June 28, 1938. D. GÁBOR 2,122,095

CATHODE RAY DEVICE

Filed July 13, 1937 2 Sheets-Sheet 1

Fig. 1.

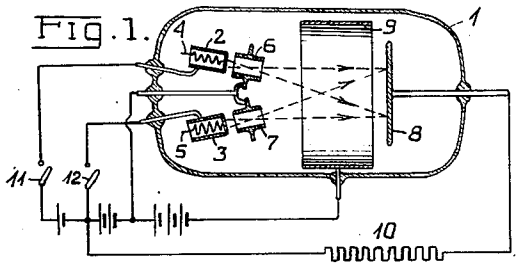


Fig. 2.

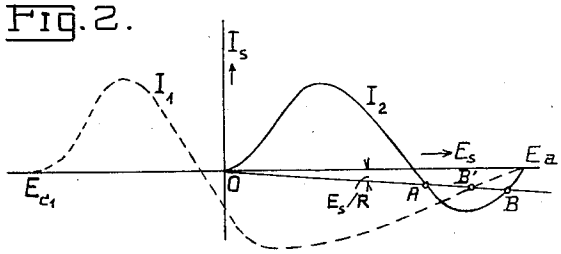


Fig. 3.

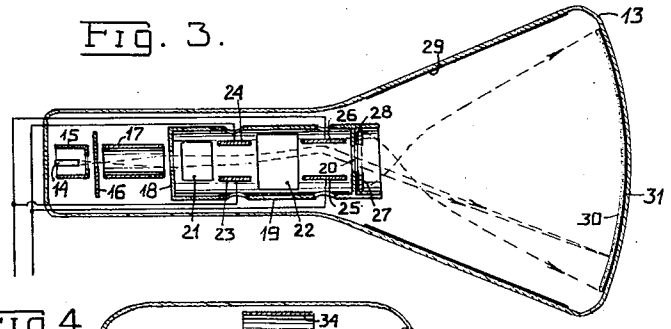


Fig. 4.

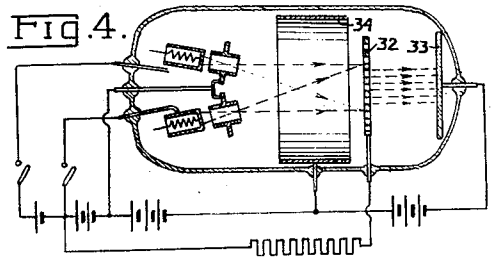
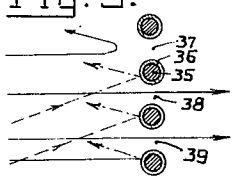


Fig. 5.



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Filed July 13, 1937 2 Sheets-Sheet 2

Fig. 6.

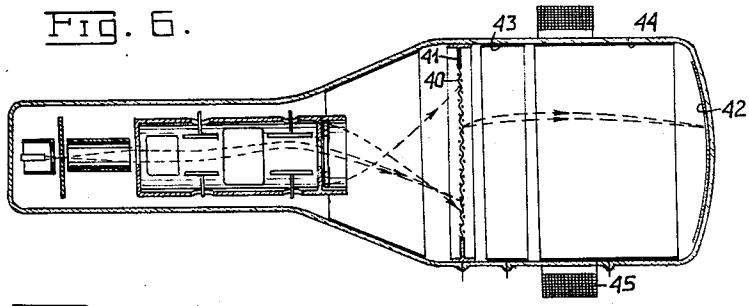


Fig. 7.

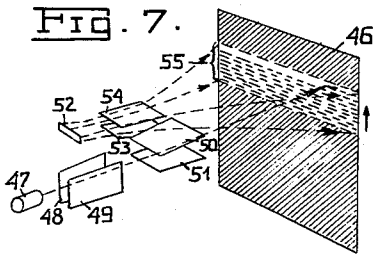


Fig. 8.

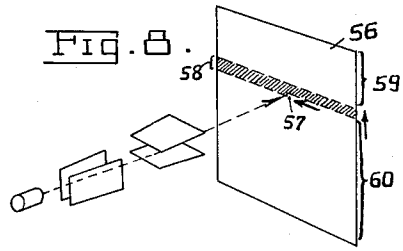


Fig. 9.

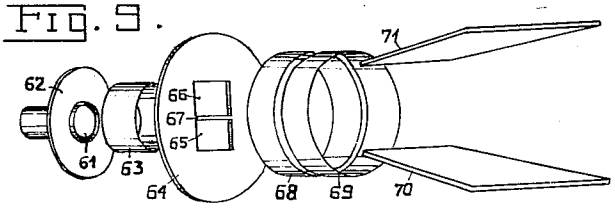
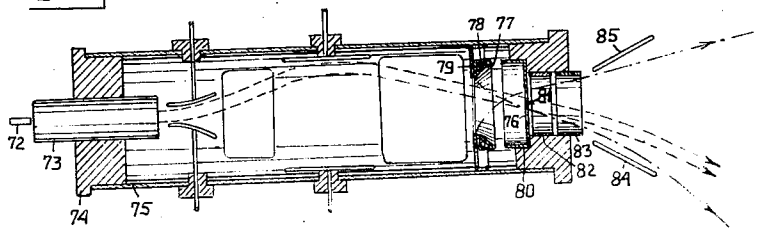


Fig. 10.



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Patented June 28, 1938

2,122,095

UNITED STATES PATENT OFFICE

2,122,095

CATHODE RAY DEVICE

Dénes Gábor, Rugby, England

Application July 13, 1937, Serial No. 153,412
In Great Britain June 4, 1936

28 Claims. (Cl. 250—27.5)

This invention relates to devices such as cathode ray oscillographs and cathode ray tubes for television, in which oscillograms or electrically transmitted pictures are recorded by a beam of electrons on a fluorescent screen or other recording member. The object of this invention is to provide a device by means of which a once described curve or picture can be made permanent, persisting until it is wiped out intentionally.

According to the invention an electron beam is utilized for opening a passage for another electron beam to a fluorescent screen, in such a way that the passage once opened remains permanently open. In the following the beam which opens the passage shall be called the first, or scanning, beam, whereas the beam for which the passage is opened shall be called the second, or broad, beam. The device according to the invention comprises means for producing two electron beams with different velocities, and a member with a surface covered with insulating or semiconducting materials, which are in themselves good emitters of secondary electrons or are covered with a mosaic of good secondary emitters. Thus elemental areas of the secondary-electron emissive surface can be maintained at different potentials, by means hereinafter described, and hence may be considered as charge-retaining. Both electron beams are directed towards the said surface. Means are provided to adjust its potential to such a level, that initially, in the absence of the first, or faster beam the electrons of the second or slower beam are repelled by it. According to the invention those parts or elements of said member which are hit by electrons of the first beam, are made by this to trip over into a second electric state with higher potential, in which second state the electrons of the second beam are admitted to the fluorescent screen. In one form of the invention the electrostatic controlling member of the kind described is itself used as a fluorescent screen, whereas in a second form the said member is perforated and serves for controlling the beam intensities on a fluorescent screen on which it is electron-optically imaged. In each case the potential pattern thus created on the said member may be considered as controlling the reproduction of the image by controlling the admission of electrons to the recording surface. It is an essential feature of the invention, that each part or element of said member operates discontinuously between two distinct electrical states, and that the process of tripping-over from the lower state into the upper state involves the emission of secondary electrons.

The novel features which I desire to protect herein will be pointed out in the appended claims. The invention may be best understood by reference to the following description and the accompanying drawings. In the drawings Fig. 1 shows a device for demonstrating the principle of the invention. Fig. 2 is a diagrammatical illustration of the processes involved. Fig. 3 shows one form of the cathode ray tube according to the invention, in which the electrostatic controlling member is itself a fluorescent screen. Fig. 4 shows a device by means of which a further application of the principle of the invention may be demonstrated. Fig. 5 is a diagrammatical illustration of the action of the perforated controlling member or "gate" utilized therein. Fig. 6 shows a second form of a cathode ray tube according to the invention, with separate controlling member or "gate" and fluorescent screen. Figs. 7 and 8 illustrate the application of cathode ray tubes according to the invention to television reception. Fig. 9 is a schematic representation of an electron-optical system to produce the second or illuminating beam in television tubes, and Fig. 10 shows a system, in which the means for producing the two electron beams are united in one construction.

