

Oct. 4, 1938.

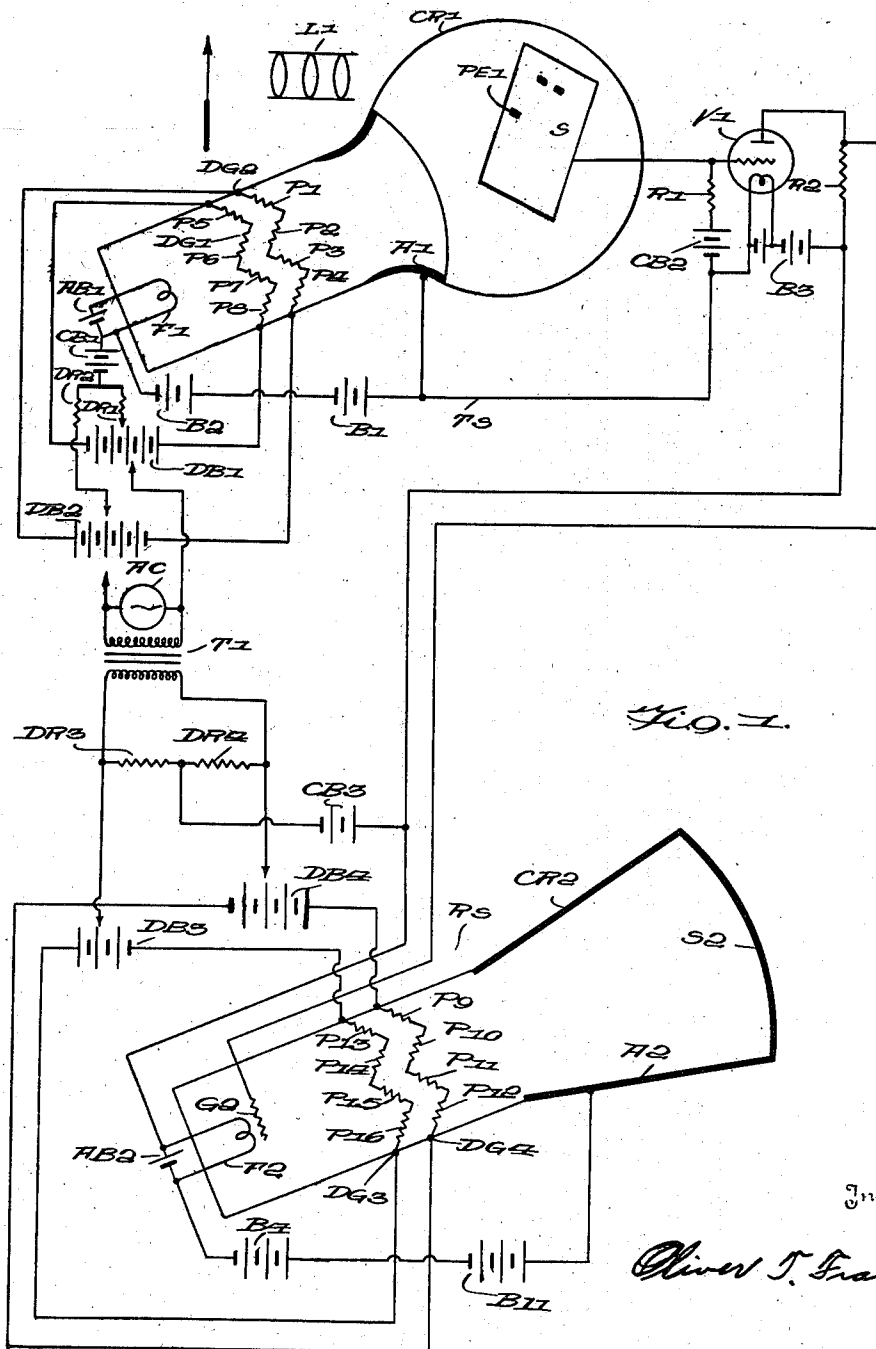
O. T. FRANCIS

2,131,886

TELEVISION SYSTEM

Filed Oct. 9, 1934

2 Sheets-Sheet 1

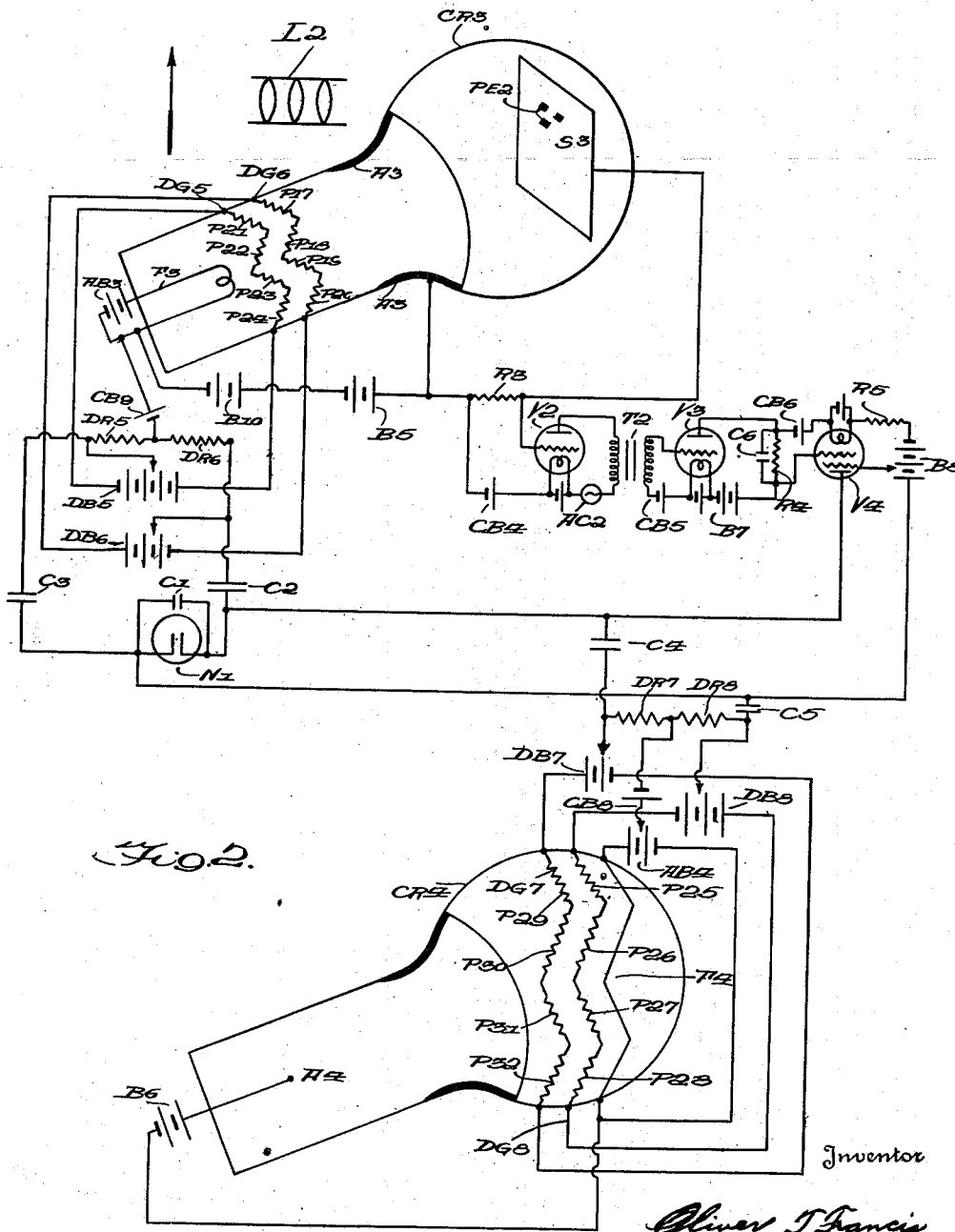


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2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

2,131,886

TELEVISION SYSTEM

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18 Claims. (Cl. 178—6.8)

This invention relates to cathode ray tubes and more particularly to a means for utilizing cathode rays in the transmission of pictures or similar intelligence, and to means for deflecting cathode rays.

