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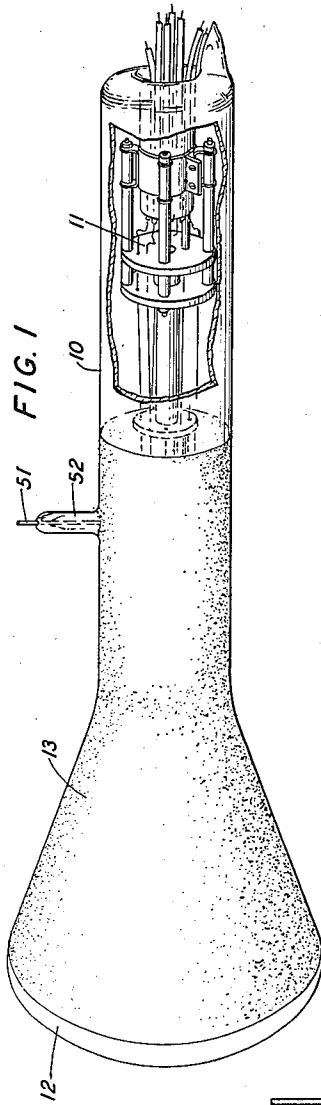
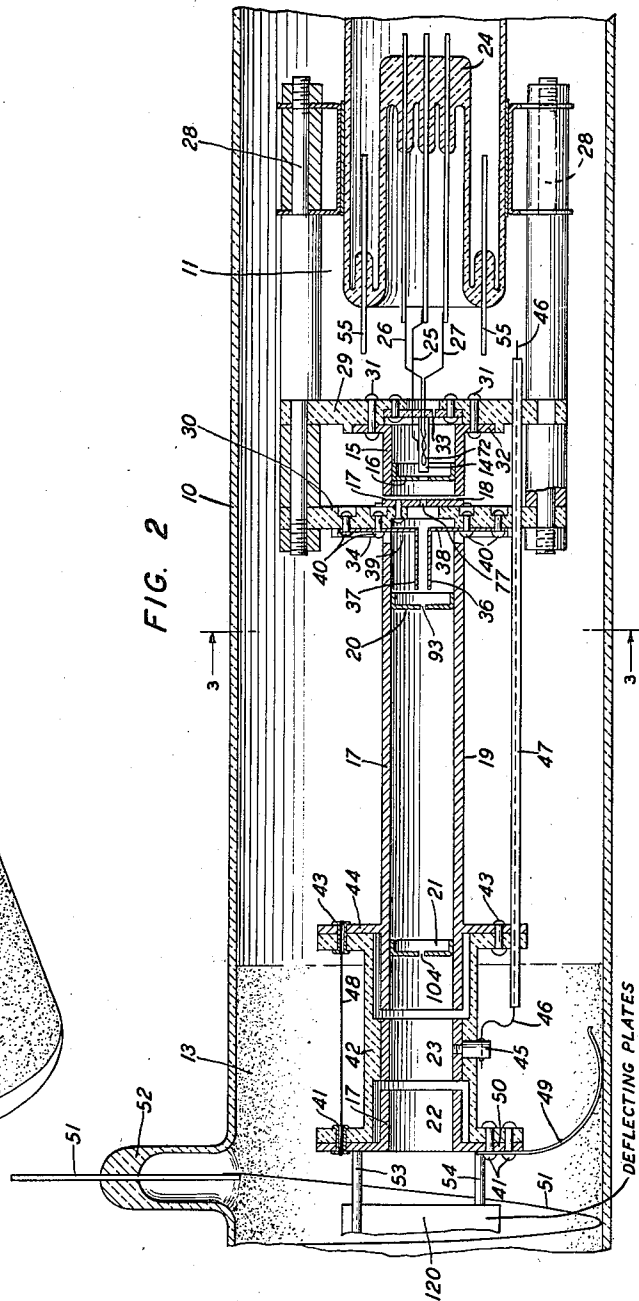
F. GRAY