In Fig. 1, which is a section of a device for demonstrating and explaining the principle of the invention, 1 is an evacuated envelope, 2 and 3 are two indirectly heated cathodes, for producing the first and the second electron beam respectively. 4 and 5 are heating filaments, 6 and 7 accelerating electrodes, which may have a common potential. 8 is a target on which both electron beams impinge, which may be thinly powdered with fluorescent substances, for visual demonstration of the effects in question. 9 is a collecting electrode or anode. The electrodes 2, 3, 6–7 and 9 are connected with successively increasing potentials, whereas the target 8 is connected with the same potential as the cathode 3, through a high resistance 10. Switches 11 and 12 are provided for connecting the cathodes to the battery and switching in the electron beams.

If the cathode 3 is switched in by itself, no current will flow to the target and no fluorescence appears on it, as its potential is the same as that of the cathode 3, and it repels all electrons. If however the cathode 2 is also switched in, provided that the potentials are suitably chosen, fluorescence appears on the tar-

get, which persists after the switch 11 is opened again.

This phenomenon can be best understood by reference to Fig. 2. In this diagram the voltage between the target and the cathode is called E_a and the current to the target I_a. A positive sign means electrons flowing to the target. In an equilibrium state the current flowing to the target must be equal to that leaking away through the resistance R, i. e. it must be $-E_a/R$. This is represented in the diagram by a straight line. The diagram contains further the characteristics which are obtained if one or the other of the cathodes is switched in, and the target is maintained at a potential E_a. I_1, shown as a dotted line represents the electron current flowing to the target if only the first cathode, (2) is switched in, the continuous line I_2 corresponds to the current from the second cathode, (3). Both curves have an S-shape, due to the secondary electron emission of the target, which sets in at a certain electron energy. The current becomes negative if more than one secondary electron is released for every impinging electron. Both curves reach zero again at or near the point E_a, which represents the potential of the collecting electrode or anode 9.

With only the second cathode working, equilibrium is possible only in the points O, A and B, in which the characteristic I_2 and the resistance line intersect. Of these three points A is unstable, whereas O and B are stable. If the cathode 3 is switched in by itself, the target will rest at the point O, at which it repels all electrons. If however the cathode 2 is switched in, the electrons emitted by it will impinge on the target with an energy corresponding to the voltage difference E_{c1} between the two cathodes. This energy is sufficient to release more than one secondary electron per impinging electron, that is, at a ratio greater than unity. The potential of the target will therefore rise until it reaches the point B' at which equilibrium is again established. This point is beyond the unstable point A. If therefore the beam emitted by the first cathode is switched off again, the second beam will shift the equilibrium point to B. In this condition the system is maintained for any time, until the second beam is switched off, and the leakage takes the system back to O.

Fig. 3 shows a longitudinal section of a cathode ray tube according to the invention, in which the above described arrangements and phenomena are utilized for obtaining on a fluorescent screen permanent records of passing electric signals. 13 is an evacuated envelope containing means for producing two electron beams of different velocities. One of these, the first and faster beam, is focussed on the fluorescent screen which is scanned by it in the usual way. This beam is produced by the cathode 14, modulated by the electrode 15, accelerated and focussed on the fluorescent screen in the usual way by the electrodes 16, 17 and 18 with successively increasing potentials. The last accelerating electrode 18 is connected with the tubular member 19, which contains the electrostatic deflecting electrodes. These are arranged in four pairs, in such a way, that the deflected beam passes through an aperture 20. Of the deflectors producing a deflection normal to the plane of the drawings only the plates 21 and 22 are visible. Deflection in the plane of the drawings is produced by the pairs 23—24 and 25—26, which are cross-connected in such a way as to produce opposed deflections, the deflected beam pivoting around the centre of 20. The second or slower beam, which may be also called the illuminating beam, is produced by the cathode 27. This has the form of a flat annular shell, containing a heating filament 28. This annular cathode surrounds the aperture through which the fast beam is passing. The potential of the second cathode is preferably equal to or near to the potential of 18 and 19. The second beam obtains its energy and the first beam an increase of its energy in the field of the final anode 29, which is shown as a conductive coating of the envelope. This anode, which has the highest potential in the whole system, corresponds to the collecting electrode in Fig. 1. One of its functions is to collect the secondary electrons emitted by the screen 30. This screen consists of fluorescent substance, capable of secondary electron emission, and is backed with a transparent metallic coating 31, connected with the cathode 27, or with a suitable potential near that of the cathode.

It has been found that a fluorescent screen of the kind described, provided that the coating is not too thin, can be considered as built up of a very great number of elements, each of which can exhibit independently the effects described in connection with Fig. 1. The resistance 10 is here replaced by the conductivity of the fluorescent coating between the surface exposed to the electrons and the metallic backing. It has been found that most of the usual fluorescent substances have sufficiently good secondary electron emission and sufficiently low conductivity to enable small area-elements, with dimensions comparable to the thickness of the coating, to change their equilibrium states independently of the surrounding parts by the effects as above described. Screens with not sufficiently low conductivity may be improved by applying a semiconductor of sufficiently low conductivity on the metallic coating and applying the fluorescent substance on top of this in single grains, which may have also an admixture of good secondary emitters.

In the device described, an oscillogram once described by the first beam is made permanently visible by the second beam which spreads out over the whole area of the screen, hits it however only on those parts where the first beam has passed. This device is therefore very suitable as an oscillograph for transient electric phenomena, which can be observed or photographed on the screen for any length of time.

The main application of the invention is however in the field of television. Cathode ray tubes for television reception could not hitherto be operated with the very great brightness as required for projection, for two reasons: The first is the destruction of the fluorescent screen at great inputs, the second is the difficulty of concentrating very great inputs in small writing spots. The first difficulty is very strongly reduced with the new cathode ray tube, for the following reasons: The destruction of the screen in cathode ray tubes is caused mainly by that the spot covers only about 1/100,000 of the screen area at a time and rests on it only for about 1/100,000 of the time. The whole input, which has to cause a visual impression lasting at least for 1/50th of a second is transferred to a point of the screen in less than a millionth of a second. In consequence the screen is heated up for a very short time to very high peak temperatures. Artificial cooling is of no avail for substantially reducing these peaks, as the speed of heat conduc-

tion is far too low for the extraordinary peak input densities. According to the present invention however the input may be averaged out over a considerable fraction of the total time. If e. g. the bombardment time by the illuminating beam is 10% of the total time, this means that in order to create the same screen brightness and the same visual impression the input density can be reduced to 1/10,000 of its former value. Although the total input remains the same, not only the maximum but also the average temperature of the screen is now strongly reduced, as the rate of heat leakage can now easily be made comparable with the rate of energy inflow.

The second difficulty, viz. that of concentrating very strong beam currents in small writing spots, is also overcome in the tubes according to the invention, as the illuminating beam is not concentrated but diffuse, and covers a large part of the screen area.

A problem particular to television tubes, as distinct from cathode ray oscillographs is that of the modulation of screen brightness. As the trip-over process on which the invention is based, is a discontinuous process, it might seem that the usual methods of intensity modulation can not be applied. This applies however only to screens which are entirely homogeneous. In reality the unavoidable inhomogeneities of the screen, due to different grain size, etc. create already a certain degree of gradation. Grains of different size, of different conductivity and of different secondary electron emissivity can be made to trip over in a certain sequence, in such a way that at a small intensity of the scanning beam only a few trip over into the upper,—permanently bright,—stage, whereas at a certain higher current all trip over and saturation is reached. This effect may be utilized by mixing the fluorescent substance of grains of different properties. In order to obtain good gradation and the impression of continuously changing screen brightnesses, it is however also necessary that the spot shall cover at the same time a great number of grains of different properties.

