the film inside of this elemental area. Then, the resistance from the latter region to the region outside of the elemental area is less than the lateral resistance of the ring-like section of the film. The ring-like section will have a lateral resistance equal to

$$R_2 = \int_{r_1}^{r_2} \frac{\rho dr}{2\pi r s} = \frac{\rho}{2\pi s} \log \frac{r_2}{r_1} \quad (3)$$

where ρ is the specific resistance of the film and s is its thickness. When current can emerge directly opposite, the resistance through the film is

$$R_1 = \frac{\rho s}{\pi r_1^2} \quad (4)$$

Inasmuch as it is desirable to limit the lateral flow of current, the resistance R_2 must be so large that the current flow is limited because of the large potential drop across this resistance. If E is the series electromotive force, the maximum current that can flow from the region of radius r_1 is

$$i = \frac{E}{R_2} \quad (5)$$

Suppose that it is demanded that i be one-tenth of the total normal current from an elemental area when

$$\frac{r_1}{r_2}$$

is equal to 0.9. Then taking the normal current as 10^{-10} amperes which is a reasonable and practical value for television currents, and taking E as 10 volts, it is seen that R_2 should be about 10^{12} ohms. This can be expressed as

$$\frac{\rho}{2\pi s} \log \frac{1}{.9} = 10^{12} \quad (6)$$

For a film 2.5×10^{-3} cm. thick, this requires that

$$\rho = 3.44 \times 10^{11} \text{ ohms/cm.}^3 \quad (7)$$

With the above constants, the current from the inner region is 0.10 of the normal current, the current from the ring-like region is about 0.19 normal (ratio of the area of the ring-like region to the area of the elemental region), and the total spurious leak is about 0.29 of the normal current from an elemental area.

This spurious leak may be further reduced by using a higher resistance material. A higher electromotive force will also demand a higher specific resistance. In general, then, a material having a specific resistance of the order of 10^{12} ohms/cm.³ will be desirable for satisfactory operation for a picture current of 10^{-10} amperes. If a current of 10^{-6} amperes is obtained, the specific resistance of the material need only be of the order of 10^8 ohms/cm.³. It should be understood, however, that these figures are only examples and are not limits.

Summing up, it is clear that the film 3 should be of very high specific resistance to reduce the lateral flow in the second case (Fig. 7) and sufficiently thin with respect to the size of the scanning spot to reduce the lateral flow to a relatively small amount in the first case (Fig. 5). The thinness of the film also tends to reduce the degree of specific resistance required with reference to the second case. The specific resistance should not be too high, however, as the operation of the device depends upon the conduction of electrons transversely therethrough. It will be appreciated that with so many vari-

ables, it is difficult to set a definite value of specific resistance for the film 3 which will cover all cases but it can be stated as a rough guide that the specific resistance of the material should preferably lie within the range from 10^1 to 10^3 times the reciprocal of the average image current. The film thickness should be preferably one-tenth or less of the size of the scanning spot.

The scanning control member M has for its function the generation of a moving beam of electrons which beam is used to scan the successive elemental areas of the composite target or screen C. This moving beam of electrons is preferably generated by a moving beam of light produced by an apparatus outside the scanning device S. The scanning control member M preferably comprises a glass plate G on which is mounted a transparent metallic film 6 of silver or similar metal, on which is mounted a non-conducting, photo-emissive layer 7 of atomic thickness. By making the photo-emissive coatings or layers very thin, there is emission only from the elemental area being scanned as the layer is thus made substantially non-conducting laterally thereof. Another way this can be done is to make the layer of a number of discrete globules.

The conducting transparent metallic layer 6 is connected to the electrode 2 by an external circuit, including a battery 8 in series with a resistance 9. The latter is included in the input circuit of an amplifier 10. The negative terminal of the battery is connected to the transparent metallic layer 6, and an intermediate point thereof is connected through an extremely high resistance 11 to the opaque resistance plate 3, whereby this plate is positively polarized with respect to the transparent metal backing 6 of the photo-emissive layer 7, and somewhat negatively polarized with respect to the electrode 2, the positive terminal of battery 11 being connected through the resistance 9 to the anode 2. The arrangement is operative, however, if the connection from the intermediate point of the battery 8 is omitted, the plate 3 then tending to assume a potential intermediate that of the transparent metallic layer 6 and the mesh electrode 2.