2,296,102

CATHODE RAY DEVICE

Original Filed March 22, 1940

2 Sheets-Sheet 1



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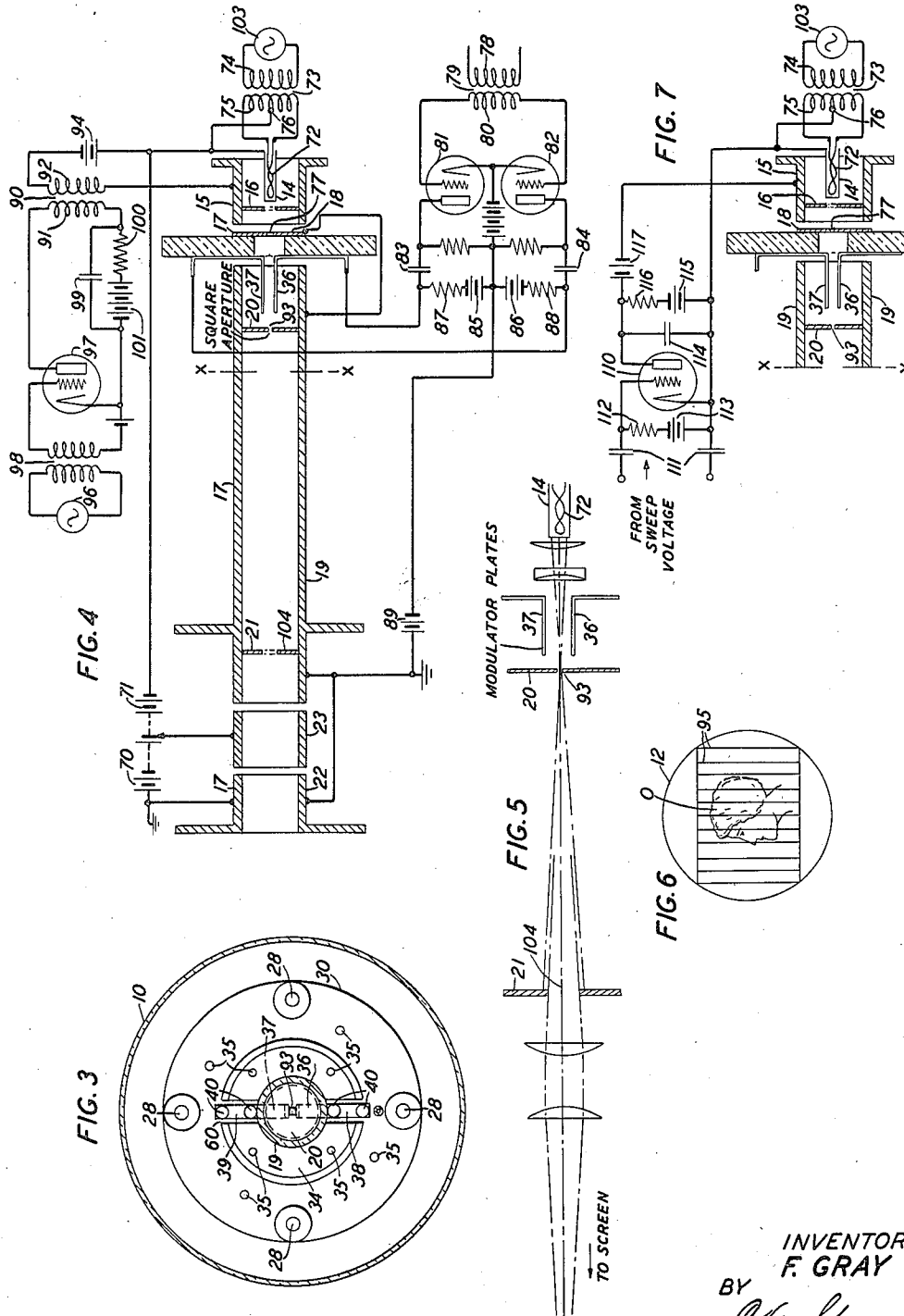
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UNITED STATES PATENT OFFICE

2,296,102

CATHODE RAY DEVICE

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Original application March 22, 1940, Serial No. 325,345. Divided and this application October 31, 1940, Serial No. 363,588

16 Claims. (Cl. 250—27)

This application relates to electron optical apparatus and also to image production, and more specifically to electron arrangements for cathode ray tubes.

This application is a division of an application, Serial No. 325,345, filed March 22, 1940, by Frank Gray.

An object of this invention is to provide a novel electron optical system for a cathode ray device.

In Patent 2,217,198, issued October 8, 1940, to C. J. Davisson, there is described an electrode system for a cathode ray television receiver tube in which modulation is achieved by deflecting a beam of electrons with respect to an aperture by means of a signal applied between a pair of modulating plates arranged on opposite sides of the axis of the tube. In the Davisson tube, a cross-shaped cathode is located in a uniform field which is not varied in accordance with signals, the only varying potential being applied to the modulating plates which are balanced with respect to a point of fixed potential. While signals other than the television signals, such as timing pulses or blanking pulses, may be applied to the modulating plates in addition to the television signals, this is usually not desirable as the modulating plate circuits are frequently designed to have a certain impedance and this impedance is varied when other signals are mixed in with the television signals. It is, therefore, desirable to have means in addition to the modulating plates for modulating the beam intensity.

It is a further object of this invention to provide a cathode ray device in which two different types of modulating means are provided to simultaneously control the intensity of the beam which reaches the screen or target.