A second method of effecting modulation according to the invention is that of building up the picture of points with maximum brightness but of different size, similarly as in half-tone printing. This may be effected by modulating not the beam intensities but the beam diameter. It is moreover preferable to move the spot in the line direction not continuously but in jerks. This may be effected by superimposing on the line-sweep movement a high frequency movement, with a frequency corresponding to the desired number of picture points per second. This superimposed oscillation has preferably a saw-tooth waveform, but it has been found that a superimposed sine-wave is sufficient for resolving the line apparently into a series of sharp dots. This method of modulation is also effective only in case of independent screen-elements much smaller than the maximum area covered by the scanning spot.

The most effective method consists in a combination of the two methods above described, i. e. in a modulation both of spot size and beam intensity and the use of an inhomogeneous screen as above described.

The cathode ray tube according to the invention can be adapted to even higher screen inputs by a modification, the principle of which can be explained with reference to Fig. 4. This device contains the same elements as the one shown in Fig. 1, but with the following difference: The electrode **32**, corresponding to **8** in Fig. 1, is made perforated, and behind it is placed a further electrode **33**, with a potential higher than that of the collecting electrode **34**. If the electrode **32** is in the state corresponding to "O" in Fig. 2, the current to the anode **33** due to the broad beam alone will be very small, and it can be made exactly zero by connecting **32** not to the cathode but to a somewhat lower potential. In the upper state however,—corresponding to B in Fig. 2,—the electrons of the second broad beam will shoot freely through the holes of **32**. A part of them impinges on the perforated electrode and releases a sufficient number of secondary electrons for maintaining the high potential.

This effect is utilized according to the invention as shown in Fig. 5. The grid **32** is replaced by a perforated or gauze-like structure **35**, with an insulating or semiconducting coating **36**. Such a structure may be called for shortness' sake a "gate". It is sufficient, or even preferable if the coating extends only over the face of the structure exposed to the electron beams, the other face being left bare. By the insulation the elements of the surface are made independent of each other. Every hole may be considered as an independent element, which may or may not transmit electrons, independently of the state of the surrounding holes. In Fig. 5 the top opening **37** is assumed to be at or below cathode potential, and the electrons of the illuminating, or broad, beam,—starting horizontally and shown in continuous lines,—are repelled. The scanning beam,—shown in dotted lines,—just passes the hole **38** in its upward sweep, and releases secondary electrons which are moving towards the collecting electrode. (Secondary electrons are indicated by dot-dash lines.) By this the potential is raised and the passage is opened for the illuminating beam. In the bottom opening, which has been passed by the fast beam, the illuminating beam maintains this higher potential, by releasing secondary electrons.

As rather small voltage differences are sufficient for controlling the illuminating beam current from zero to a maximum, it is advantageous to provide good secondary emitters on the surface of the insulating or semiconducting coating, i. e. substances from which electrons with rather low energy may release more than one electron. By this the voltage jump between the lower and the upper state is reduced. A high voltage jump represents in this case a waste, whereas in the device shown in Fig. 3 this voltage difference is useful, as it serves for exciting the fluorescent screen.

Fig. 6 shows a device according to the invention utilizing a "gate". The means for producing the two electron beams are the same as described in connection with Fig. 3. In this device however no fluorescent screen but a gauze **40**, prepared in the above described manner, is scanned by the fast beam. This gauze is held by the frame **41**. It is electron-optically imaged on the fluorescent screen **42**. The electron-optical system is composed of the electrodes **43** and **44**,—shown as coatings of the envelope,—and the magnet coil **45**.

As compared with the device shown in Fig. 3, this form of the invention has the advantage, that the accelerating voltage between 40 and 42 can be chosen freely, independently of the secondary emitting properties of the "gate". It is therefore possible to realize by means of this device

even higher screen inputs than with the first form. This device is therefore especially suited for television projection on large screens, e. g. cinema theatre screens.

In the reproduction of television pictures the difficulty arises, that if the illuminating beam is switched off once after every frame or picture, those parts of the picture which have been traced last will emit less light than those traced at the beginning. This difficulty is overcome according to the invention with the arrangement diagrammatically illustrated in Fig. 7. In this figure 46 is the control screen such as the screen 30 of Fig. 3 or gate 40 of Fig. 6, as the case may be, on which the potential pattern is produced. 47 represents the electron gun for producing the scanning beam. 48—49 and 50—51 are the two pairs of deflecting plates producing the scanning. 52 represents diagrammatically the large cathode emitting the second broad beam, which irradiates the screen on a band 55 and is deflected by the plates 53, 54. The deflections of the two beams are matched in such a way, that the illuminating beam follows the scanning beam, its upper edge moving a little ahead of it. The picture lines are indicated by dotted lines. If in this arrangement the width of the illuminating band is chosen equal to or a little less than the dark spaces following each frame, every picture point will receive equal illumination. By this method it is therefore possible to utilize about 10% of the time, as compared with about .001% by the usual method.

A further improvement is effected by the method diagrammatically illustrated in Fig. 8. This method allows utilizing almost the whole time for electron bombardment. In this figure only the screen,—or gate,—56 is shown, with means for producing and deflecting the scanning beam, which are the same as in the previous figure. The illuminating beam covers here the whole area of the screen, with the exception of a narrow dark band 58, which moves a little ahead of the scanning spot 57. This dark band wipes out the picture, by giving the elements of the screen or gate just sufficient time to discharge. The previous picture 59 changes therefore almost continuously into the next picture 60, and the flicker is reduced to a minimum.

Fig. 9 is a simplified representation of an electron-optical device for producing full illumination of the screen, interrupted only by a thin dark band. A cathode 61 of sufficiently large area is surrounded by a guard ring 62. The electrons emitted by the cathode are accelerated by the tubular electrode 63 and thrown at the disc 64, which itself has a suitable positive potential. This disc is fitted with two windows 65, 66, each of which has the proportions of the picture, and which are divided by a narrow cross-bar 67. The electrostatic lens system 68, 69 is adjusted in such a way that a strongly magnified sharp image of the window with the cross-bar appears on the screen. The electrode 63, or other condensing system by which it may suitably be replaced, is arranged in such a way as to produce uniform illumination of the window and therefore of the picture. The whole image of 65 and 66 is moved during the course of the frame scan across the screen by means of the deflecting electrodes 70 and 71. On the screen there will appear therefore a dark band which wipes out the preceding picture before the next one takes its place. In order to avoid wiping out the picture during the fly-back of the dark band, the following method may be used according to the invention: During the fly-back the potential of one or both of the focussing electrodes 68, 69 is changed in such a way that the picture of the window is defocussed and the image of the cross-bar vanishes almost completely. If however the fly-back is sufficiently rapid, and the time of the passage of the dark strip is considerably shorter than the time constant of discharge of the screen or gate elements, this defocussing is unnecessary.

Fig. 10 shows a section of a gun construction, containing the means for producing and deflecting both electron beams, in symmetrical arrangement. This consists of the cathode 72 for the first or scanning beam, with the focussing system 73, held by the insulating part 74 in the tubular member 75, which carries the deflector system for the scanning beam. These are arranged in four pairs, corresponding to Figs. 3 or 6, arranged in such a way as to make the deflected beam pivot around the centre of the aperture 76.

The organs for producing the second or illuminating beam are essentially the same as in Fig. 9, and are arranged near the end of the tubular member 75. The cathode consists of an annular ring 77 of triangular cross section, enclosing the heating filament 78. Its active surface has the shape of a truncated cone, situated behind the diaphragm 79. The condensing electrode 80 is arranged in such a way, that the cathode rays emitted by 77 illuminate the window 76 uniformly. This window has the same shape as described in connection with Fig. 9 and has a thin cross bar 81 in its middle. It is followed by the focussing electrodes 82 and 83 and by the deflecting electrodes 84 and 85.