Television apparatus heretofore provided includes the use of a cathode ray for scanning elemental areas at a transmitting station, a plurality of synchronizing voltages for maintaining synchronism between said cathode ray and a second cathode ray at the receiving station, and means for controlling the magnitude of said second cathode ray in accordance with the intensity of light impinging upon said elemental areas, thereby controlling the brightness of elemental areas of a fluorescent screen at a receiving station. Such systems have numerous disadvantages. The light available from the fluorescent screen is small and the color of the light is often objectionable.

It is one of the objects of this invention to utilize an incandescent body in place of the fluorescent screen, and to absorb energy from the elemental areas of said incandescent body to produce the picture.

Another object is to illustrate means for producing variations in light given off by elemental areas of a receiving incandescent screen by varying the space charge in the vicinity of said elemental areas, in accordance with light variations striking the elemental areas of a light sensitive screen at the transmitting station.

In U. S. Patent No. 1,819,599 issued to me August 18, 1931, means are illustrated of differentially applying an input voltage to a plurality of vacuum tubes, each having a plurality of control grids whereby space currents may be successively caused to flow from the cathodes to the anodes of said tubes. It is well known that the light given off by the cathode of a vacuum tube is determined by the energy absorbed by the space current flowing in said tube in accordance with the well known Einstein photo-electric equation, this principle being utilized in U. S. Patent No. 1,976,120 issued to me October 9, 1934. It is an object to utilize the basic principles of these two patents for controlling the light given off by elemental areas of a receiving screen.

It is often difficult to concentrate a cathode beam so that only the desired portions of the target are struck by electrons. Electro-static "lenses" have been used for this purpose. It is an object of this invention to illustrate a novel means for concentrating the electrons given off by a cathode into an electron beam, by a plu-

rality of deflecting grids in the path of said electrons, and means for controlling the position of said beam by differentially applying a voltage to said deflecting grids.

Another object is to control the path of a cathode beam in accordance with variations in potential of elemental areas in the path of said beam, the potential of said elemental areas being controlled by the magnitude of light falling on same.

Another object is to illustrate a vacuum tube having a plurality of grids wherein the illumination of different portions of the filament of said vacuum tube may be varied by differentially applying a signal voltage to said grids.

Cathode ray tubes in use today employ a small "window" or opening in front of the source of electrons to effectively obtain a point source of electrons. It is an object to illustrate means whereby such a point source may be moved to any desired portion of a cross-sectional area of said tube by application of a voltage differentially to a plurality of grids in said tube.

Another object is to illustrate novel means for controlling a variable speed scanning cathode ray, means for synchronizing said variable speed cathode ray with a second cathode ray at a receiving station, said controlling means being controlled by light falling on elemental areas in the path of said first cathode ray, and said second cathode ray controlling the light given off by elemental areas of said receiving station.

Another object is to illustrate a system of television wherein one variable magnitude synchronizing voltage is the only signal transmitted, the length of time said voltage remains constant at a predetermined magnitude governing the brightness of a predetermined elemental area at the receiving station.

Another object is to illustrate a variable speed scanning cathode beam wherein said speed is controlled by the magnitude of said beam.

Other objects of the invention will become apparent from the following description and appended claims taken in connection with the accompanying drawings wherein:

Fig. 1 is a diagrammatic illustration of the invention wherein synchronism is maintained between elemental areas scanned at transmitting and receiving stations by differentially applying a separate source of synchronizing voltage to deflecting grids in the path of cathode rays at said stations, the brightness of said elemental areas being determined by the magnitude of said rays.

Fig. 2 illustrates a similar means for deflecting cathode rays at a transmitting and receiving sta-

tion by a variable speed source of synchronizing voltage.