In the present invention, means are provided for modulating the beam in the vicinity of the cathode and also for modulating it at a point more remote from the cathode by deflecting the beam with respect to an aperture in a diaphragm. Thus, signal voltages from a transmitting station can be applied to the modulating plates to modulate the beam by deflecting it with respect to an aperture, and a control voltage, such as a timing pulse or a voltage to prevent the beam from reaching the screen when the sweep circuits are not operating, can be applied to the cylinder surrounding the cathode to change the field in the vicinity of the cathode. A negative voltage on this cylinder both defocusses the beam with respect to a small aperture adjacent the modulating plates and cuts down the emission of electrons from the cathode, thus furnishing a method

of control in addition to that furnished by the modulating plates.

In an embodiment of this invention, shown by way of example for purposes of illustration, a cathode ray tube is provided which employs two means for modulating the intensity of the beam, one of these means preferably being balanced and the other being unbalanced. The electron gun arrangement of this cathode ray tube preferably comprises a cathode, a control cylinder surrounding and negatively biased with respect to the cathode for focussing electrons from said cathode to a focal point, a three-part first anode comprising an apertured diaphragm member, a relatively long tubular member having two apertured diaphragms therein, the first one (the one nearer the cathode) being the focal point of the electron beam, and a relatively short tubular member, a second anode placed between the two tubular members of the first anode, a pair of modulating plates placed between the apertured diaphragm member and the first apertured diaphragm in the long tubular member, and a conducting coating on the inner wall of the tube. The intensity of the beam can be controlled by applying a signal voltage, balanced with respect to a point of fixed potential, between the modulating plates and also by controlling the potential of a negatively biased control cylinder surrounding the cathode. All members of the first anode and the conducting coating are preferably placed at ground potential which is also the average potential of the deflecting plates. The average of the potentials applied to the modulating plates is preferably made negative with respect to the first anode to prevent a flow of secondary electrons emitted from the anode from influencing the television circuit.

The tube described in the preceding paragraph is adaptable for many types of circuits, two simple forms of which are illustrated in the drawings. In one of these circuits a time scale is superposed on the image on the fluorescent screen of the tube by means of sharp periodic impulses which are applied to the focussing cylinder around the cathode. Each impulse defocusses and also suppresses the beam current, and the result is a series of black lines across the image field, these lines constituting a time scale. By means of this circuit it is possible to study the distortion of television images introduced by the transmission channel, such as echo or "ghost" effects, it often being desirable to know the time intervals between different features of the distortion. The period between the black lines in

the image is the reciprocal of the frequency of the pulses.

A second illustrative circuit is one in which the beam is suppressed in the absence of any sweep voltage on the television tube to prevent the screen from being burned. In this circuit a portion of the sweep voltage is applied to a discharge tube through a high input resistance so that very little power is drawn from the sweep circuit. This discharge tube is biased negatively so that it passes no current in the absence of a sweep signal. Assuming that the sweep signal is cut off, then the voltage on the focussing cylinder around the cathode is made large enough to defocus the beam and to cut down the current from the cathode to such an extent that there is substantially no current in the electron beam of the television tube. When the sweep voltage is turned on, the discharge tube passes current and substantially shorts at least a portion of the biasing voltage, thus making it possible for a large beam current to pass to the screen. The television tube is thus in operation only when the sweep voltage is on.

Other and ancillary objects and features will be apparent from the following description, the accompanying drawings and the appended claims.

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

Fig. 1 is a perspective view of the cathode ray tube of this invention;

Fig. 2 is an enlarged longitudinal cross-section of a portion of the tube of Fig. 1 showing the electron gun arrangement in the tube;

Fig. 3 is a cross-section taken along line 3—3 of Fig. 2;

Fig. 4 is a schematic view of the electron gun of Fig. 2 with circuit connections therefor for applying a timing potential to the focusing cylinder of the gun;

Fig. 5 shows schematically an equivalent optical system corresponding to the electron optical system of the electron gun of Fig. 2;

Fig. 6 is an end view of the fluorescent screen of the tube shown in Fig. 1 showing the timing scale introduced by the circuit shown in Fig. 4; and

Fig. 7 is a schematic diagram of a portion of the electron optical system of Fig. 2 together with a circuit for cutting off or at least substantially decreasing the intensity of the beam when the sweep voltage is off.

Referring more specifically to the drawings, Fig. 1 shows a cathode ray tube preferably adapted for television reception having an envelope 10 enclosing an electron gun arrangement 11, two pairs of electrostatic deflecting plates 120 for producing deflection of the beam so that it is possible to scan every elemental area of a field at the end of the tube, and a fluorescent screen 12. A coating 13 of Aquadag or any similar material covers the inside wall of a large portion of the tube.