As the potential of the cathode 72 is considerably lower than that of 77, the electrons of the scanning beam have a much higher velocity than those of the illuminating beam. They will suffer therefore only a small additional focussing and deflecting effect by the electrodes 80—85. By suitable dimensioning of the gun system and of the applied voltages it is possible to obtain at the screen simultaneously a sharp spot for the scanning beam and a sharp image of the cross bar.

While I have shown particular embodiments of my invention, it will be understood that many modifications and applications may be made by those skilled in the art, without departing from the invention as set forth in this specification and in the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a cathode ray signal reproducing tube, the combination which comprises a control screen having a conductive base and a secondary-electron-emissive charge-retaining surface thereon connected to the conductive base through resistive material, an electron gun for producing a scanning beam of electrons of relatively high velocity positioned and adapted to impinge on said control screen, deflecting means for said scanning beam, a second electron gun for producing a broad beam of electrons of relatively low velocity positioned and adapted to impinge on said control screen, said second electron gun having an electrode including a window having a cross bar thereacross adapted to divide said broad beam of electrons into two portions separated by a band free of electrons, means for electron-optically imaging said window on said control screen, a collecting anode positioned to collect secondary electrons emitted from said control screen, the

conductive base of the control screen being connected to the cathode of the broad beam electron gun so that initially, prior to the passing of the scanning beam, electrons of the broad beam will not liberate secondary electrons from the emissive surface thereof at a ratio greater than unity, the relatively high velocity electrons of the scanning beam being adapted to liberate secondary electrons from the scanned areas of the control screen at a ratio greater than unity, said secondary electrons being collected by said collecting anode and thereby raising the potentials of the scanned areas so that electrons of the broad beam thereafter impinge on the scanned areas at increased velocities and liberate secondary electrons at a ratio greater than unity to maintain the scanned areas at elevated potentials so long as electrons in the broad beam continue to impinge thereon, thereby creating a potential pattern on said control screen, means for utilizing said potential pattern to reproduce an image corresponding thereto, and deflecting means for deflecting across the control screen said portions of the broad beam separated by said band free of electrons and thereby permit the charge on the scanned emissive areas lying at said band to leak away through the resistive material and restore the areas to their initial potentials.

2. In a cathode ray signal reproducing tube, the combination which comprises a control screen having a conductive base and a secondary-electron-emissive charge-retaining surface thereon connected to the conductive base through resistive material, an electron gun for producing a scanning beam of electrons of relatively high velocity positioned and adapted to impinge on said control screen, deflecting means for said scanning beam, a second electron gun for producing a broad beam of relatively low velocity electrons positioned and adapted to impinge on said control screen in a band covering a plurality of scanning lines, a collecting anode positioned to collect secondary electrons emitted from said control screen, the conductive base of the control screen being connected to the cathode of the broad beam electron gun so that initially, prior to the passing of the scanning beam, electrons of the broad beam will not liberate secondary electrons from the emissive surface thereof at a ratio greater than unity, the relatively high velocity electrons of the scanning beam being adapted to liberate secondary electrons from the scanned areas of the control screen at a ratio greater than unity, said secondary electrons being collected by said collecting anode and thereby raising the potentials of the scanned areas so that electrons of the broad beam thereafter impinge on the scanned areas at increased velocities and liberate secondary electrons at a ratio greater than unity to maintain the scanned areas at elevated potentials so long as electrons in the broad beam continue to impinge thereon, thereby creating a potential pattern on said control screen, means for utilizing said potential pattern to reproduce an image corresponding thereto, and deflecting means for deflecting the broad beam across the control screen and thereby permitting the charges on the scanned areas from which the broad beam has been deflected to leak away through the resistive material and restore the areas to their initial potentials.

3. In a cathode ray signal reproducing tube, the combination which comprises a perforated conductive control grid having on the surface thereof secondary-electron-emissive charge-retaining elements connected to said grid through resistive material, an electron gun for producing a scanning beam of electrons of relatively high velocity positioned and adapted to impinge on said control grid, deflecting means for said scanning beam, a second electron gun for producing a broad beam of electrons of relatively low velocity positioned and adapted to impinge on said control grid in a band covering a plurality of scanning lines, a collecting anode positioned and adapted to collect secondary electrons emitted from said control grid, a luminescent screen positioned to receive electrons of said broad beam passing through said control grid and adapted to be rendered luminescent thereby, the conductive control grid being connected to the cathode of the broad beam electron gun so that initially, prior to the passing of the scanning beam, the potentials of the emissive elements thereof will substantially prevent the electrons of the broad beam from impinging on said luminescent screen and electrons in the broad beam will not liberate secondary electrons from the emissive elements at a ratio greater than unity, the relatively high velocity electrons of the scanning beam being adapted to liberate secondary electrons from the scanned areas at a ratio greater than unity, said secondary electrons being collected by said collecting anode and thereby raising the potentials of the scanned areas so that electrons of the broad beam thereafter impinge on the scanned areas at increased velocities and liberate secondary electrons at a ratio greater than unity to maintain the scanned elements at elevated potentials so long as electrons in the broad beam continue to impinge thereon, said elevated potentials permitting electrons in the broad beam to pass through corresponding areas of the control grid and impinge on the luminescent screen, and deflecting means for said broad beam for deflecting the beam away from the scanned areas and thereby permitting the charge on said emissive elements to leak away through the resistive material and restoring the elements to their initial potentials.

4. In a cathode-ray signal reproducing tube, the combination which comprises a perforated conductive control grid having on the surface thereof secondary-electron-emissive charge-retaining elements connected to said grid through resistive material, an electron gun for producing a scanning beam of electrons of relatively high velocity positioned and adapted to impinge on said control grid, deflecting means for said scanning beam, a second electron gun for producing a broad beam of electrons of relatively low velocity positioned and adapted to impinge on said control grid, said second electron gun having an electrode including a window having a cross bar thereacross adapted to divide said broad beam of electrons into two portions separated by a band free of electrons, means for electron-optically imaging said window at said control grid, a collecting anode positioned to collect secondary electrons emitted from said control grid, a luminescent screen positioned to receive electrons of said broad beam passing through said control grid and adapted to be rendered luminescent thereby, the conductive control grid being connected to the cathode of the broad beam electron gun so that initially, prior to the passing of the scanning beam, the potentials of the emissive elements thereof will prevent the electrons of the broad beam from impinging on said luminescent screen and electrons in the

broad beam will not liberate secondary electrons from the emissive elements at a ratio greater than unity, the higher velocity electrons of the scanning beam being adapted to liberate secondary electrons from the scanned areas at a ratio greater than unity which are collected by the said collecting anode, the potential of the collecting anode being sufficiently high so that the potentials of the scanned areas are raised by said secondary electron emission so that electrons of the broad beam thereafter impinge on the scanned areas at increased velocities and liberate secondary electrons at a ratio greater than unity to maintain the scanned elements at elevated potentials so long as electrons in the broad beam continue to impinge thereon, said elevated potentials permitting electrons in the broad beam to pass through corresponding areas of the control grid and impinge on the luminescent screen, and deflecting means for deflecting across the control grid said portions of the broad beam separated by said band free of electrons and thereby permit the charge on the scanned emissive elements lying at said band to leak away through the resistive material and restore the elements to their initial potentials.

