

Aug. 8, 1939.

C. J. CALBICK

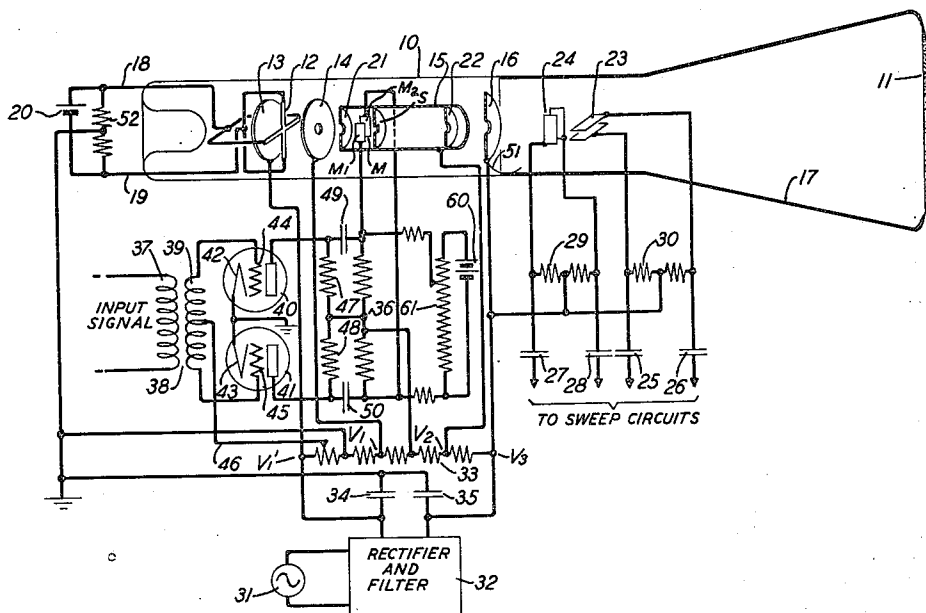
2,168,760

CATHODE RAY DEVICE

Filed Dec. 30, 1936

2 Sheets-Sheet 1

FIG. 1



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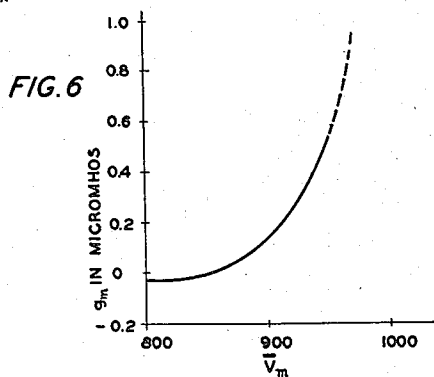
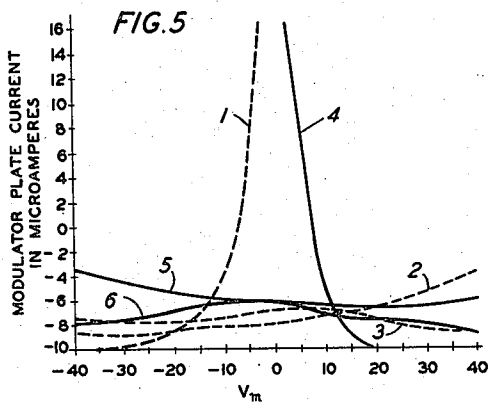
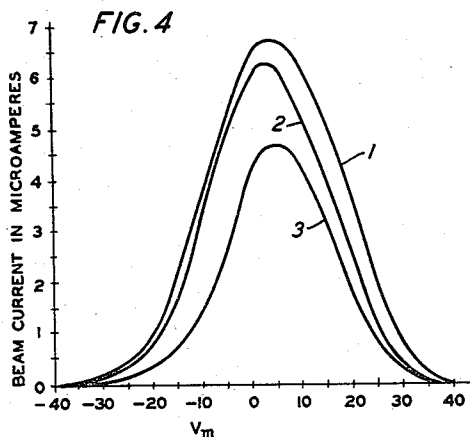
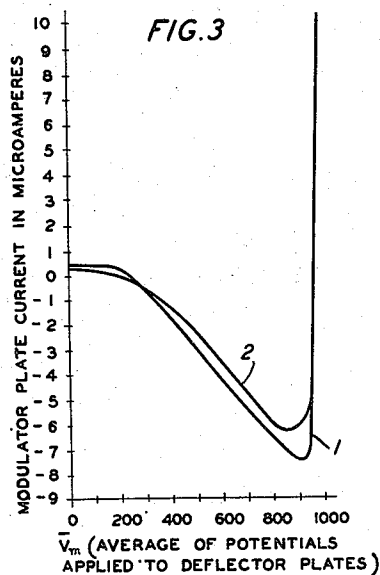
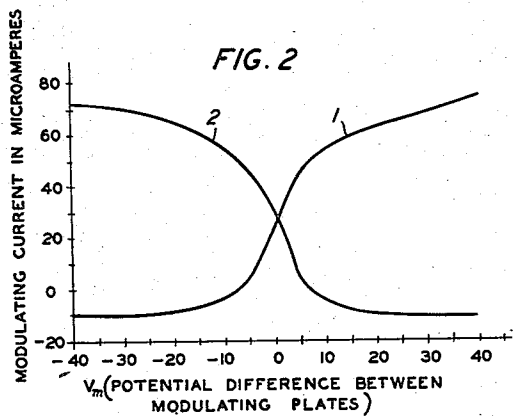
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CATHODE RAY DEVICE