Referring now to Fig. 2, wherein the electron gun arrangement is shown in greater detail, the electron optical system 11 comprises a cathode 14, a control cylinder 15 surrounding the cathode 14 and having an apertured diaphragm 16 therein closely adjacent the end of the cathode 14, a first anode 17 comprising an apertured diaphragm 18, a long tubular member 19 having two apertured diaphragms 20 and 21 therein, and a short tubular member 22, and a second anode 23 placed

between the long cylinder 19 and the short cylinder 22. Within the member 19 is arranged a pair of modulating plates 36 and 37.

The cathode 14 is supported from a press 24 by means of a supporting wire 25. Supporting wires 26 and 27 are electrical connections to a heater 72 for the cathode. Also supported from the press 24 are four rods 28 of any suitable conducting material, such as aluminum, which rods, in turn, support insulating discs 29 and 30 which hold the cylinder 15, the diaphragm 18, the tubular member 19 and the modulating plates 36 and 37 in place within the tube 10. The cylinder 15 is attached to the disc 29 by rivets or bolts 31 which pierce a flange 32 of the cylinder 15. The cathode 14 is held in position within the interior of the cylinder 15 by means of an apertured insulating disc 33 which is riveted to the disc 29. The long tubular member 19 is held in position within the tube 10 by means of a flange 34 which is attached to the insulating disc 30 by means of rivets 35 (see Fig. 3). A pair of metallic modulating plates 36, 37 is held in position within the long tubular member 19 by means of flanges 38 and 39 thereon which are attached to the insulating disc 30 by means of rivets 40. The short tubular member 22 is attached by means of rivets 41 to an insulating cylinder 42 which is in turn attached by means of rivets 43 to a flange 44 on the long tubular member 19. The second anode 23 is positioned within the insulating cylinder 42 and connection is made to the cylinder by means of lug 45 to which is attached a connecting wire 46 which passes through the glass insulating tubing 47 to the stem 24. Electrical contact is made between the long tubular member 19 and the short tubular member 22 by means of a contact wire 48. A contact is made from the short tubular member 22 to the conducting coating 13 by means of spring contact member 49 which is fastened to the flange 50 on the tubular member 22 by means of rivets 41. Connection between the long tubular member 19 and the diaphragm 18 is made by means of rivets 35. Electrical contact between the conducting coating and the outside is made by means of a contact member 51 which passes out through a press 52 in the side of the tube. Deflecting plates 120 (not shown in full) are attached to the electron gun structure by means of supports 53 and 54. The leads to the deflecting plates and to the focussing or control electrodes have not been shown connected to these elements for the sake of simplicity in the drawing, but these leads 55 pass through the press 24. There are eight leads 55 in all, four of them being for the deflecting plates, two for the modulating plates, one for the second anode 22 and one for the focussing or control electrode 15. The lead 46 also passes out through the press.

In Fig. 3 is shown the manner in which the modulating plates 36 and 37 are supported without making contact to the flange 34 of the tubular member 19. The flange 34 has a gap 60 therein within which the supporting members 38 and 39 for the plates 36 and 37 extend and are riveted to the insulating disc 30. Leads 55 (not shown in this figure) are connected to the supporting members 38 and 39 to make contact with the modulating plates 36 and 37 which are preferably made of aluminum material $\frac{1}{8}$ -inch wide and .01 inch in thickness, although it is to be understood that these dimensions are merely given by way of example of a practical embodiment of this invention.

In Fig. 4 a schematic representation of the

electron gun arrangement 11 is shown together with one of many circuit arrangements for which it is adapted. In this arrangement the first anode 17 is preferably placed at ground or some other fixed or reference potential thus placing the diaphragm 18, the long tubular element 19 and the short tubular element 22 all at ground potential. The first anode 17 is made positive with respect to the second anode 23 by means of a source of potential 70. The second anode 23, in turn, is made positive with respect to the cathode 14 by means of the source 71. Heating current for the heater 72 of the cathode 14 is supplied from transformer 73 having a primary winding 74 and a secondary winding 75. The mid-tap 76 of the secondary winding is placed at the potential of the cathode 14. The primary winding 74 is connected to a suitable source of heating current 103.

As an example of voltages actually used on a tube of the type being described, the second anode member 23 is made about 1500 volts negative with respect to the potential of the first anode member 17 (ground) and the cathode is about 3000 volts negative with respect to ground. In operation, electrons are drawn from the end of the equipotential cathode 14 by the relatively positive potential on the diaphragm 18 of the first anode located directly in front of the cathode and condensed by the negative cylinder 15 (usually placed 100 to 200 volts negative with respect to the cathode 14) upon a small aperture 93 in the diaphragm 20. An electron image of this aperture is then projected on the fluorescent screen 12 (shown in Fig. 1) by the lens system near the end of the long tubular anode 19. (See Fig. 5 for the substantially equivalent optical system for the electron gun system of this invention.) This lens system is in effect constructed by cutting a section out of the long tubular anode 19 and replacing it with the tubing 23 at a lower potential. The diaphragm 21 with the aperture 104 therein confines the electron beam to the center of this lens system and reduces the aberration that would otherwise result from edge effect in the lenses. The intensity of the projected image may be controlled by a television signal applied to the pair of modulator plates 36, 37 which deflect the incident beam of electrons on or off the small aperture 93 in the diaphragm 20. This aperture is preferably of the order of .006 inch square (all other apertures in the electron lens system being circular). The condensing cylinder 15 contains an apertured plate 16 primarily introduced to furnish a reference position for centering the cathode in the mechanical assembly of the tube. Having been introduced it plays a role in the electron condensing system and the required value of the negative focussing voltage is to a large degree determined by the distance the cathode is located behind this plate.