Referring to Fig. 1, transmitting station TS comprises a high vacuum tube CR1, having an anode A1, a cathode F1, a deflecting grid DG1 composed of resistances P5, P6, P7, P8, a deflecting grid DG2 composed of resistances P1, P2, P3, P4. P1, P2, P3, P4 (or P5, P6, P7, P8) are inside the tube and are all in the same plane, said plane being perpendicular to the electron beam passing from the cathode to the anode of said tube. These resistances are not necessarily at right angles to each other but must be close enough together to create an inhomogeneous field between F1 and S at all points in said plane, other than at one predetermined point. As shown in Fig. 1, DG2 is in a plane closer to the anode than the plane in which DG1 is located. In the present invention each grid may comprise small resistance wire wound around an insulated core, said core weaving back and forth in a plane perpendicular to the electron stream, and suspended at the points where the wires enter the glass envelope. Deflecting batteries DB1 and DB2 have been poled so as to cause current to flow through DG1 and DG2 in opposite directions. The center taps of these batteries have been connected to cathode F1 through deflecting resistances DR1 and DR2 respectively and a biasing battery CB1 which tends to place a negative charge on both of these grids. A source of alternating current AC is also connected to the center taps of DB1 and DB2, respectively. B1 impresses a high positive potential on anode A1. The target of CR1 comprises a mosaic consisting of photo-active elements PE1, a dielectric such as mica, or other insulating material used in the art for such purposes, separates these elements from a signal plate S. The grid of vacuum tube amplifier V1 is connected to the signal plate S. Load resistance R1 and biasing battery CB2 are connected between the grid and filament of V1, and battery B3 and resistance R2 are connected in the output circuit of V1. Light from the arrow is focused on photo-active elements PE1 by lens L1. Plate S has been arranged so that all photo-sensitive elements PE1 are at equal distances from the image.

At the receiving station RS, vacuum tube CR2 has an anode A2, a cathode F2, headed by an A-battery AB2, a control electrode G2, the potential of which is controlled by the IR drop across R2, deflecting grid DG3 composed of resistances P13, P14, P15, P16; deflecting grid DG4 composed of resistances P9, P10, P11, P12. Deflecting batteries DB3 and DB4 have been poled so as to cause current to flow through these deflecting grids in opposite directions. The center tap of these batteries are connected across secondary of transformer T1, the primary of which is connected across AC. Deflecting resistances DR3 and DR4 have been connected across secondary of T1, and the contact between these resistances has been connected to AB2, in order that AC may differentially vary the potential of DG3 and DG4. A C-battery CB3 has been connected so as to tend to impress a negative potential on both DG3 and DG4. B11 impresses a high positive potential on focusing anode A2. A fluorescent screen S2 is provided at the end of tube CR2 for observing the amount of deflection of the cathode ray, although a photographic plate or other indicating device known in the art may be used.

In operation when synchronizing voltage AC is

zero, the P4 portion of DG2, and the P5 portion of DG1 are so far negative as to block the flow of electrons through the upper and lower portions of tube CR1. Under such a condition the electron beam would proceed through the center of CR1 and strike the photo-active elements in the center of the photo-sensitive mosaic on S, discharging the positive charge which has accumulated thereon by reason of the light from arrow causing electrons to flow from photo-sensitive elements PE1 to anode A1. This discharging current is amplified by V1 and causes grid G2 of CR2 to tend to assume a positive potential with respect to filament F2. Since DB3 causes the P13 portion of DG3 to be negative and DB4 causes the P12 portion of DG4 to be negative with respect to filament F2 electrons will flow through the center of tube CR2 only and impinge upon the center portion of screen S2, and a bright spot will occur in the center of this screen.