5. In a cathode-ray signal reproducing tube, the combination which comprises a perforated conductive control grid having on the surface thereof secondary-electron-emissive charge-retaining elements connected to said grid through resistive material, an electron gun for producing a scanning beam of electrons of relatively high velocity positioned and adapted to impinge on said control grid, deflecting means for said scanning beam, a second electron gun for producing a broad beam of electrons of relatively low velocity positioned and adapted to impinge on said control grid in a band covering a plurality of scanning lines, a collecting anode positioned to collect secondary electrons emitted from said control grid, a luminescent screen positioned to receive electrons of said broad beam passing through said control grid and adapted to be rendered luminescent thereby, the conductive control grid being connected to the cathode of the broad beam electron gun so that initially, prior to the passing of the scanning beam, the potentials of the emissive elements thereof will substantially prevent the electrons of the broad beam from impinging on said luminescent screen and electrons in the broad beam will not liberate secondary electrons from the emissive elements at a ratio greater than unity, the higher velocity electrons of the scanning beam being adapted to liberate secondary electrons from the scanned areas at a ratio greater than unity which are collected by the said collecting anode, the potential of the collecting anode being sufficiently high so that the potentials of the scanned areas are raised by said secondary electron emission so that electrons of the broad beam thereafter impinge on the scanned areas at increased velocities and liberate secondary electrons at a ratio greater than unity to maintain the scanned elements at elevated potentials so long as electrons in the broad beam continue to impinge thereon, said elevated potentials permitting electrons in the broad beam to pass through corresponding areas of the control grid and impinge on the luminescent screen, and deflecting means for said broad beam for deflecting the beam away from the scanned areas and thereby permitting the charge on said emissive elements to leak away through the resistance material and restoring the elements to their initial potentials.

6. A cathode ray signal reproducer tube which comprises an electron gun for producing a scanning beam of relatively high velocity electrons, a second electron gun for producing a broad beam of relatively low velocity electrons, a secondary-electron-emissive charge-retaining luminescent screen positioned and adapted to be impinged by said broad beam and said scanning beam of electrons, and a collecting anode positioned and adapted to collect secondary electrons emitted from said screen, the velocity of the electrons in said broad beam being initially too low to strike said luminescent screen and render it substantially luminescent and too low to liberate secondary electrons therefrom at a ratio greater than unity, the electrons in said scanning beam being of sufficiently high velocity to liberate secondary electrons from the scanned areas at a ratio greater than unity, said secondary electrons being collected by said collecting anode at a sufficiently high potential to thereby raise the potentials of the scanned areas so that electrons of the broad beam thereafter impinge on the scanned areas at increased velocities to render said scanned areas luminescent and to liberate secondary electrons therefrom at a ratio greater than unity to maintain the scanned areas at increased potentials and thereby maintain said luminescence so long as electrons in the broad beam continue to impinge thereon.

7. A cathode ray signal reproducer tube which comprises an electron gun for producing a scanning beam of relatively high velocity electrons, deflecting means for said scanning beam, a reproducing screen having a conductive base and secondary-electron-emissive charge-retaining elements on the surface thereof connected to said conductive base through resistive material, said reproducing screen being adapted to be rendered luminescent by electrons impinging thereon, a second electron gun for producing a broad beam of relatively low velocity electrons positioned and adapted to impinge on said reproducing screen in a band covering a plurality of scanning lines produced by said scanning beam, a collecting anode positioned and adapted to collect secondary electrons emitted from said screen, the conductive base of said reproducing screen being maintained at a potential such that the electrons in said broad beam have velocities initially too low to strike said reproducing screen and render it substantially luminescent and too low to liberate secondary electrons therefrom at a ratio greater than unity, whereas the electrons in said scanning beam have sufficiently high velocities to liberate secondary electrons from the scanned areas at a ratio greater than unity, said collecting anode being maintained at a sufficiently high potential to collect said secondary electrons to raise the potentials of the scanned areas so that electrons of the broad beam thereafter impinge on the scanned areas at increased velocities to render said scanned areas luminescent and to liberate secondary electrons therefrom at a ratio greater than unity to maintain the scanned areas at increased potentials, thereby maintaining said luminescence so long as electrons of the broad beam continue to impinge on the scanned areas, and deflecting means for said broad beam for deflecting the beam away from the scanned areas and thereby permitting the charges on the scanned elements to leak away through the re-

sistive material to the conductive base and restore the elements to their initial potentials.

8. In cathode-ray tube signal reproducing apparatus in which the reproduction persists after the signal has passed, the combination which comprises means for producing a concentrated electron scanning beam and a broad electron beam of different velocities, a secondary-electron emissive surface positioned to be impinged by said scanning and said broad electron beams, means for impressing upon said emissive surface an initial potential such that prior to the passing of said scanning beam over elemental areas thereof the electrons in said broad beam do not raise the potentials of said elemental areas, whereas electrons in said scanning beam do raise the potentials of the scanned elemental areas by secondary electron emission therefrom to an extent sufficient to cause electrons in said broad beam to thereafter impinge on the scanned areas at velocities sufficient to maintain the scanned areas at elevated potentials by secondary electron emission therefrom so long as electrons in the broad beam continue to impinge thereon.

9. In cathode-ray tube signal reproducing apparatus in which the reproduction persists after the signal has passed, the combination which comprises means for producing a concentrated electron scanning beam and a broad electron beam of different velocities, a secondary-electron emissive surface positioned to be impinged by said scanning and said broad electron beams, elemental areas of said surface being charge-retaining, means for impressing upon the elemental areas of said emissive surface initial potentials such that prior to the passing of the scanning beam thereover the electrons in said broad beam do not liberate secondary electrons therefrom at a ratio greater than unity, whereas electrons in said scanning beam do liberate secondary electrons at a ratio greater than unity and thereby raise the potentials of the scanned areas an extent sufficient to cause electrons in said broad beam to thereafter impinge on the scanned areas at velocities sufficient to maintain the scanned areas at elevated potentials by secondary electron emission at a ratio greater than unity so long as electrons in the broad beam continue to impinge thereon.

10. In cathode-ray tube signal reproducing apparatus in which the reproduction persists after the signal has passed, the combination which comprises a secondary-electron emissive screen, elemental areas of which are charge-retaining; means for producing a potential pattern on said screen corresponding to the signal to be recorded comprising means for producing a scanning beam of relatively high velocity electrons and a broad beam of relatively low velocity electrons, said scanning beam being adapted to impinge on said screen in an elemental area and said broad electron beam being adapted to impinge on said screen over a relatively large area, means for impressing upon elemental areas of the emissive screen initial potentials such that prior to the passing of the scanning beam thereover the electrons in said broad beam do not liberate secondary electrons therefrom at a ratio greater than unity whereas electrons in said scanning beam do liberate secondary electrons at a ratio greater than unity and thereby raise the potentials of the scanned areas an extent sufficient to cause electrons in said broad beam thereafter to liberate secondary electrons from the scanned areas at a ratio greater than unity and maintain the scanned areas at elevated potentials so long as electrons in the broad beam continue to impinge thereon, thereby producing a potential pattern on said screen; and means for utilizing the potential pattern so produced to reproduce an image corresponding thereto.

11. In cathode-ray tube reproducing apparatus for producing on a luminescent screen records of electric signals which persist after the signals have passed, the combination which comprises an electron gun including a cathode and an anode co-operating therewith to define an electron scanning beam of elemental cross-section, a second electron gun including a cathode and an anode co-operating therewith to define a broad electron beam of relatively large cross-section, means for maintaining the cathode of the first electron gun at a lower potential than the cathode of the second electron gun, a control screen positioned in the paths of said electron beams, said control screen being conductive and having thereon a layer of substantially discrete secondary-electron emissive elements connected to the screen through resistive material, a collecting anode positioned to collect secondary electrons emitted from said elements, a luminescent screen positioned and adapted to receive electrons of said broad beam under the control of said control screen, means for maintaining the conductive screen at a potential with respect to said cathodes such that initially, prior to the passing of the scanning beam, the electrons in the broad beam will be substantially prevented from producing an image on said luminescent screen and the potential difference between the emissive elements and the cathode of the second electron gun will be less than required for the emission of secondary electrons from the elements in a ratio sufficient to raise the potential of the elements, whereas the potential difference between the emissive elements and the cathode of the first electron gun, in conjunction with the potential of the collecting anode, will cause electrons in the scanning beam to liberate secondary electrons from the scanned emissive elements in a ratio sufficient to raise the potential of the scanned elements to at least the potential level at which electrons from the second cathode also release secondary electrons in a ratio sufficient to balance the leakage current from the scanned elements in the conducting screen, thereby maintaining the scanned emissive elements at at least said potential level so long as electrons in the broad beam continue to impinge thereon, means for modulating the scanning beam to create a potential pattern of elements maintained at at least said potential level corresponding to the signal to be recorded, said potential level admitting electrons of said broad beam to said luminescent screen to produce an image thereon.