The television signal which is applied across the pair of modulating plates 36 and 37 is shown in the drawing as being applied to the primary winding 78 of a transformer 79. The secondary winding 80 is connected to the input of a balanced amplifier arrangement represented by the tubes 81 and 82, the output of which is connected through coupling condensers 83 and 84 to the deflecting plates 36 and 37. Connected across the plates 36 and 37 in series with equivalent batteries 85 and 86 are equivalent high resistances 87 and 88. The common terminal of the batteries 85 and 86 is connected through a source

of potential 89 to ground which is the potential of the first anode member 17. The source of potential 89 biases the pair of plates 36 and 37 as a whole negatively with respect to the first anode and thus prevents any flow of secondary electrons back into the television circuit. For a more complete description of a circuit employing the feature of biasing the plates negatively with respect to a limiting aperture adjacent thereto, reference may be made to Patent 2,168,760, issued August 8, 1939, to C. J. Calbick. The sources of potential 85 and 86 are included in the circuit to partially deflect the beam off the aperture 93 so that the tube operates on the more linear portion of its characteristic. For a more detailed description of tubes employing balanced modulation by deflecting a beam with respect to an aperture and characteristic curves for this type of tube, reference may be made to Patent 2,217,197, issued October 8, 1940, to C. J. Davison, and to the above-mentioned Calbick patent.

When the tube is used as an oscillograph the modulating plates 36 and 37 may be connected to ground with a variable voltage in one plate lead for controlling the intensity of the beam. In cases where it is desirable, this variable voltage may be an electrical signal for turning the beam off and on, such as a time signal for giving a time scale on the tube. Such a case will be described more fully below in connection with a television arrangement but the principle may be used for oscillographic purposes as well.

The tube is adjusted as follows: With a reasonable negative voltage of about 150 volts on the condensing cylinder 15, voltages of the values given above are applied to the anodes, and the spot on the screen 12 is roughly focussed by adjusting the voltage on the anode 23. The voltage on the condensing cylinder 15 and the biasing voltage on the modulating plates are then adjusted to give maximum brightness. Under these conditions, the beam of electrons is usually centered directly on the small aperture 93. If, however, the tube is slightly misaligned the alignment can be corrected by placing a small magnet or other magnetic field forming means outside the tube to hold the beam in place. The spot on the screen is then given a final focus by adjusting the voltage on the anode member 23 to such a value that the spot on the screen remains stationary when its intensity is varied with the modulating plates. In the tubes so far constructed the mechanical alignment has been sufficiently accurate to center the beam directly on the small aperture and no external magnet has been necessary. Fig. 2 is drawn to scale except for the aperture sizes which are as follows: The aperture in diaphragm 16, 0.080 inch, the aperture 77 in diaphragm 18, $\frac{1}{8}$ inch, the aperture 93 in diaphragm 20, 0.006 x 0.006 inch and the aperture 104 in diaphragm 21, $\frac{1}{8}$ inch. The modulating plates 36 and 37 are $\frac{1}{8}$ inch wide x 0.010 inch thick. The tube 19 is 3 $\frac{3}{4}$ inches long.

It is an important feature of the present tube that the intensity of the beam can also be controlled by a voltage applied to the condensing cylinder 15. An increase in the negative voltage on this cylinder both defocusses the beam from the small aperture 93 and cuts down the emission of electrons from the cathode, thus furnishing a sensitive method of control. For a description of another arrangement where modulation is obtained by varying the emission from a cathode and simultaneously defocussing the beam with respect to an aperture, reference may be made

to Patent 2,260,313 issued Oct. 28, 1941, to Frank Gray. In cases where it is desirable, the intensity of the beam can therefore be simultaneously controlled by two independent circuits or signals; one applied to the modulating plates and the other to the condensing cylinder.