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2 Sheets-Sheet 2



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2,168,760

CATHODE RAY DEVICE

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Application December 30, 1936, Serial No. 118,292

11 Claims. (Cl. 250—27)

This invention relates to cathode ray devices and more specifically to modulating systems for devices of this character.

It is an object of this invention to provide an improved modulating system for cathode ray devices used as television receivers.

In a copending application of C. J. Davisson, Serial No. 118,277, filed Dec. 30, 1936, there is described an electrode system for a cathode ray receiver tube in which modulation is achieved by deflecting a beam with respect to an aperture by means of a signal applied between a pair of deflecting plates arranged on opposite sides of the optical axis of the tube. The modulating plates are located in a field free space within a metallic cylinder having three apertured diaphragms, the middle diaphragm containing the aperture through which the electrons pass after having been deflected by the modulating plates. A high resistance is connected across the modulating plates and the mid-point is connected to the metallic cylinder. A balanced input signal is applied to the modulating plates through a pair of coupling condensers. The effect of a balanced input circuit to the modulating plates is to place the average of the potentials of the modulating plates always equal to that of the metallic cylinder within which the field free space is located. Thus the average potential of the modulating plates, inasmuch as it is the same as the average of the apertured diaphragm on either side of the plates, does not cause acceleration or deceleration of the beam which would distort the beam if it were present. With this arrangement, however, a disadvantage has been discovered, in that secondary emission from the middle apertured diaphragm in the metallic cylinder and also from the most negative (at that particular instant) of the modulating plates takes place between these elements and the more positive of the modulating plates. This, in effect, lowers the resistance path between the modulating plates or, stated differently, increases the alternating current conductance between them.

It is an object of this invention to substantially diminish the alternating current conductance between the modulating plates of a modulating system of the type described above.

It has been discovered that if the average of the potentials applied to the modulating plates is made negative by a value of from 100 to 500 volts, depending on the other constants of the tube, with respect to the potential of the cylindrical anode member containing the three apertured diaphragms, the alternating current con-

ductance between the modulating plates in the tube is very substantially reduced or, in other words, the secondary emission from the metallic diaphragms to the more positive of the modulating plates is substantially reduced. To accomplish this result, the mid-point of the high resistance across the modulating plates is connected to a point on the potentiometer resistance across which the rectifier output is applied which is negative with respect to the point at which the potential for the cylindrical anode member is taken. A balanced input signal is applied through a pair of coupling condensers to the pair of modulating plates to deflect the beam with respect to the aperture in the middle diaphragm in the cylindrical anode in accordance with the intensity of the modulating signal and hence in television in accordance with the light-tone value of the corresponding elemental area of the object at the transmitting station.