If AC increases in such a manner as to throw a positive potential on DG1 and DG3, and a negative charge on DG2 and DG4, the P2, P3, P4 portions of DG2 will be so far negative as to block the electron flow through the lower portion of CR1, and P10, P11, and P12 portions of DG4 will be thrown so far negative as to block the flow of electrons through the lower portions of CR2, and the electron beam will impinge upon the upper part of screen S2. It is thus evident that the scanning of CR1 and CR2 will proceed in synchronism governed by the direction and magnitude of synchronizing voltage, AC, and the magnitude of photo-electric current from elemental areas of mosaic comprising PE1 to anode A1 will govern the magnitude of the electron beam striking S2. DG1, DG2, DG3 are shown in the present instance as in respective planes perpendicular to the cathode beams of CR1 and CR2 respectively. While in Fig. 1 only a four line picture would appear the number of lines could be increased by increasing the number of times these elements zig zag across the tube in their respective planes. The functioning of CR1 is further clarified by assuming a specific example. Assume DR1, DR2 each to be one megohm; P1 to P8 to be each ten thousand ohms; DB1, DB2 to be each 100 volts; CB1 to be 50 volts; AC to be 50 volts both sides of the zero line; B1, B2 to be of such value that the anode voltage is 750 volts; that the design of DG1, DG2 is such that they each have a control over the force exerted by A1 of ten, that is that they have a mu of 10. The central portion of each of these grids would then be minus fifty volts. Since mu equals 10, 500 volts of anode voltage would be neutralized by the minus fifty grid voltage and the force exerted upon the electrons at the cathode by the anode through the center of the tube would be as if 250 volts were impressed on the anode and no grids were present in the tube. At the top of the tube however P5 would be 100 volts negative which is beyond the anode current cutoff and consequently no anode current could flow through the top of the tube. Similarly no current could flow through the bottom of the tube. As the electrical axis is shifted along DG1, DG2 the anode field of force can penetrate only at the point of electrical axis. This fact that the anode field of force cannot penetrate to the cathode when any one of a plurality of control electrodes is biased past the current cutoff is clearly brought out by Fig. 1 of my U. S. Patent No. 1,819,599.

Referring to Fig. 2, vacuum tube CR3 has a cathode F3 heated by "A" battery AB3, an anode A3 upon which a positive potential is impressed by B5, a signal plate S3, from which photo-sensitive elements PE2 have been insulated in a manner similar to that described above. Light from the arrow is focused on these photo-sensitive elements by lens L2. Deflecting grid DG5, and DG6 composed of resistances P21, P22, P23, P24, and P17, P18, P19, P20 respectively, have been arranged in planes perpendicular to electron beam in CR3. Deflecting batteries DB5, and DB6 have been so poled as to cause current to flow through these deflecting grids in opposite directions. The center points of these deflecting batteries are connected through deflecting resistances DR5 and DR6 to cathode F3 through "C" battery CB9 which tends to place a negative potential on both of these deflecting grids. DR5 and DR6 in series have been connected across an alternating voltage source N1 C1 through C2 and C3 respectively. This alternating source of voltage differentially varies the potential of DG5 and DG6 with respect to cathode F3.

Impedance R3 has been connected between A3 and plate S3. Discharge currents between photo-electric elements PE2 to F3 are impressed upon the grid of V2 by R3, adding to the negative potential impressed thereon by "C" battery CB4. In the output circuit of V2 has been connected an alternating current source AC2, of comparatively high frequency and primary of transformer T2. The secondary of T2 is connected in the input circuit of V3. "C" battery CB5 impresses a negative potential on the grid of V3 and battery B7 and resistance R4 in parallel with condenser C6 are connected in the output circuit of V3, in order to impress a rectified voltage on the grid of V4, opposing the potential impressed thereon by "C" battery CB6. B8 and N1 C1 in parallel are connected in the output circuit of V4. A second grid of V4 has been connected to the filament of V4 through resistance R5 and a portion of B8 to limit the rate of charge of C1 to a predetermined value when R4 impresses a positive potential on the other grid of V4.

At the receiving station vacuum tube CR4, contains a cathode F4 zig zagging across the base of the tube, as a receiving screen. AB4 heats F4 to incandescence. A high positive potential is impressed on anode A4 by battery B6. Deflecting grids DG7 and DG8 are disposed in the path of the electron stream between F4 and A4, and may be wound around F4. DG7 is composed of resistances P29, P30, P31, P32, and DG8 is composed of resistances P25, P26, P27, P28. Deflecting batteries DB7 and DB8 are so poled as to cause current to flow through these grids in opposite directions. Deflecting resistances DR7 and DR8 are connected in series across AC source of voltage N1 C1 through condensers C4 and C5. C2, C3, C4 and C5 have been chosen of large capacity in order to offer little impedance to alternating current from N1 C1. Similarly DR5, DR6, DR7, DR8 have been chosen of considerable magnitude so as not to materially affect the frequency of alternating current generator N1 C1. The connection between DR7 and DR8 has been connected through a "C" battery CB8 to F4, which tends to impress a negative potential on both grids DG7 and DG8.