In the arrangement shown in Fig. 4 and to be hereinafter described, a timing circuit is utilized but it is not essential that the voltage applied to the cylinder 15 be of the simple form generated by the apparatus shown in Fig. 4. Instead of the circuit arrangement shown for applying this voltage to the cylinder 15, there may be applied a more complex signaling voltage such as that supplied, for example, to the transformer 79. If desired, phase adjusting means can be supplied to give the two signaling means any desired phase relation. This latter feature of supplying signal voltages of the same kind but differing in phase may also be carried out by the use of a cathode ray tube with a single modulating means upon which said signal voltages are simultaneously impressed. However, it is more satisfactory to use the two methods of control rather than one, as the modulating plate input circuits are designed for a fixed impedance and this impedance would be varied if additional signals were mixed with those originally intended for the circuit. In the arrangement of Fig. 4, a timing circuit is connected by means of a transformer 90 having a primary winding 91 and a secondary winding 92 between the cathode 14 and the focussing cylinder 15. A source of potential such as the battery 94 is also connected in the circuit including the secondary winding 92 of the transformer 90. This source 94 biases the cylinder 15 negatively with respect to the cathode 14 to focus the beam on the small aperture 93. The pulses causing the formation of the time scale (such as is shown by the vertical lines 95 in Fig. 6 which are superimposed upon the image O on the field of the fluorescent screen 12) are applied to the focussing cylinder 15 through the transformer 90. Each impulse defocusses the beam with respect to the aperture 93 and also suppresses the beam current. The result is a series of black lines across the image field as shown in Fig. 6, these lines constituting a time scale.

The impulses may be generated by applying an alternating current voltage of known frequency from a suitable source 96 to the grid of a trigger tube such as the "Thyratron" 97 through a transformer 98. When the trigger tube 97 is not passing current, the capacity 99 in the cathode-plate circuit of the tube 97 charges up through the resistance 100, it receiving charging current from a source of potential 101. When the tube 97 breaks down on a peak of the alternating current voltage, the condenser 99 suddenly discharges through the transformer winding 91 and impresses a sharp voltage impulse on the focussing cylinder 15. The period between the black lines 95 in the image field of Fig. 6 is the reciprocal of the alternating current frequency and the lines thus constitute a background time scale superimposed on the image. In studying the distortions in television images introduced by the transmission channel, such as echo effects which produce "ghosts" in the television image, it is desirable to know the time interval between different features of the distortion. This circuit and this cathode ray tube make it possible to study these distortions. To make the time scale remain stationary on the image, the alternating current frequency should be an integral multiple

of the line scanning frequency. If trouble is encountered in avoiding drift of the lines 95 there may be substituted for the source 96 an arrangement in which the line scanning synchronizing signal (for controlling the line or high frequency sweep circuit in television) is obtained from the composite received television receiver by any known means and fed into a harmonic generator which is not shown but is well known in the art. Proper phasing means may also be provided for the time scale. For rapid operation, the trigger tube 97 may be a high vacuum tube. If desired, two lines or sets of lines at right angles to each other may be formed by providing, in addition, a circuit similar to that described above but in which the frequency is a multiple of the frame frequency. Moreover, it is obvious that the background pattern introduced need not be straight lines nor need the whole pattern be of the same intensity, as the pattern and the intensity of the background may be controlled at will at the local receiving station by varying the signal applied to the focussing cylinder 15. As a further modification, the television signal may be applied to the focussing cylinder 15 and the timing or background signals applied to the modulating plates 36, 37. Moreover, by proper arrangement, the background lines may be white rather than black.

A second circuit for which the tube of this invention is particularly adapted is shown in Fig. 7. This figure shows a circuit for suppressing the beam in the absence of any sweep voltage on the television tube to prevent the screen from being burned. In this circuit the portion to the left of line X—X is the same as that to the left of the line X—X in Fig. 4 and the sources of voltages and connections therefrom to the various electrode elements are the same as in Fig. 4 so will not be repeated. In this circuit a fraction of the power of one of the sweep voltage waves is applied to the grid of a tube 110 through coupling condensers 111. The input resistance 112 for the tube 110 is made high so that very little power is drawn from the sweep circuit. The grid of the tube 110 is biased negatively by means of a suitable source 113 so that it passes no current in the absence of a sweep signal. Connected between the anode and the cathode of the tube 110 is a condenser 114, the purpose of which will be explained below. Also across the anode-cathode path of tube 110 is a source 115 and a resistance 116. The anode of the tube 110 is connected to the focussing cylinder 15 through a source 117 and the cathode of the tube 110 is connected to the midpoint 76 of the secondary winding 75 of the transformer 73 and the cathode 14.

Suppose now that there is no sweep signal being applied to one pair of the deflecting plates 123 and also to the input circuit of the tube 110, then the voltage on the focussing cylinder 15 is approximately equal to the total voltage output of the sources 115 and 117. This is large enough to defocus the beam and suppress the current from the cathode 14 to such an extent that there is substantially no current in the electron beam of the television tube. When the beam is defocussed the aperture 104 in the diaphragm 21 cuts off a large number of the electrons in the beam. Thus only a relatively small central portion of the beam gets through the aperture 104 to pass to the screen and this amount is further decreased because of the suppression of the beam by means of the voltage applied to the negative cylinder 15.