The balanced input signal is achieved by applying a signal which may be balanced or unbalanced to the primary of an input transformer, the secondary of which comprises a balanced amplifier circuit including two tubes connected in a push-pull circuit, the output of which is connected through coupling condensers to the modulating plates. In some cases, the two tubes are not necessary, the only requirement being that the secondary circuit of the input transformer be balanced with respect to a fixed potential, the value of this potential being in general, negative with respect to the potential of the apertured diaphragm.

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

Fig. 1 is a schematic diaphragm of a television receiving tube and its associated circuits embodying this invention; and

Figs. 2 to 6, inclusive, are graphical representations to assist in explaining the operation of this invention.

Referring more specifically to the drawings, Fig. 1 shows a cathode ray tube and its associated circuits for use as a television receiving device. This tube comprises a gas-tight envelope containing an electron gun assembly for generating, focusing and accelerating a beam of electrons, means for modulating this beam in accordance with signals received from a transmitting station, and means for deflecting the beam so that it traverses every elemental area in turn

of a field of view on a fluorescent screen 11 located at one end of the tube.

The electron gun arrangement comprises a cathode 12, a back plate or electrode 13, a first accelerating anode 14, a second accelerating anode 15 and a third accelerating anode 16 which is electrically connected to a conducting coating 17 of any suitable material such as aquadag on the inside walls of the tube. Broadly speaking, the electron gun arrangement comprises two electron focusing or lens systems of the electrostatic type; one a condensing lens system for concentrating a beam of electrons generated by the cathode 12 upon the aperture in the metallic diaphragm S which is located in the metallic anode cylinder 15, and the other a projection lens system for projecting an image of this electron "illuminated" aperture upon the screen or target 11. Preferably the shape of the aperture in the diaphragm S is made square or rectangular.

The cathode 12 is preferably formed in the shape of a cross from a single sheet of tungsten of the order of .001 inch thick. The opposite ends of this cross are electrically connected together and terminals 18 and 19 connected to a suitable source of heating current 20. A resistance 21 is also connected across terminals 18 and 19, the mid-point of which is connected to ground. By this method of connection the electrostatic and electromagnetic fields due to filament current and potential are reduced to substantially zero. For a more complete description of a cross-shaped element similar to the one described above, reference may be made to Patent No. 2,117,709, issued May 17, 1938, to C. J. Davisson.

The back electrode 13 comprises a circular plate spaced a short distance from the cathode 12 and parallel thereto. The first accelerating electrode 14 comprises an apertured circular plate which is located on the side of the cross-shaped filament element 12 remote from the back electrode 13. A positive potential with respect to that of the cathode is applied to the first accelerating anode 14, while a negative potential with respect to that of the cathode is applied to the back electrode 13. In order to produce a uniform field between the back electrode 13 and the first accelerating anode 14 the spacings of these members from the cathode 12 are so chosen with respect to the respective potentials applied thereto that the ratio of the potentials is equal to the ratio of the distances. The second accelerating anode 15 comprises a metallic cylinder having (starting at the end nearer the first accelerating anode 14) three circular apertured diaphragms 21, S and 22. The second accelerating anode 15 has applied thereto a positive potential with respect to that of the first accelerating anode 14. This potential and the spacings and aperture sizes of the diaphragms of the members 15 and 14 are so chosen that the electron beam is brought to a focus in the plane of the apertured diaphragm S.

The third accelerating anode 16 which, preferably, comprises a metallic circular plate having an aperture therein is placed at a positive potential with respect to that of the second accelerating anode 15. The potentials applied to the members 15 and 16 and the distance between them are so chosen that an electron image of the aperture in the plate S is formed on the fluorescent screen 11, which may be of any suitable fluorescent material such as, for example, willem-

ite. The third accelerating anode is electrically connected inside the tube to the conducting coating 17 which serves to make a field free space between the anode 16 and the fluorescent screen and at the same time to serve as a return path for the electrons impinging upon the fluorescent screen 11 to the cathode 12.