The object or field of view O is illuminated by a source of radiations (not shown) and an optical system represented generally by the lens 12 gathers radiations reflected by the object or field of view O and directs them through the interstices of the electrode 2 upon the photo-emissive coating 4 of the supporting plate 3. The elemental areas of the coating 4 are thereby illuminated in accordance with the tone values of corresponding elemental areas of the field of view O. There will be some electronic emission to the mesh electrode 2, but because of the low capacity between the coating 4 and the mesh electrode 2, a static condition is quickly reached. Due to the high lateral resistance of the plate 3, no more electrons will flow to the mesh electrode 2 except those later released under the influence of the scanning control member M.

Associated with the device S is a second optical means adapted to control the operation of the photo-emissive scanning control member M which optical means may comprise a source of radiations 13, a lens system, represented generally by a lens 14, for gathering radiations from the source 13 and applying them in the form of a beam 15 toward a rotating disc 16 provided with a series of apertures a arranged near its periph-

ery in the form of a spiral through which, one at a time, a portion of the beam 15 passes. This optical system is aligned with the assembly of the scanning tube or device S and the apertures *a* serve to produce a moving beam of radiations B, of small dimensions compared with that of the beam 15, which passes through an opening 17 in an opaque mask or shutter 18 and a lens system, illustrated generally by a lens 19. As the disc rotates, the moving beam of radiations B is caused to sweep in succession across parallel lines of the layer of photo-emissive material 7 of the scanning control member M. Opening 17 is of such shape and dimensions that light from only one aperture is permitted to emerge at a time and the disc 16 is driven by a motor 20 at such a speed that apertures *a* pass through the beam 15 and thereby control the production of the moving beam of radiations B which traverses, in succession, the unit lines of the layer 7, once per revolution and in a time interval within the period of persistence of vision.

The moving beam of radiations B passes through the transparent plate G and the transparent metallic layer 6 to successively scan elemental areas of the photo-emissive layer 7, which areas are thereby activated to emit electrons and, since the insulating plate 3 has a positive polarity with respect to the layer 7, there results a moving beam of electrons which scans the opaque high resistance plate 3. Because of the short distance between layer 7 and the resistance plate 3, the beam of electrons passes almost directly from the layer to the plate with practically no lateral spread and through that plate to the photo-emissive coating 4, each elemental area of which is thereby activated in succession to emit electrons to the more positive electrode or anode 2.

As each elemental area of the photo-emissive coating 4 is supplied with radiations corresponding to the brightness of a corresponding elemental area of the object or field of view O, the electron emission from this area of the coating is substantially proportional to the tone value of the object over that area. This is due to the fact that the high lateral resistance of the supporting plate 3 and of the photo-emissive coating 4 will prevent appreciable flow of current from any area other than that directly in front of the electron beam, which occupies a position corresponding to that of the moving beam of radiations B used to scan the photo-emissive layer 7. In order to insure that the electron emission from the coating 4 shall be proportional to the intensity of the radiations reflected from the elemental areas of the object or field of view, the intensity of the moving beam of radiations B should be such that the electronic emission from the photo-emissive layer 7, as the spot moves over it, is always greater than the emission from any of the corresponding areas of the photo-emissive coating 4 due to the radiations reflected from the object.

It will thus be seen that the moving beam of radiations B operates to control the flow of electrons within the scanning device in such manner that successive current impulses, respectively proportional to the tone values of corresponding elemental areas of the object or field of view, are supplied to the external circuit, and hence an image current is caused to flow through resistance 9.

After being raised to the desired power level by the device 10, which may comprise a multi-

stage amplifier, the image current is transmitted over the line L to a remote station including a receiver R. For line carrier or radio transmission, the amplified image current would be used to modulate a carrier current of the proper frequency for transmission.

Receiver R may comprise an amplifier 20, the output of which includes a glow lamp 21 which cooperates with a rotating disc 22, having a series of apertures arranged in a spiral and adapted to be driven in synchronism and in phase with the disc 16 at the transmitter, to produce an image of the object or field of view scanned at the transmitter. In the case of line carrier or radio transmission, the receiver would include means for detecting or demodulating the incoming modulator carrier wave to yield the image current, which would be supplied to the glow lamp either directly or after amplification if found necessary. Any suitable receiver may be used. For example, a satisfactory receiver is disclosed in U. S. Patent 1,728,122, September 10, 1929, to Horton, which may include a glow lamp of the type disclosed in U. S. Patent 1,918,309, July 18, 1933, to Weinhart, provided with a gas charge of the character disclosed in U. S. Patent 1,871,266, August 9, 1932, to Gray.