When the sweep voltage is applied to the plates

120 and to the tube 110, the tube 110 passes current to substantially short out the source 115 from the cathode circuit, because the source 115 has a large series resistance 116. The bias on the cylinder 15 is then about equal to the voltage from the source 117. This voltage is adjusted so that it focusses the beam on the small aperture 93 in the television tube. There is then a large beam current to the screen 12. The television tube 10 is thus in operation only when the sweep voltage is on. The capacity 114 smooths over the transient operations of the tube 110 when the sweep signal is on, and gives a constant bias on the cylinder 115.

It will be apparent from the description above that the tube 10 of this invention is particularly adaptable to cases where it is desired to have the tube respond to two types of signals, one of them being balanced with respect to a point of fixed potential and the other of which is unbalanced with respect to said point. The tube is also adaptable to cases where it is desired to modulate the tube from an unbalanced circuit at some times and from a balanced circuit at other times, this tube being suitable for operation in both situations. Instead of applying a balanced circuit to the modulating plates, it is obvious that one of them can be placed at a fixed potential and the other one left free to vary in accordance with signals, in a manner well known to the art. Its use is thus very flexible. Various other modifications may be made in the embodiment of the invention as above described, the scope of the invention being indicated by the appended claims.

What is claimed is:

1. An electron optical arrangement comprising a cathode, a screen or target, an anode member having an apertured diaphragm therein, means for focussing a beam of electrons from said cathode on the aperture in said diaphragm, means including a pair of modulating plates placed between the cathode and said apertured diaphragm on opposite sides of the axis of the gun for moving the position of said focus with respect to said aperture, means including said focussing means for varying in accordance with signals the intensity of said beam and the focus thereof with respect to said aperture, and means for focussing an image of the aperture in said anode member upon said screen or target, said last-mentioned means including an apertured diaphragm member.

2. An electron gun arrangement comprising a cathode, a cylindrical focussing member surrounding said cathode, a three-part first anode member comprising an apertured diaphragm, a relatively long tubular member and a relatively short tubular member having substantially the same diameter as said first tubular member, all parts of said first anode being placed at the same potential, and a second anode comprising a tubular member having substantially the same diameter as the two tubular members of said first anode, said second anode being placed between the two tubular members of said first anode and at a potential which is negative with respect to said tubular members.

3. An electron gun arrangement comprising a cathode, a cylindrical focussing member surrounding said cathode, a three-part first anode member comprising an apertured diaphragm, a relatively long tubular member and a relatively short tubular member, all parts of said first anode being placed at the same potential, a second anode, said second anode being placed be-

tween the two tubular members of said first anode and at a potential which is negative with respect to said members, and a pair of modulating plates within said relatively long tubular member near said apertured diaphragm.

4. An electron gun arrangement comprising a cathode, a tubular anode member having an apertured diaphragm therein symmetrically arranged with respect to the axis of the gun arrangement, means including a cylindrical member at least partially surrounding said cathode and negatively biased with respect thereto for focussing electrons from said cathode on the aperture in said diaphragm, and means including a pair of modulating plates for moving the focal point of said electrons with respect to the aperture in the diaphragm in a direction transverse to said axis.

5. In an electron discharge device, a press, an insulating disc, means including four rods for supporting said insulating disc from said press, a tubular element, an apertured diaphragm, means for supporting said tubular element and said apertured diaphragm from said insulating disc, a pair of modulating plates, and means for supporting said modulating plates within a groove in said insulating disc.

6. In an electron discharge device, a press, an insulating disc, a second insulating disc, means for supporting said insulating discs from said press, a cathode, a focussing cylinder, means for supporting said cathode and said focussing cylinder from said first insulating disc, an apertured diaphragm, a long tubular member, a pair of modulating plates, means for supporting said apertured diaphragm, said long tubular member and said modulating plates from said second insulating disc, a small tubular element, a second small tubular element, an insulating member surrounding said two small tubular members, and means for supporting said insulating member from said long tubular member to support in turn said two short tubular members.

7. An electron gun arrangement for projecting a beam of electrons upon a screen or target comprising a cathode, a tubular anode member having two apertured diaphragms therein symmetrically arranged with respect to the axis of the gun arrangement, means at least partially surrounding said cathode and negatively biased with respect thereto for focussing electrons from said cathode on the aperture in the first of said diaphragms, means including a pair of modulating plates for moving the focal point of said electrons with respect to the aperture in said first diaphragm in a direction transverse to said axis, and means including a portion of said tubular anode member remote from the cathode and the second of said apertured diaphragms for focussing an image of the aperture in said first diaphragm upon said screen or target.