In order to cause the electron beam generated by the electron gun apparatus described above to scan every elemental area in turn of the field of view on the screen or target 11, suitable deflecting means, such as, for example, two pairs of deflecting plates 23 and 24, the axes of which are located at right-angles to each other, are provided. To the deflecting plates 23 are applied deflecting voltages of framing frequency and of saw-tooth wave form to produce the vertical deflection, while suitable deflection voltages of line scanning frequency and of saw-tooth wave form are applied to the deflecting plates 24 to produce the horizontal deflection of the beam. Any suitable sweep circuits (not shown) may be used to generate these horizontal and vertical deflecting voltages. For example, reference may be made to an application of M. W. Baldwin, Jr., Serial No. 98,165, filed Aug. 27, 1936, which discloses a suitable balanced sweep circuit for this purpose. Connections may be made from the balanced sweep circuits to the pairs of plates 23 and 24 by means of coupling condensers 25, 26 and 27, 28, respectively. High coupling resistances 29 and 30 are respectively connected across the pairs of plates. The mid-points of the resistances 29 and 30 are connected to the third accelerating anode 16 in order that the average potential of the deflecting plates does not deviate from the potential of the third accelerating anode 16 with consequent distortion of the image. For a full description of the advantages of balanced sweep circuits, reference may be made to the above-mentioned Baldwin application and also to an application of Frank Gray, Serial No. 65,606, filed Feb. 25, 1936.

The direct current potentials for biasing the different elements of the electron gun are derived from an alternating current oscillator 31, the output of which is rectified and filtered by any suitable device represented schematically by the block 32, which has in its output circuit a potentiometer resistance 33 having a plurality of taps from which the various voltages may be taken. An alternating current ground is provided for two spaced-apart terminals of the potentiometer resistance 33 by means of condensers 34 and 35 which are connected between these terminals and ground.

Modulation of the electron beam generated by the apparatus described above is achieved by applying signals between the pair of deflecting plates M₁ and M₂ which are located in a field free space determined by the cylinder 15 and the diaphragms 21 and S, all of these elements being at the same potential. The potentials applied to these plates are balanced with respect to a fixed source of potential by means of a high resistance 36, the mid-point of which is connected to a tap on the potentiometer resistance 33 which is negative with respect to the potential applied to the second accelerating anode 15 a balanced modulating circuit is connected across the terminals of the resistance 36. An input signal is applied (after demodulation by a suitable circuit or circuits) to the primary winding 37 of a transformer 38, the secondary winding 39 of which is connected to the input circuits of two tubes 40 and 75

41 which are connected in push-pull manner to produce a balanced output. The cathodes 42 and 43 of the tubes 40 and 41 are connected to ground and negative bias is applied to the grids 44 and 45 by means of a connection 46 from the mid-point of the transformer secondary winding 39 to a point on the potentiometer resistance 33 which is negative with respect to the tap representing ground potential. The output circuits of the tubes 40 and 41 include resistances 47 and 48, the common terminal of which is connected to the mid-point of the resistance 36. The output of the tubes 40 and 41 is applied to the modulating plates M through coupling condensers 49 and 50.

By means of the arrangement described in the preceding paragraph, the average of the potentials applied to the modulating plates M_1 and M_2 is at all times negative with respect to the potential applied to the accelerating anode 15 and hence the diaphragms 21 and S which are connected to the metallic cylinder. The difference between this average potential and the potential applied to the second accelerating anode 15 may be of the order of from 100 to 500 volts although it is to be understood that this invention is not limited to these specific values. While this average voltage has the effect of slowing down the beam in the deflection chamber formed by the cylinder 15 and the diaphragms 21 and S, it has been found that this does not cause objectionable distortion of the beam. The fact that when this average is made negative with respect to the potential of the electrode 15 the secondary emission, and hence the current in the modulator circuit, is very substantially reduced more than makes up for any slight distortion caused by the fact that this average is negative and hence alters slightly the velocity of the beam while going through this modulating chamber. This current flowing through the modulator circuit can very materially distort the received picture so that the elemental areas thereof are not proportional to the tone values of the respective elemental areas of the object at the transmitting station.

Modulation is achieved by deflecting the electron beam on and off of the square hole in the apertured diaphragm S. The electrons are deflected toward the more positive of the modulating plates M_1 . By thus controlling the number of electrons incident upon the square hole in the diaphragm S, modulation of the brightness of the beam can be achieved.