In operation when the cathode beam from F3 is falling upon the portion of PE2 receiving no light from L2, a pulsating current will flow from AC2 through primary of transformer T2, be rectified by V3 and impress a positive potential on

control grid of V4, permitting C1 to charge at a rate determined by the value of R5 and point where second grid is connected to B8. When this cathode beam strikes the brighter portions of PE2, a negative potential is impressed on the grid of V2, which blocks current from AC2 flowing through primary of T2, with the result that CB6 impresses such a negative potential on V4 as to prevent the further charge of C1. The electron beam then remains momentarily on these bright portions of PE2 until the electrons which have been released by the light from PE2 to A3 have been replaced by electrons from F3, when the negative potential impressed on the grid of V2 by R3 will be small enough to permit the charging of C1 to proceed at normal rate. When C1 has become charged N1 breaks down to discharge it. The alternating voltage generated across N1 is passed through condensers C2, C3, C4, C5, and differentially applied to the deflecting grids of tubes CR3 and CR4. Thus the electron beam at the receiving station moves in synchronism with that of the transmitting station and a bright spot on the transmitting screen will appear as a dark spot on the receiving screen.

Some of the novel features involved in this invention are: 1. Means for concentrating electrons liberated from a cathode into a beam by causing current to flow through a plurality of grids in the path of said beam in opposite directions. 2. Means for moving said cathode beam by differentially applying a variable source of voltage to two of said plurality of grids. 3. Means for varying the energy radiated by different portions of an incandescent body by varying the energy absorbed in electron emission from said portions. 4. A variable speed scanner voltage source for a cathode ray tube, comprising a relaxation circuit controlled by the space current of said cathode ray tube.

It is obvious that the invention may take widely different forms from those illustrated without departing from the spirit of the invention, and it is understood that the invention is to be limited in scope only by prior art and as described in the following claims.

What is claimed is:

1. In a vacuum tube device, a cathode, means for accelerating the electrons from said cathode in a predetermined direction, means for confining said electrons to a small stream and deflecting said electrons, said last means comprising a plurality of grids in the path of said electrons, means for causing current to flow through one of said grids in one direction, means for causing current to flow through a second of said grids in the opposite direction, control means for differentially varying the potential of said grids with respect to said cathode for deflecting said electron stream, according to a quantity to be observed, a screen upon which said electrons impinge, and means for indicating the portion of said screen struck by said electron stream.

2. In a vacuum tube device, a cathode, an anode, means for impressing a positive potential on said anode with respect to said cathode, means for confining the electrons from said cathode to a small stream and deflecting said electrons, said last means comprising a plurality of grids in the path of said electrons, means for producing a voltage drop along one of said grids in one direction, means for producing a voltage drop along a second of said grids in the opposite direction, a screen to be scanned by said stream and means for differentially varying the potential of said

grids with respect to said cathode, for directing said stream to different portions of said screen.

3. In a vacuum tube device, a screen comprising a cathode from which electrons are emitted, an anode, upon which a portion of said electrons impinge, a plurality of grids between said anode and said cathode for producing movement of the beam of electrons, means for producing a voltage drop along one of said grids to block the electron flow from one portion of said cathode to said anode, means for producing a voltage drop along a second of said grids in the opposite direction to block the electron flow from another portion of said cathode to said anode, a source of voltage to be observed, and means for differentially applying said voltage to said grids to change the portions of said screen from which electrons are blocked from flowing to said anode.