12. In apparatus for producing an optical image including a recording screen adapted to be rendered luminescent by electrons impinging thereon under the control of a potential pattern created on a secondary electron emissive charge-retaining surface, the method of creating said potential pattern which comprises initially exposing said secondary-electron emissive charge-retaining surface to a relatively broad uniform stream of electrons whose velocities are too low to strike said surface and emit secondary electrons at a ratio greater than unity, and bombarding elemental areas of said surface by a scanning beam of relatively high velocity electrons to raise the potentials of said areas by secondary electron

emission therefrom to an extent sufficient to cause electrons of said broad beam to thereafter impinge on said areas at increased velocities sufficient to maintain said areas at raised potentials so long as the exposure of the scanned areas to said broad beam is continued.

13. In cathode-ray tube apparatus for producing images by a flow of electrons under the control of a potential pattern created on a secondary-electron emissive surface, elemental areas of which are charge-retaining, the method of creating said potential pattern which comprises creating a broad beam of electrons and directing the beam toward said secondary-electron emissive surface, the velocities of said broad beam electrons being initially insufficient to raise the potentials of said elemental areas, and raising the potentials of elemental areas of said emissive surface by bombarding said areas, in the presence of said broad electron beam, with a relatively high velocity scanning beam of electrons to an extent such that electrons of the broad beam will thereafter impinge on the scanned areas at increased velocities sufficient to maintain the scanned areas at elevated potentials by secondary electron emission therefrom so long as the flow of electrons in the broad beam to the scanned areas is continued, thereby producing a potential pattern on said emissive surface.

14. In cathode-ray tube apparatus for producing images by a flow of electrons under the control of a potential pattern created on a secondary-electron emissive surface, the method of creating said potential pattern which comprises initially exposing said secondary-electron emissive surface to a broad beam of electrons having velocities too low to strike said emissive surface and liberate secondary electrons at a ratio sufficient to raise the potentials of elemental areas of said surface, and scanning elemental areas of said surface in the presence of said broad beam with a scanning beam of electrons having velocities sufficiently high to liberate secondary electrons to raise the potentials of the scanned areas to such an extent as to cause electrons of the broad beam to thereafter impinge on said scanned areas at velocities sufficient to liberate secondary electrons to maintain said areas at raised potentials so long as the flow of the electrons in the broad beam to the scanned areas is continued, thereby producing a potential pattern on said emissive surface.

15. The method of producing an image by a cathode-ray tube which comprises creating a broad beam of electrons for producing an image, controlling the production of said image by said broad beam by means of a secondary-electron-emissive surface positioned in the path of said broad beam, initially maintaining said emissive surface at a potential such that electrons of the broad beam will be substantially prevented from producing an image, and scanning elemental areas of said emissive surface with a scanning beam of relatively high velocity electrons to raise the potentials of the scanned areas by secondary electron emission to a degree such that electrons of the broad beam will thereafter impinge thereon with sufficiently high velocities to maintain the scanned areas at raised potentials so long as the flow of the electrons in the broad beam to the scanned areas is continued, the raised potentials of said scanned areas permitting the electrons of the broad beam to produce an image corresponding thereto.

16. The method of producing an image by a cathode-ray tube which comprises creating a broad beam of relatively low velocity electrons for producing an image on a recording surface, controlling the production of said image by said broad beam by means of a secondary-electron-emissive charge-retaining surface positioned in the path of said broad beam, initially maintaining said emissive surface at a potential such that electrons in said broad beam will be substantially prevented from producing an image and will not raise the potential thereof by secondary-electron emission, and scanning elemental areas of said emissive surface in the presence of said broad beam with a scanning beam of relatively high velocity electrons to raise the potentials of the scanned areas by secondary electron emission therefrom to an extent such that electrons of the broad beam will thereafter impinge thereon with sufficiently high velocities to maintain the scanned areas at raised potentials by secondary-electron emission therefrom so long as the flow of electrons in the broad beam to the scanned areas is continued, the raised potentials of said scanned areas permitting electrons of the broad beam to produce an image on the recording surface.

17. The method of producing an image on a recording surface by a cathode-ray tube which comprises initially exposing to a relatively broad beam of electrons a screen having secondary-electron-emissive charge-retaining elements on the surface thereof, the velocity of said electrons being too low to raise the potentials of said elements by the emission of secondary electrons at a ratio greater than unity, scanning elemental areas of said screen during said exposure by a scanning beam of relatively high velocity electrons to emit secondary electrons at a ratio greater than unity, collecting said secondary electrons at a potential sufficiently high to cause the potentials of the scanned elemental areas to be raised by said secondary electron emission to an extent sufficient to cause electrons in said broad beam to thereafter emit secondary electrons at a ratio greater than unity and thus maintain said scanned areas at elevated potentials so long as the flow of electrons in the broad beam to the scanned areas is continued, thereby producing a potential pattern on said screen, and utilizing said potential pattern to control the flow of electrons to a recording surface adapted to record an image by electrons impinging thereon.

18. The method of producing an image on a recording surface by a cathode-ray tube which comprises creating a broad beam of relatively low velocity electrons for producing an image on a recording surface, controlling the admission of electrons of said broad beam to said recording surface by means of a secondary-electron-emissive screen positioned in the path of said broad beam, elemental areas of said screen being charge-retaining, initially maintaining said elemental areas at such low potentials that electrons in said broad beam will be substantially prevented from producing an image on said recording screen and will not raise the potentials of said areas by secondary electron emission therefrom, scanning elemental areas of said screen in the presence of said broad beam by a scanning beam of relatively high velocity electrons to emit secondary electrons at a ratio greater than unity, collecting said secondary electrons at a potential sufficiently high to cause the potentials of the scanned elemental areas to be raised by said secondary electron emission to an extent sufficient to cause electrons in said broad beam

to thereafter emit secondary electrons at a ratio greater than unity and thus maintain said scanned areas at elevated potentials so long as the flow of electrons in the broad beam to the scanned areas is continued, the raised potentials of said scanned areas permitting electrons of the broad beam to produce an image on the recording screen corresponding thereto.

19. The method of producing an image on a recording surface by a cathode-ray tube which comprises creating a broad beam of relatively low velocity electrons for producing an image on a recording surface, controlling the admission of electrons of said broad beam to said recording surface by means of a secondary-electron-emissive screen positioned in the path of said broad beam, elemental areas of said screen being charge-retaining, initially maintaining said elemental areas at such low potentials that electrons in said broad beam will be substantially prevented from producing an image on said recording screen and will not raise the potentials of said areas by secondary electron emission therefrom, scanning elemental areas of said screen in the presence of said broad beam by a scanning beam of relatively high velocity electrons to emit secondary electrons at a ratio greater than unity, collecting said secondary electrons at a potential sufficiently high to cause the potentials of the scanned elemental areas to be raised by said secondary electron emission to an extent sufficient to cause electrons in said broad beam to thereafter emit secondary electrons at a ratio greater than unity and thus maintain said scanned areas at elevated potentials so long as the flow of electrons in the broad beam to the scanned areas is continued, the raised potentials of said scanned areas permitting electrons of the broad beam to produce an image on the recording screen corresponding thereto, and periodically restoring the elemental areas of said emissive screen to substantially their initial low potentials for rescanning thereof.