For a description of tube and circuit constants of a tube which has been in practical operation and which is similar to the tube described above except for the fact that in the present device the average of the modulating potentials is made negative with respect to that of the second oscillating anode, reference may be made to an application of C. J. Davisson, Serial No. 118,277, filed Dec. 30, 1936. The value of the resistance 36 may be varied slightly as a practical matter but it is not very critical. A resistor of the order of 200,000 ohms would be used, this being the same order of magnitude of the corresponding resistor in the Davisson application.

Reference will now be made to Figs. 2 to 6, which show graphic characteristics of the tube described above, in order to fully understand the operation of this invention. Fig. 2 shows curves of modulator plate current versus modulating voltage V_m for the two modulating plates M_1 and M_2 , respectively, when their average potential

$\bar{V}_m$ is equal to the potential V_2 of the second accelerating end anode 15. V_m represents the potential difference between the two modulating plates. To be more explicit, it may be defined mathematically that

$$V_m = V_{m1} - V_{m2}$$

$$\bar{V}_m = \frac{V_{m1} + V_{m2}}{2}$$

where V_{m1} and V_{m2} are the potentials, with respect to the cathode, of that modulating plate designated as M_1 , and of that modulating plate designated as M_2 , respectively. Fig. 2 shows in curve 1 that when plate M_1 is considerably, say 20 volts, positive with respect to V_2 , while plate M_2 is an equal amount negative (see curve 2), plate M_1 receives a large current of electrons, which is plotted as positive in the graph, while plate M_2 is receiving a smaller current of opposite sign, which may be attributed to its emission of excess secondary electrons. When V_m is made negative, plate M_2 receives electrons, and plate M_1 emits the excess secondary electrons. If now V_m were made an alternating voltage, an alternating current of approximately 80 microamperes peak value would flow between the modulating plates under the conditions to which Fig. 2 is applicable. In taking this curve, the ratio of the voltages applied to the back electrode 13 and the first accelerating anode 14 was made equal to 0.25, the ratio of the voltages applied to the second accelerating anode and the first accelerating anode was made equal to 7.1, and $V_2 = \bar{V}_m$ was made equal to 1000 volts. The currents to the modulating plates M_1 and M_2 are designated by i_{m1} and i_{m2} , respectively. To understand how excess secondary electrons may be emitted by the more negative of the modulating plates, it must be assumed that the electrons incident upon it, which give rise to the excess secondaries, are not primary electrons from the cathode, but are themselves secondary electrons which have been emitted from the area on which the primary beam is incident, i. e., from S and possibly also from the more positive modulating plate. Independent experimental evidence confirms the above assumption.

It will now be considered what happens when $\bar{V}_m$, that is, the average of the potentials applied to the modulating plates, is reduced, all other conditions being fixed and V_m is made equal to zero. At the point where $\bar{V}_m = V_2 = 1000$, the modulator plate currents are electron currents. As $\bar{V}_m$ is reduced (see Fig. 3), these currents decrease rapidly, pass through zero, increase to maximum values of excess secondary electron emission, and then decrease relatively slowly, and pass through zero again at the point where $\bar{V}_m$ is equal to 200. It is evident from Fig. 3 that if $\bar{V}_m$ lies only slightly below V_2 small fluctuations in voltage or possibly slight variations in character of surface bombarded by the primary beam will give rise to large fluctuations in modulator plate current. It is therefore desirable to operate with $\bar{V}_m$ less than its value at the maximum of Fig. 3, provided this does not greatly reduce beam current.

A modulation curve may be defined as a curve plotted with beam current as ordinates and modulating voltage as abscissae. Fig. 4 shows a group of modulation curves for several values of $\bar{V}_m$. Curve 1 is a modulation curve taken when $\bar{V}_m$ is equal to 1000, curve 2 when $\bar{V}_m$ is equal to

900 and curve 3 when $\bar{V}_m$ is equal to 800, in all three curves V_2 being placed equal to 1000 volts. It should be noted that the peak of the modulation curve does not occur at $V_m=0$, but has a slightly positive value, and also that a longer linear region is available on the right than on the left side of the maximum. This region is therefore selected for operation, modulating bias of about 20 volts being indicated, the exact value depending on type of signal voltage applied to the modulator. It is evident that the maximum beam current is not greatly reduced by operating with $\bar{V}_m$ less than V_2 . This bias is obtained by means of a suitable source of potential 60 and a potentiometer resistance 61.