4. In a vacuum tube device, a screen comprising an electron emitting cathode of a vacuum tube, means for rendering said cathode incandescent, an anode in said tube, means for impressing a positive potential on said anode, a plurality of grids between said anode and said cathode for producing movement of the beam of electrons, means for confining to a predetermined small area the portion of said cathode from which energy is extracted by electrons proceeding from said cathode to said anode, said last means comprising means for impressing a negative charge on one of said grids in the vicinity of one portion of said cathode and a negative charge on a second of said grids in a different portion of said cathode, a signal voltage to be observed, and means for differentially varying the potential of said grids with respect to said cathode in accordance with said signal voltage, to vary the portion of said cathode from which energy is absorbed by said electrons.

5. In a television system, an object to be televised, a vacuum tube having an anode, a cathode and a plurality of grids, means for confining the electrons given off by said cathode to a small beam and for producing movement of said beam, said means comprising means for producing a potential drop along one of said grids in one direction, and means for producing a potential drop along another of said grids in the opposite direction, a mosaic comprising photo-sensitive elements insulated from each other in the path of said beam, means for removing electrons from said photo-sensitive elements to said anode, said last means comprising means for focusing light from said object on said elements, a source of variable voltage, means for scanning said mosaic with said beam, said last means comprising means for differentially varying the potential of said grids with respect to said cathode in accordance with said variable voltage, a receiving screen comprising elemental areas, and means for controlling the brightness of said elemental areas of said receiving screen in accordance with the number of electrons removed from corresponding photo-sensitive elements of said mosaic.

6. In a vacuum tube device, a screen comprising a cathode source of electrons, an anode upon which a portion of said electrons impinge, a plurality of grids between said anode and said cathode for controlling the portion of said screen from which said electrons are emitted, means for producing a voltage drop along one of said grids in one direction to block the electrons flowing from one portion of said cathode to said anode, means for producing a voltage drop along a second of said grids in the opposite direction to

block the electrons flowing from another portion of said cathode to said anode, a source of variable voltage, means for differentially applying said variable voltage to said grids with respect to said cathode to permit electrons from different portions of said cathode to flow to said anode, said source comprising a vacuum tube having an input and an output circuit, a gas discharge device shunted by a condenser connected in said output circuit, a signal voltage to be observed, and means for applying said signal voltage to said input circuit to prevent the charging of said condenser when said signal voltage exceeds a predetermined value.

7. In a television system, the combination with a transmitting and a receiving station of a cathode ray generator at each of said stations including a source of electrons, means at each station for forming said cathode rays generated into a beam and for producing movement of said beam, each of said means comprising a plurality of grids in the path of each of said beams and means for producing a potential drop along one of said grids in one direction and a potential drop along another of said grids in the opposite direction, a screen at each of said stations, means for moving said beams over the surfaces of said screens synchronously, said last means comprising a source of variable voltage, and means for applying said variable voltage to said plurality of grids at each of said stations differentially with respect to each of said sources of electrons, an object at said transmitting station, means for focusing an image of said object on said screen at said transmitting station, and means cooperating with said beams for obtaining by the agency of the beam at the transmitting station a current representing the brightness of that portion of the object corresponding to the position of the beams, and means for controlling said variable voltage by said current to produce a lingering of said beams over the various points of said screen corresponding to the brighter points of said image.

8. In a television system, an object, a transmitting station comprising a vacuum tube having an anode, a cathode, a plurality of deflecting grids between said anode and said cathode, a screen comprising a mosaic of photo-sensitive elements insulated from each other, means for liberating electrons from said elements to said anode, said means comprising means for focusing light from said object on said elements, means for concentrating electrons from said cathode into a beam, said last means comprising means for producing a potential drop along one of said grids in one direction and means for producing a potential drop along a second of said grids in the opposite direction, means for scanning said mosaic with said beam, said last means comprising a source of deflecting voltage, and means for differentially applying said deflecting voltage to said grids, said source of deflecting voltage comprising a second vacuum tube having an output circuit and a control electrode, a gas discharge device shunted by a condenser connected in said output circuit, means for producing a lingering of said beam over the brighter portions of said screen for a period of time depending on the magnitude of light from said object striking said portions, said last mentioned means comprising means for producing a voltage the magnitude of which varies in accordance with the magnitude of said electron flow from said cathode to said photo-sensitive elements being scanned and means for applying

said last mentioned voltage to said control electrode to bias said control electrode past the current cutoff of said second tube, a receiving station, a cathode ray indicating device at said receiving station, and means for controlling the position of said cathode ray by said deflecting voltage whereby an image of said object is produced by said indicating device.