20. In a cathode-ray tube signal reproducing apparatus for producing, on a reproducing screen, records of electric signals which persist after the signals have passed, the combination which comprises means for producing a scanning electron of elemental cross-section and a broad electron beam of relatively large cross-section, the electrons in the scanning beam having higher velocities than the electrons in the broad beam, a secondary-electron emissive reproducing screen adapted to reproduce images by the impingement of electrons thereon, said electron beams being directed toward said reproducing screen, means for scanning elemental areas of said reproducing screen with said scanning beam in the presence of said broad beam, means for maintaining elemental areas of said screen initially, prior to the passing of the scanning beam thereover, at such potentials that electrons in said broad beam substantially do not reproduce an image on said areas and do not raise the potentials thereof by secondary-electron emission therefrom, whereas at said potentials the higher velocity electrons in the scanning beam liberate secondary-electrons from the scanned areas at a ratio greater than unity, and means for collecting the secondary-electrons liberated by the scanning beam at a potential sufficiently high so that the potentials of the scanned areas are raised to at least the level at which electrons in the broad beam thereafter impinge thereon at increased velocities sufficient to maintain said areas at at least said potential level by secondary electron emission therefrom at a ratio greater than unity so long as electrons in said broad beam continue to impinge thereon, said increased velocities of the electrons in the broad beam being sufficient to reproduce an image on said reproducing screen.

21. In cathode-ray tube signal reproducing apparatus in which the reproduction persists after the signal has passed, means for producing a potential pattern for controlling the reproduction of an image corresponding thereto which comprises, in combination, means for producing a scanning electron beam of elemental cross-section and a broad electron beam of relatively large cross-section, the electrons in the scanning beam having higher velocities than the electrons in the broad beam, a control screen having a secondary-electron emissive surface thereon elemental areas of which have substantial resistance therebetween, means for scanning elemental areas of said emissive surface with said scanning beam in the presence of said broad beam, means for impressing upon elemental areas of said emissive surface initial potentials such that prior to the passing of the scanning beam thereover the electrons in the broad beam do not raise the potentials thereof by secondary electron emission therefrom, whereas at said potentials the higher velocity electrons in the scanning beam liberate secondary electrons from the scanned areas at a ratio greater than unity, and means for collecting the secondary electrons liberated by the scanning beam at a potential sufficiently high so that the potentials of the scanned areas are raised to at least the level at which electrons in the broad beam thereafter impinge thereon at increased velocities sufficient to maintain said scanned areas at at least said potential level by secondary electron emission therefrom at a ratio greater than unity so long as electrons in the broad beam continue to impinge thereon, whereby a potential pattern may be created on said control screen.

22. In a cathode-ray tube signal reproducing apparatus for producing, on a luminescent screen, records of electric signals which persist after the signals have passed, the combination which comprises means for producing a scanning electron beam of elemental cross-section and a broad electron beam of relatively large cross-section, the electrons in the scanning beam having higher velocities than the electrons in the broad beam, a secondary-electron emissive surface, said electron beams being directed toward said emissive surface, a luminescent surface adapted to be rendered luminescent by electrons impinging thereon and positioned to be impinged by electrons of said broad beam under the control of said emissive surface, means for maintaining elemental areas of said emissive surface initially, prior to the passing of the scanning beam thereover, at such low potentials that the slower electrons of the broad beam do not release secondary electrons therefrom at a ratio greater than unity and do not produce substantial luminescence of said luminescent surface, whereas at said potentials the faster electrons of the scanning beam release secondary electrons from the scanned areas at a ratio greater than unity and thereby raise the potentials of the scanned areas to a level at which the electrons of the broad beam also release secondary electrons at a ratio greater than unity and sufficient to maintain said scanned areas at at least said

level, whereby the raised potentials of the scanned areas persist after the scanning beam has passed on, so long as electrons in the broad beam continue to impinge thereon, said raising of the potentials of the scanned areas admitting electrons in the broad beam to said luminescent surface to produce a luminescent image thereon

23. In a cathode-ray tube reproducing apparatus for producing on a luminescent screen, records of electric signals which persist after the signals have passed, the combination which comprises an electron gun adapted to produce a scanning electron beam of elemental cross-section, a second electron gun adapted to produce a relatively broad electron beam, said electron guns having respective cathodes, means for maintaining the cathode of the first electron gun at a lower potential than the cathode of the second electron gun, a control screen positioned in the path of said electron beams having a conductive member and a secondary-electron emissive surface exposed to said electron beams, elemental surface areas of said emissive surface having substantial resistance therebetween and being connected to the conductive member through substantial resistance, a collecting anode positioned to collect secondary electrons emitted from said emissive surface, a luminescent screen positioned and adapted to receive electrons of said broad beams under the control of said control screen, means for scanning elemental areas of said emissive surface with said scanning beam in the presence of said broad beam, means for maintaining the potential of said conductive member at a potential near that of the cathode of the second electron gun such that initially, prior to the passing of the scanning beam over elemental areas of the emissive surface, the broad beam electrons are substantially prevented from producing an image on said luminescent screen and the potential difference between the elemental surface areas and the cathode of the second electron gun is less than required for electrons in the broad beam to raise the potentials of said areas by secondary-electron emission therefrom at a ratio greater than unity, the potential of the cathode of the first electron gun being selected with respect to the potential of the conductive member so that electrons in the scanning beam liberate secondary electrons from scanned areas at a ratio greater than unity, the potential of the said collecting anode being maintained sufficiently high so that the potentials of the scanned areas are raised by the said liberation of secondary electrons therefrom to at least the potential level at which electrons in the broad beam also liberate secondary electrons in a ratio greater than unity and sufficient to balance the leakage current from the scanned areas to the conducting member, thereby maintaining the scanned areas at at least said potential level, so long as electrons in the broad beam continue to impinge thereon, said potential level admitting electrons of said broad beam to said luminescent screen to produce an image thereon, and means for periodically discontinuing the flow of electrons in the broad beam to the scanned areas to permit the charge on the scanned areas to leak away to the conductive member and restore the scanned areas to substantially their initial potentials at which the electrons in the broad beam are substantially prevented from producing an image on the luminescent screen.

24. In cathode-ray tube signal reproducing apparatus for producing, on a luminescent screen, records of electric signals which persist after the signals have passed, the combination which comprises a control screen having a secondary-electron emissive surface elemental areas of which have substantial resistance therebetween, means for producing a scanning electron beam of elemental cross-section and a broad electron beam of relatively large cross-section, the electrons in the scanning beam having higher velocities than the electrons in the broad beam, a luminescent surface adapted to be rendered luminescent by electrons impinging thereon and positioned to be impinged by electrons of said broad beam under the control of said emissive surface, means for scanning elemental areas of said emissive surface with said scanning beam in a plurality of lines in the presence of said broad beam electrons, said broad beam covering an area of said emissive surface including a plurality of scanning lines, means for maintaining elemental areas of said emissive surface initially, prior to the passing of the scanning beam thereover, at such low potentials that the slower electrons of the broad beam do not release secondary electrons therefrom at a ratio greater than unity and do not produce luminescence of said luminescent surface, whereas at said potentials the faster electrons in the scanning beam liberate secondary electrons from the scanned areas at a ratio greater than unity, means for collecting the secondary electrons liberated by the scanning beam at a potential sufficiently high so that the potentials of the scanned areas are raised to at least the level at which electrons in the broad beam thereafter impinge thereon at increased velocities sufficient to maintain said scanned areas at at least said potential level by secondary electron emission therefrom at a ratio greater than unity, whereby the raised potentials of the scanned areas persist after the scanning beam has passed on so long as electrons in said broad beam continue to impinge thereon, said raising of the potentials of the scanned areas admitting electrons in the broad beam to said luminescent surface to produce a luminescent image thereon, and means correlated with the deflection of the scanning beam for deflecting the broad beam in a direction substantially perpendicular to the direction of the scanning lines to cause electrons of the broad beam to impinge on the scanned areas when they are scanned and to periodically discontinue the flow of electrons of the broad beam to scanned areas and thereby permit the scanned areas to be restored to their initial potentials prior to rescanning.