Fig. 5 shows the curves of modulator plate currents versus V_m . In taking these curves V_2 was made equal to 1000 volts, and the voltage ratios between the plates were made the same as in the case wherein the data for Fig. 2 were taken. The dotted curves 1, 2 and 3 represent the modulator plate currents to the more positive of the modulating deflecting plates M_1 , when $\bar{V}_m$ is respectively 1000, 900 and 800 volts while curves 4, 5 and 6 are respectively the corresponding curves for these values of $\bar{V}_m$ in the circuit to the more negative of the modulating plates M_2 . It should be noted how sharply the modulator plate currents are reduced when $\bar{V}_m$ is decreased 100 or 200 volts from the potential of V_2 .

Fig. 6 shows the alternating current conductance as a function of $\bar{V}_m$, which goes to zero at approximately 850 volts. The alternating current conductance g_m is defined by the relation

$$g_m = \frac{d}{dV_m}(i_{m1} - i_{m2})$$

The value $\bar{V}_m=850$ is, therefore, chosen as the operating value, although it is not at all critical since any conductance less than 10^{-6} mhos is probably satisfactory.

It is also possible to calculate the transconductance

$$\frac{di_3}{dV_m}$$

over the linear range. Related to

$$\frac{di_3}{dV_m}$$

is a quantity

$$\mu = \frac{V_3}{i_3'} \cdot \frac{di_3}{dV_m}$$

which proves to be of considerable engineering importance in television receivers. Here i_3' is the maximum value of i_3 for a given set of operating conditions, i. e., the maximum value is the linear part of the scanning modulation curve. Assuming that screen brightness B is proportional to i_3 we may write

$$\mu = d\left(\frac{B}{B'}\right) / d\left(\frac{V_m}{V_3}\right)$$

Where B' is the maximum brightness, thus showing that μ is the rate of change of percentage brightness with

$$\frac{V_m}{V_3}$$

An efficient receiver will have a large value of μ and it is desirable that for a given receiver, μ should be the same for all operating conditions. From Fig. 6, μ is equal to 170 ± 5 for values of $\bar{V}_m$ from 800 to 1000 volts. If values

are taken for a case where emission is limited by temperature of the cathode μ increases to about 190. This represents a fairly wide jump in operating conditions, so that it appears certain that μ will lie between 160 and 200 for all probable conditions. If we call μ the modulation brightness sensitivity, then the present tube has a sensitivity of 175 ± 10 for virtually all conditions likely to be encountered.

Summing up the tube characteristics, the recommended operating conditions are:

$$\frac{-V_1'}{V_1} = 0.26$$

$$\frac{V_2}{V_1} = 7.1$$

$$\frac{V_3}{V_2} = 4.2$$

$$\frac{\bar{V}_m}{V_2} = 0.85$$

$$I_a = 4.3 \text{ amperes for maximum brightness or a smaller value for lower brightness.}$$

In addition to these constants μ is 175 ± 10 and the alternating current conductance across the modulator terminals is of the order of 10^{-8} mhos. The recommended spacings between the elements of the electron gun are as follows: Between the back electrode 13 and the filament 12, 2 millimeters; between the filament 12 and the first accelerating anode 14, 6 millimeters; between the first accelerating anode 14 and the diaphragm 21, 4 millimeters; between the diaphragm 21 and the diaphragm S, 10 millimeters; between the diaphragm S and the diaphragm 22, 45 millimeters; between the diaphragm 22 and the apertured diaphragm 16 comprising the third accelerating anode, 15 millimeters; and between the third accelerating anode 16 and the fluorescent screen 11, 30 centimeters. With these spacings and with the voltage ratios given above, a very fine intense spot is produced on the fluorescent screen 11.

Various modifications may obviously be made without departing from the spirit of the invention, the scope of this invention being defined by the appended claims.