For maintaining the discs 16 and 22 in synchronism and in phase, any suitable system may be used, as, for example, that disclosed in U. S. Patent 1,999,376, issued to H. M. Stoller on April 30, 1935.

The television transmitting and receiving system shown in Fig. 4 differs from that described above mainly in regard to the means provided at the transmitter for producing the moving beam of radiations for scanning the photo-emissive layer 7 of the scanning member M and also as to the type of image producer used at the receiving station. It is to be understood that the transmitter of Fig. 1 may be used with the receiver of Fig. 4 or the transmitter of Fig. 4 uses in a system which used a receiver similar to that described in connection with Fig. 1.

The transmitter T' of the system shown in Fig. 4 comprises a cathode ray tube 30 of any well-known design which is substituted for the elements to the right of section line AA in Fig. 1. The cathode beam of the tube 30 is deflected in two directions at right angles to each other and at such relative speeds in the two directions that its fluorescent screen 31 is activated to produce a moving spot of light which preferably moves across the screen from one side to the other in successive parallel lines and to completely traverse the screen from top to bottom in a time interval within the period of persistence of vision.

Deflection of the beam in one direction is effected by means of the field between a pair of deflecting plates P produced by current having a saw-tooth wave form supplied to the plates, the production of this current being controlled by oscillations of line scanning frequency supplied by the oscillator 32 to the deflection-current producing device 33. Deflection in the other direction is effected by supplying a second pair of deflecting plates P₁ with a second current of saw-tooth wave form supplied by the deflection-current producing device 34, controlled by oscillations of image cycle frequency produced by a sub-harmonic generator 35 supplied with oscillations from the oscillator 32. Any suitable apparatus, such as that disclosed in U. S. Patent 1,613,954, January 11, 1927, to Knoop, may be used to produce the deflecting currents.

Radiations from the moving spot of light on the fluorescent screen are directed by the lens system generally represented by lens 19 through the transparent plate G and the transparent metallic layer 8 to scan successively the elemental areas of the photo-emissive layer 7 of the scanning member M, which operates to control the emission of electrons from the photo-emissive coating 4 of the high resistance plate 3 and hence the flow of an image current to the resistance 9, as described above in connection with Fig. 1, whence they are supplied after amplification by the device 18 to a transmission circuit and over a line L, or a line carrier or radio channel, to a distant receiving station which includes a receiver R'.

Receiver R' may include an amplifier 45 in case the image current is directly transmitted, or a demodulator and amplifier in case transmission is effected in accordance with line carrier or radio practice. It also includes a cathode ray discharge device 36 comprising a cathode 37 and an anode 38 for producing the cathode ray beam, two pairs of plates 39 and 40 for respectively effecting deflection of the beam in two directions at right angles to each other, a fluorescent screen 41, and a pair of control grids 42 and 43 connected by an external circuit 44 to which the image currents received over line L and amplified by the device 45 are supplied by means of a transformer 46. Auxiliary apparatus 33, 34 and 35, similar to that described in connection with the transmitter T' are also used in the receiving system R'. Devices 33 and 34 operate, as disclosed in the above-mentioned Knoop patent, to supply deflecting current of saw-tooth wave form to respective pairs of deflecting plates 39 and 40. The apparatus for producing the deflecting current is controlled by current of line scanning frequency received from the oscillator 32 at the transmitting station over a transmission line L'. In this manner, the cathode ray beam of the receiver R' is deflected in synchronism and in phase with the deflection of the cathode ray beam of the cathode ray discharge device 30 used for producing the scanning spot of light at the transmitter T'.

The cathode ray discharge device 36 operates in the following manner:

The control electrodes or grids 42 and 43 are closely adjacent each other in a position between the anode 38 and the fluorescent screen 41 and preferably comprise segments of a sphere, the centers of which are close to the centers of the deflecting fields produced by the plates 39 and 40. The grid 42 is maintained at substantially the same potential as the anode 38 and the signal potentials are applied to the grid 43 which may be negatively polarized with respect to the grid 42. The two grids, therefore, serve to define a very limited zone in which the signal potentials are effective for controlling the cathode ray beam, and this zone is substantially isolated from the equipotential section established between the anode 38 and grid 42, within which zone deflection of the beam is effected. In this manner, deflection of the beam is controlled by the field established between the pairs of plates 39 and 40 without being influenced by the signal potentials, and the signal potentials operate to control the velocity or number of electrons constituting the beam and hence the intensity of the excitation of the fluorescent screen, which determines the quality of the image produced, without causing the direction of travel of the electrons to be varied.