25. In cathode-ray tube signal reproducing apparatus for producing, on a luminescent screen, records of electric signals which persist after the signals have passed, the combination which comprises a control screen having a secondary-electron emissive surface elemental areas of which have substantial resistance therebetween, means for producing a scanning electron beam of elemental cross-section and a broad electron beam of relatively large cross-section, the electrons in the scanning beam having higher velocities than the electrons in the broad beam, a luminescent surface adapted to be rendered luminescent by electrons impinging thereon and positioned to be impinged by electrons of said broad beam under the control of said emissive surface, means for periodically scanning a selected area of said emissive surface with said scanning beam in a plurality of lines in the presence of said broad beam electrons, said broad beam substan-

tially covering said selected area except for a band free of broad beam electrons extending substantially the width of the scanning lines, means for maintaining elemental areas of said emissive surface initially, prior to the passing of the scanning beam thereover, at such low potentials that the slower electrons of the broad beam do not release secondary electrons therefrom at a ratio greater than unity and do not produce substantial luminescence of said luminescent surface, whereas at said potentials the faster electrons in the scanning beam liberate secondary electrons from the scanned elemental areas at a ratio greater than unity, means for collecting the secondary electrons liberated by the scanning beam at a potential sufficiently high so that the potentials of the scanned elemental areas are raised to at least the level at which electrons in the broad beam thereafter impinge thereon at increased velocities sufficient to maintain said scanned elemental areas at at least said potential level by secondary electron emission therefrom at a ratio greater than unity, whereby the raised potentials of the scanned elemental areas persist after the scanning beam has passed on so long as electrons in the broad beam continue to impinge thereon, said raising of the potentials of the scanned elemental areas admitting electrons in the broad beam to said luminescent surface to produce a luminescent image thereon, and means correlated with the deflection of the scanning beam for periodically deflecting said broad beam in a direction substantially perpendicular to the direction of the scanning lines at substantially the same velocity as that of the scanning beam in that direction to cause electrons of the broad beam to impinge on the scanned elemental areas when they are scanned and to cause said band free of broad beam electrons to move across the selected area and thereby periodically permit the scanned elemental areas to be restored to their initial potentials prior to rescanning.

26. In cathode-ray tube signal reproducing apparatus for producing, on a luminescent screen, records of electric signals which persist after the signals have passed, the combination which comprises a control screen having a secondary-electron emissive surface elemental areas of which have substantial resistance therebetween, means for producing a scanning electron beam of elemental cross-section and a broad electron beam of relative large cross-section, the electrons in the scanning beam having higher velocities than the electrons in the broad beam, a luminescent surface adapted to be rendered luminescent by electrons impinging thereon and positioned to be impinged by electrons of said broad beam under the control of said emissive surface, means for scanning elemental areas of said emissive surface with said scanning beam in the presence of said broad beam electrons, means for maintaining elemental areas of said emissive surface initially, prior to the passing of the scanning beam thereover, at such low potentials that the slower electrons of the broad beam do not release secondary electrons therefrom at a ratio greater than unity and do not produce substantial luminescence of said luminescent surface, whereas at said potentials the faster electrons in the scanning beam liberate secondary electrons from the scanned areas at a ratio greater than unity, means for collecting the secondary electrons liberated by the scanning beam at a potential sufficiently high so that the potentials of the scanned areas are raised to at least the level at which electrons in the broad beam thereafter impinge thereon at increased velocities sufficient to maintain said scanned areas at at least said potential level by secondary electron emission therefrom at a ratio greater than unity, whereby the raised potentials of the scanned areas persist after the scanning beam has passed on so long as electrons in said broad beam continue to impinge thereon, said raising of the potentials of the scanned areas admitting electrons in the broad beam to said luminescent surface to produce a luminescent image thereon, and means for modulating the cross-sectional area of the scanning beam at the control screen in accordance with the signal to be reproduced.

27. In cathode-ray tube signal reproducing apparatus for producing, on a luminescent screen, records of electric signals which persist after the signals have passed, the combination which comprises a control screen having a secondary-electron emissive surface elemental areas of which have substantial resistance therebetween, means for producing a scanning electron beam of elemental cross-section and a broad electron beam of relatively large cross-section, the electrons in the scanning beam having higher velocities than the electrons in the broad beam, a luminescent surface adapted to be rendered luminescent by electrons impinging thereon and positioned to be impinged by electrons of said broad beam under the control of said emissive surface, means for deflecting said scanning beam to scan said emissive surface in lines composed of a series of substantially discrete points, the scanning of elemental areas of said emissive surface being in the presence of electrons of said broad beam, means for maintaining elemental areas of said emissive surface initially, prior to the passing of the scanning beam thereover, at such low potenials that the slower electrons of the broad beam do not release secondary electrons therefrom at a ratio greater than unity and do not produce substantial luminescence of said luminescent surface, whereas at said potenials the faster electrons in the scanning beam liberate secondary electrons from the scanned areas at a ratio greater than unity, means for collecting the secondary electrons liberated by the scanning beam at a potential sufficiently high so that the potentials of the scanned areas are raised to at least the level at which electrons in the broad beam thereafter impinge thereon at increased velocities sufficient to maintain said scanned areas at at least said potential level by secondary electron emission therefrom at a ratio greater than unity, whereby the raised potentials of the scanned areas persist after the scanning beam has passed on so long as electrons in said broad beam continue to impinge thereon, said raising of the potentials of the scanned areas admitting electrons in the broad beam to said luminescent surface to produce a luminescent image thereon, and means for modulating the scanning beam in accordance with the signal to be reproduced.

28. In cathode-ray tube reproducing apparatus for producing on a luminescent screen, records of electric signals which persist after the signals have passed, the combination which comprises an electron gun adapted to produce a scanning electron beam of elemental cross-section, a second electron gun adapted to produce a relatively broad electron beam, said electron guns having respective cathodes, means for maintaining the cathode of the first electron gun at a lower potential than the cathode of the second

electron gun, a control screen positioned in the path of said electron beams having a conductive member and a secondary-electron emissive surface exposed to said electron beams, elemental surface areas of said emissive surface having substantial resistance therebetween and being connected to the conductive member through substantial resistance, a collecting anode positioned to collect secondary electrons emitted from said emissive surface, a luminescent screen positioned and adapted to receive electrons of said broad beam under the control of said control screen, means for deflecting said scanning beam to scan said emissive surface in lines composed of a series of substantially discrete points, the scanning of elemental areas of said emissive surface being in the presence of electrons of said broad beam, means for maintaining the potential of said conductive member at a potential near that of the cathode of the second electron gun such that initially, prior to the passing of the scanning beam over elemental areas of the emissive surface, the broad beam electrons are substantially prevented from producing an image on said luminescent screen and the potential difference between the elemental surface areas and the cathode of the second electron gun is less than required for electrons in the broad beam to raise the potentials of said areas by secondary-electron emission therefrom at a ratio greater than unity, the potential of the cathode of the first electron gun being selected with respect to the potential of the conductive member so that electrons in the scanning beam liberate secondary electrons from scanned areas at a ratio greater than unity, the potential of the said collecting anode being maintained sufficiently high so that the potentials of the scanned areas are raised by the said liberation of secondary electrons therefrom to at least the potential level at which electrons in the broad beam also liberate secondary electrons in a ratio greater than unity and sufficient to balance the leakage current from the scanned areas to the conducting member, thereby maintaining the scanned areas at at least said potential level so long as electrons in the broad beam continue to impinge thereon, said potential level admitting electrons of said broad beam to said luminescent screen to produce an image thereon, means for modulating the cross-sectional area of the scanning beam at the control screen in accordance with the signal to be reproduced, and means for periodically discontinuing the flow of electrons in the broad beam to the scanned areas to permit the charge on the scanned areas to leak away to the conductive member and restore the scanned areas to substantially their initial potentials at which the electrons in the broad beam are substantially prevented from producing an image on the luminescent screen.

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