What is claimed is:

1. In a cathode ray device, a cathode for generating a beam of electrons, an apertured plate in the path of said beam of electrons, said plate being placed at a potential which is positive with respect to that of said cathode, a pair of plates between said apertured plate and said cathode located on opposite sides of the beam for modulating said beam by deflecting it with respect to said aperture to vary the number of electrons which pass through said aperture in accordance with signals, certain of the electrons in said beam being caused to strike said plate resulting in the emission of secondary electrons, and means for placing the average of the potentials applied to the modulating plates at any time at a potential which is negative with respect to that of the apertured plate to greatly reduce the flow of secondary electrons between said apertured plate and either of the modulating plates.

2. In a cathode ray device, a pair of electrode elements, means for placing said electrode elements at the same potential to constitute a field free space between them, a pair of modulating plates in said field free space, means for passing an electron beam through said field free space

and between said modulating plates, certain of the electrons of said beam being caused to strike the remote electrode element in the path of the beam resulting in the emission of secondary electrons, and means for placing the average of the potentials applied to said modulating plates at a potential which is negative with respect to that of the electrodes constituting the field free space to greatly reduce the flow of secondary electrons between said remote electrode element and either of said modulating plates.

3. In a cathode ray device, means for generating a beam of electrons, an apertured anode, a pair of modulating plates located on opposite sides of the beam and adjacent said anode on the side thereof nearer said cathode, a high resistance connected across the plates, a source of potential, a connection from the mid-point of said resistance through said source of potential to said anode, and means for applying signals to said plates to modulate said beam by deflecting said beam with respect to the aperture in said anode, said source being so poled that the flow to either of said modulating plates of secondary electrons which are emitted from said anode by the action of said beam of electrons to either of said modulating plates is greatly reduced.

4. A modulating circuit for a cathode ray device comprising two electron discharge devices connected in push-pull manner, a pair of modulating plates in said cathode ray tube, a pair of coupling condensers and a coupling resistance for connecting the output circuit of said pair of tubes to said pair of modulating plates, an anode, a source of potential, and means for connecting substantially the mid-point of said coupling resistance to said source of potential in such a manner that the flow of secondary electrons from said anode to either of said modulating plates is greatly reduced.

5. In a cathode ray device, an apertured diaphragm, means for causing a beam of electrons to pass through said apertured diaphragm, a pair of modulating plates located on opposite sides of said beam and between said apertured diaphragm and said beam generating means, and means for applying to said modulating plates a signal which is balanced with respect to a potential which is fixed and negative with respect to the potential of the apertured diaphragm to greatly reduce the flow of secondary electrons from said diaphragm to either of said modulating plates.

6. In a cathode ray device, means for generating a beam of electrons, an apertured diaphragm, a screen, electron optical means for focusing said electrons upon said apertured plate, a pair of modulating plates, located on opposite sides of the path of the beam between said beam generating means and said apertured plate for deflecting the beam with respect to the aperture in said plate in accordance with signals, means for projecting an image of the aperture in said plate upon said screen, and means for applying to said modulating plates potentials which are balanced with respect to a potential which is negative to that of said apertured plate to greatly reduce the flow of secondary electrons from said diaphragm to either of said modulating plates.

7. In a cathode ray device, means for generating a beam of electrons, an apertured anode, a pair of modulating plates located on opposite sides of the beam and adjacent said anode,

means for placing a direct current bias between the plates to vary the position of the beam with respect to the aperture in said anode when said beam is in its neutral position, and means for applying signals to said plates to modulate said beam by deflecting it with respect to said aperture to vary the number of electrons which pass therethrough.

8. In a cathode ray device, a cathode for generating a beam of electrons, a cylindrical anode having three apertured diaphragms therein all of which are placed at the same potential, a pair of modulating plates placed on opposite sides of an axial line drawn through the centers of said apertured diaphragms and located between the first and second of said apertured diaphragms, considering the first of said diaphragms as the one nearest said cathode, means for focussing said beam upon the plane of said second diaphragm, a high resistance connected between said modulating plates, means for connecting a balanced circuit serving as a source of signals to said modulating plates to deflect the beam with respect to the aperture in said second diaphragm to vary the number of electrons which pass through said aperture in accordance with said signals, a source of potential, and means for connecting substantially the mid-point of said high resistance through said source of potential to said cylindrical anode, said source of potential being so poled that the flow to either of said modulating plates of secondary electrons which result from certain of the primary electrons of said beam impinging upon said second diaphragm is greatly reduced.