In other words, the two sets of elements for respectively controlling the deflection and intensity of the beam, each of which tends to interfere with the other and thereby cause loss of focus of the beam and distortion of the image, are so positioned and electrically controlled as to materially, if not completely, avoid such interference. For a more complete disclosure of the construction and method of operation of the image producing cathode ray discharge device 36, briefly described above, reference may be made to Patent 2,155,192, issued April 18, 1939, to J. B. Johnson.

In each of the systems described in connection with Fig. 1 and Fig. 4, there is provided a scanning tube S enclosing a screen adapted to be illuminated with radiations received from an object or field of view, an associated electrode, and a scanning member, combined with simple optical means for rendering the scanning member operative to effect scanning of the screen, and thereby control the production of an image current varying with the light-tone values of the object or field of view.

The radiations applied to the object and those constituting the scanning beam supplied by the source 13 or the cathode ray discharge device 30 may be wholly within, partly within and partly without, or wholly outside the visible portion of the spectrum. When invisible rays are used, suitable lenses and glass will be used so as to pass these radiations. It may also be advisable in such a situation to provide appropriate filters to exclude all except the radiations of the desired wave-length range. The object may be a human being or beings, an out-of-doors study, a motion picture film or any other suitable field of view.

Other changes may be made without departing from the spirit or principles of the invention as hereinbefore expressed, the scope of which is defined by the appended claims.

What is claimed is:

1. In an electro-optical system, an evacuated vessel enclosing a thin, high resistance conducting plate with a photoemissive surface coating, means for projecting an image of an object on said coating to cause emission of electrons therefrom and thereby place positive charges simultaneously on different areas respectively of said plate, and a light transmitting plate-like element having a photo-emissive surface adjacent said first plate and parallel thereto, the spacing between said last-mentioned surface and said first plate being so slight that when a bundle of electrons is emitted from any elemental area on said surface of said light transmitting element into said space it will pass to the geometrically opposite elemental area of said first plate without much spread, and means for scanning said second photo-emissive surface with a spot of light.

2. The combination with means for producing a moving beam of light, of a separate unitary structure comprising a gas-tight container having an element therein for receiving light from said traveling light beam and thereby setting up a beam of low-velocity electrons having a corresponding movement in a continuation of the path of the light beam, and a second element upon which said beam of low-velocity electrons impinges element by element made of poorly conducting material, said second element being generally parallel to said first-mentioned element and spaced therefrom by a distance which is small compared with any dimension of said first-mentioned element in a plane parallel to its face.

3. An image current producer comprising an

image illuminated screen comprising a thin, high resistance conducting plate with a coating thereon of photo-emissive material, means for scanning said screen with a beam of low-velocity electrons, and means for producing a moving beam of high velocity electrons for controlling the scanning of said screen by said low-velocity electrons.

4. An electro-optical transmitter comprising a screen including a thin, high resistance conducting plate with a coating thereon of photo-emissive material and means adjacent said screen for generating a beam of low-velocity electrons for scanning it, means for activating said screen with radiations controlled by an object or field of view, and means for producing a moving beam of light to control the operation of said first mentioned means.

5. A scanning apparatus for electro-optical systems comprising a thin, opaque, high resistance conducting plate adapted to transmit current transversely therethrough with substantially no lateral spread, a light sensitive electric coating for said opaque plate, means for producing an image of an object on said coating, means for producing a moving beam of light, and photo-emissive means substantially parallel to said opaque plate and activated by said beam of light for producing an electron beam for scanning the surface of said opaque plate remote from said coating.

6. A scanning apparatus for electro-optical systems comprising a gas-tight container enclosing a thin, opaque, high resistance conducting plate adapted to transmit current transversely therethrough with substantially no lateral spread, a photo-emissive coating for said plate, a scanning control member comprising a transparent plate, a transparent metallic layer, and a layer of photo-emissive material, an anode, and circuit connections between said anode and said transparent metallic layer.