9. In a vacuum tube device, a vacuum tube having an anode, a cathode, and a plurality of control electrodes, a plurality of paths for electrons to flow from said cathode to said anode, means for changing the route of most of said electrons from a first to a second of said paths, said means comprising means for varying the homogeneity of the electro-static field of said first path, said last means comprising means for producing a potential drop along each of said control electrodes in opposite directions, means for generating a variable voltage and means for applying said variable voltage differentially to said control electrodes each of said control electrodes being substantially perpendicular to each of said paths.

10. In a vacuum tube device, a cathode comprising a wire, means for rendering said wire incandescent, an anode for attracting electrons given off by said cathode, a plurality of grids in the path of said electrons, means for producing a voltage drop along one of said grids in one direction to block the flow of electrons from one end of said wire, means for producing a voltage drop along a second of said grids to block the flow of electrons from the other end of said wire, a source of voltage to be observed, and means for applying said source to said grids differentially to shift the point on said wire from which electrons are permitted to flow from said cathode to said anode.

11. In a signalling system, an electron tube comprising an incandescent screen, acting as a cathode, an anode, and means for controlling the electron emission from successive areas of said screen to lower the temperature of said successive areas to reproduce a signal on the screen, said means comprising grids whose differential potential controls the lowering of the temperature of the screen.

12. In a picture reproducing system, means for receiving picture and position signals, means for reproducing said picture comprising an electron tube having a screen shaped incandescent cathode, an anode, and grid members actuated by the picture and position signals to control the temperature of successive emitting areas of said screen to reproduce a picture thereon.

13. In a television receiver, means for receiving picture signals, means for converting the said signals into visible signal, comprising an envelope, an anode therein, an incandescent cathode there-

in, and means actuated by the picture signals to vary the electron emission from the cathode to reproduce a picture on said cathode surface.

14. In a television receiver, means for receiving picture signals, means for converting the said signals into a visible signal, comprising an envelope, an anode therein, an electron emitting light radiating cathode therein, and means actuated by the picture signals to vary the space charge in the vicinity of successive elemental areas of said cathode to control the amount of energy absorbed by electron emission from said successive elemental areas of said cathode, for producing a picture on said cathode surface.

15. In a television receiver, means for receiving picture signals, means for converting the said signals into a visible signal, comprising an envelope, an anode therein, an electron emitting light radiating cathode therein, and means actuated by the picture signals to vary the number of light quanta radiated from the successive elemental areas of said cathode for reproducing a picture on said cathode surface, said last means comprising means for varying the amount of energy absorbed from said successive elemental areas by electron emission.

16. In a picture receiver, means for receiving picture signals, means for converting said signals into a visible signal, comprising an envelope, an anode therein, an electron emitting light radiating cathode therein, and means actuated by the picture signals to vary the electron emission from the cathode to control the number of light quanta radiated from the various elemental areas comprising said cathode surface, for reproducing a picture on said cathode surface.

17. In a picture receiver, means for receiving picture signals, means for converting said signals into a visible signal, comprising an envelope, an anode therein, an electron emitting light radiating cathode therein, and means actuated by the picture signals to vary the electron emission from elemental areas of said cathode to control the predominate color of the light quanta radiated from the various elemental areas comprising said cathode surface, for reproducing a picture on said cathode surface.

18. In a television receiver, means for receiving picture signals, means for converting said signals into a visible signal, comprising an envelope, an anode therein, an electron emitting light radiating cathode therein, and means actuated by the picture signals to vary the space charge in the vicinity of successive elemental areas of said cathode to control the electron emission from said successive areas of said cathode, to reproduce a picture on said cathode surface.

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