9. In a cathode ray device, a cathode for generating a beam of electrons, a cylindrical anode having three apertured diaphragms therein all of which are placed at the same potential, a pair of modulating plates placed on opposite sides of an axial line drawn through the centers of said apertured diaphragms and located between the first and second of said apertured diaphragms, considering the first of said diaphragms as being nearest said cathode, means for focussing said beam upon the plane of said second diaphragm, a high resistance connected between said modulating plates, means for connecting a balanced circuit serving as a source of signals to said modulating plates to deflect the beam with respect to the aperture in said second diaphragm to vary the number of electrons which pass through said aperture in accordance with said signals, a source of potential, means for connecting substantially the mid-point of said high resistance through said source of potential to said cylindrical anode, said source of potential being so poled that the flow to either of said modulating plates of secondary electrons which result from certain of the primary electrons of said beam impinging upon said second diaphragm is greatly reduced, and means for applying a source of variable direct current across the terminals of said modulating plates to vary the focal point of said beam in its neutral or undeflected position with respect to the aperture of said second diaphragm.

10. In a cathode ray device, a cathode for generating a beam of electrons, a screen or target, a cylindrical anode having three apertured diaphragms therein all of which are placed at the same potential, a pair of modulating plates placed on opposite sides of an axial line drawn through the centers of said apertured diaphragms and located between the first and

second of said apertured diaphragms, considering the first of said diaphragms as the one nearest said cathode, means for focussing said beam upon the plane of said second diaphragm, a high resistance connected between the modulating plates, means for connecting a balanced circuit serving as a source of signals to said modulating plates to deflect the beam with respect to the aperture in said second diaphragm to vary the number of electrons which pass through said aperture in accordance with said signals, a source of potential, means for connecting substantially the mid-point of said high resistance through said source of potential to said cylindrical anode, said source of potential being so poled that the flow to either of said modulating plates of secondary electrons which result from certain of the primary electrons of said beam impinging upon said second diaphragm is greatly reduced, means including an apertured plate and the third of said apertured diaphragms in said cylindrical anode for focussing an image of the aperture in said second apertured diaphragm upon said screen or target, means including two pairs of electrostatic deflecting plates for causing said beam to scan every elemental area in turn of said screen or target, a high resistance connected between the respective plates of each pair of deflecting plates, means for connecting substantially the mid-point of said last-mentioned high resistances to said apertured plates, and means for placing said apertured plate at a positive potential with respect to said cylindrical anode.

11. A cathode ray device comprising a cross-shaped cathode for generating a stream of electrons, a back electrode, a first anode, a second anode comprising three apertured diaphragms at the same potential, a third accelerating anode,

two pairs of electrostatic deflecting plates, and a screen or target, means for applying a negative potential with respect to said cathode to said backing plate and a positive potential with respect to said cathode to said first anode to cause said beam to be focussed upon the aperture in the middle of said diaphragms, means including a pair of plates located on opposite sides of the beam between the first and middle diaphragms in said second anode, considering the diaphragm nearest the cathode as the first diaphragm, for deflecting said beam with respect to the aperture of said diaphragm, means for applying a positive potential with respect to said first anode to said second anode, means for applying a positive potential with respect to said second anode to said third anode whereby an electron image of the aperture in said middle diaphragm is projected upon said screen or target, means for applying a balanced input circuit to said modulating plates, means for connecting a high resistance between said modulating plates, a source of potential, means for connecting substantially the mid-point of said high resistance through said source of potential to said second anode, said source of potential being so poled that the flow to either of said modulating plates of secondary electrons which result from certain of the primary electrons of said beam impinging upon the middle diaphragm of said second anode is greatly reduced, means for applying a variable direct current between the plates to vary the position of the beam with respect to the aperture in said middle diaphragm in its neutral or undeflected position, and means for placing the average of the potentials of each of said pairs of deflecting plates at the same potential as said third anode.

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