7. A scanning apparatus for electro-optical systems comprising an evacuated container enclosing a thin, opaque, high resistance conducting plate adapted to transmit current transversely therethrough with substantially no lateral spread, a photo-emissive coating for said plate, a scanning control member comprising a transparent plate, a transparent metallic layer, and a layer of photo-emissive material, and an anode electrode, means for projecting an image of an object upon the photo-emissive coating of said opaque plate, and means producing a moving beam of light for activating successively the elemental areas of the photo-emissive layer of said scanning member for controlling the flow of electrons to said anode.

8. A scanning apparatus for electro-optical systems comprising an evacuated container enclosing a composite screen or target comprising a thin, opaque, high resistance conducting plate whose lateral conductivity is negligible with respect to its transverse conductivity, a photo-emissive coating for said opaque plate, a scanning control member comprising a transparent supporting plate, a thin, transparent metallic layer, and a layer of photo-sensitive material, and an anode, circuit connections between said anode and said transparent metallic layer so that the anode has a positive potential with respect to said scanning member, means for imparting a potential intermediate that of said anode and said scanning member to said opaque plate, means for projecting an image of an object upon the photo-emissive coating of said opaque plate, and means producing

a moving beam of light for activating successively the elemental areas of the photo-emissive layer of said scanning member for controlling the flow of a moving beam of electrons to said anode.

9. A scanning apparatus for electro-optical systems comprising a gas-tight container enclosing three elements substantially parallel to and spaced apart from each other, the first of said elements comprising a light transmitting member, the second of said elements comprising a thin opaque high resistance conducting plate adapted to transmit current transversely therethrough with substantially no lateral spread and a photo-emissive coating for said plate, said coating being adjacent said first element, and the third element comprising a transparent supporting plate, a metallic layer capable of transmitting light, and a layer of photo-emissive material, said layer of photo-emissive material being adjacent said second element.

10. A scanning apparatus for electro-optical systems comprising a gas-tight container enclosing three elements substantially parallel to and spaced apart from each other, the first of said elements comprising a light transmitting member, the second of said elements comprising a thin opaque high resistance conducting plate adapted to transmit current transversely therethrough with substantially no lateral spread and a photo-emissive coating for said plate, said coating being adjacent said first element, and the third element comprising a transparent supporting plate, a metallic layer capable of transmitting light, and a layer of photo-emissive material, said layer of photo-emissive material being adjacent said second element, a source of potential, a resistance, means for connecting the metallic layer of said third element to the negative pole of said source of potential, and means for connecting said first element through said resistance to the positive pole of said source of potential.

11. A scanning apparatus for electro-optical systems comprising a gas-tight container enclosing three elements substantially parallel to and spaced apart from each other, the first of said elements comprising a light transmitting member, the second of said elements comprising a thin opaque high resistance conducting plate adapted to transmit current transversely therethrough with substantially no lateral spread and a photo-emissive coating for said plate, said coating being adjacent said first element, and the third element comprising a transparent supporting plate, a metallic layer capable of transmitting light, and a layer of photo-emissive material, said layer of photo-emissive material being adjacent said second element, a source of potential, a resistance, means for connecting the metallic layer of said third element to the negative pole of said source of potential, means for connecting the said first element through said resistance to said positive pole of said source of potential, a second resistance, and means for connecting said high resistance conducting plate of said second element through said second resistance to a point on said source of potential intermediate said positive and negative poles.

12. A scanning apparatus for electro-optical systems comprising a gas-tight container enclosing three elements substantially parallel to and spaced apart from each other, the first of said elements comprising a light transmitting member, the second of said elements comprising a thin opaque high resistance conducting plate adapted to transmit current transversely there-

through with substantially no lateral spread and a photo-emissive coating for said plate, said coating being adjacent said first element, and the third element comprising a transparent supporting plate, a metallic layer capable of transmitting light, and a layer of photo-emissive material, said layer of photo-emissive material being adjacent said second element, a source of potential, a resistance, means for connecting the metallic layer of said third element to the negative pole of said source of potential, means for connecting the said first element through said resistance to said positive pole of said source of potential, a second resistance, means for connecting said high resistance conducting plate of said second element through said second resistance to a point on said source of potential intermediate said positive and negative poles, means for projecting an image of an object upon the photo-emissive coating of said second element through said first element, and means for activating successively the elemental areas of the photo-emissive layer of said third element with a moving beam of light through said transparent supporting plate and said metallic layer.

FRANK GRAY.