8. An electron gun arrangement for projecting a beam of electrons upon a screen or target comprising a cathode, a tubular anode member having two apertured diaphragms therein symmetrically arranged with respect to the axis of the gun arrangement, means at least partially surrounding said cathode and negatively biased with respect thereto for focussing electrons from said cathode on the aperture in the first of said diaphragms, means including a pair of modulating plates for moving the focal point of said electrons with respect to the aperture in said first diaphragm in a direction transverse to said axis,

and means including a portion of said tubular anode member remote from the cathode and the second of said apertured diaphragms for focusing an image of the aperture in said first diaphragm upon said screen or target, said last-mentioned means also including a pair of cylinders each surrounding the axis of said electron gun arrangement and being axially disposed one after the other between the tubular anode member and the screen or target.

9. An electron gun arrangement for projecting a beam of electrons upon a screen or target comprising a cathode, a tubular anode member having two apertured diaphragms therein symmetrically arranged with respect to the axis of the gun arrangement, means at least partially surrounding said cathode and negatively biased with respect thereto for focussing electrons from said cathode on the aperture in the first of said diaphragms, means including a pair of modulating plates for moving the focal point of said electrons with respect to the aperture in said first diaphragm in a direction transverse to said axis, and means including a portion of said tubular anode member remote from the cathode and the second of said apertured diaphragms for focusing an image of the aperture in said first diaphragm upon said screen or target, said last-mentioned means also including a pair of cylinders each surrounding the axis of said electron gun arrangement and being axially disposed one after the other between the tubular anode member and the screen or target, the second of said cylinders being placed at the same potential as said tubular anode member.

10. An electron gun arrangement for projecting a beam of electrons upon a screen or target comprising a cathode, a tubular anode member having two apertured diaphragms therein, symmetrically arranged with respect to the axis of the gun arrangement, means at least partially surrounding said cathode and negatively biased with respect thereto for focusing electrons from said cathode on the aperture in the first of said diaphragms, said means comprising a cylindrical member having an apertured diaphragm therein, means including a pair of modulating plates for moving the focal point of said electrons with respect to the aperture in said first diaphragm in a direction transverse to said axis, and means including a portion of said tubular anode member remote from the cathode and the second of said apertured diaphragms for focusing an image of the aperture and said first diaphragm upon said screen or target.

11. An electron gun arrangement comprising a cathode, a tubular anode member having an apertured diaphragm therein symmetrically arranged with respect to the axis of the gun arrangement, means including a cylinder at least partially surrounding said cathode and negatively biased with respect thereto and an apertured diaphragm between said cylinder and said tubular anode for focussing electrons from said cathode on the aperture in the diaphragm within said tubular anode member, and means including a pair of modulating plates for moving the focal point of said electrons with respect to the aperture in the diaphragm in a direction transverse to said axis.

12. An electron gun arrangement for projecting a beam of electrons upon a screen or target comprising a cathode, a tubular anode member symmetrically arranged with respect to the axis of the gun arrangement, said tubular anode

member having two apertured diaphragms therein, one being disposed near the cathode and the second near the end of the tubular anode member remote from the cathode, means for focussing electrons from said cathode on the aperture in the first apertured diaphragm, means including a pair of modulating plates for moving the focal point of said electrons with respect to the aperture in said first diaphragm in a direction transverse to said axis, and means including said second apertured diaphragm for projecting an image of the aperture in the first diaphragm upon the screen or target.

13. An electron gun arrangement for projecting a beam of electrons upon a screen or target comprising a cathode, a tubular anode member symmetrically arranged with respect to the axis of the gun arrangement, said tubular anode member having two apertured diaphragms therein, one being disposed near the cathode and the second near the end of the tubular anode member remote from the cathode, means for focussing electrons from said cathode on the aperture in the first apertured diaphragm, means including a pair of modulating plates for moving the focal point of said electrons with respect to the aperture in the first diaphragm in a direction transverse to said axis, two cylindrical members each symmetrically arranged with respect to the axis of the gun arrangement and being axially disposed one after the other between the tubular anode member and the screen or target, and means including the second apertured diaphragm in said tubular anode member and said two cylindrical members for focussing an image of the aperture at said first apertured diaphragm upon said screen or target.

14. An electron gun arrangement for projecting a beam of electrons upon a screen or target comprising a cathode, a tubular anode member symmetrically arranged with respect to the axis of the gun arrangement, said tubular anode member having two apertured diaphragms therein, the first being disposed near the cathode and the second near the end of the tubular anode member remote from the cathode, means including a cylinder which is negatively biased with respect to said cathode for focussing the electrons of said cathode on the aperture in the first of said diaphragms, means including a pair of modulating plates for moving the focal point of said electrons with respect to the aperture in the first diaphragm in a direction transverse to said axis, two cylindrical members each symmetrically arranged with respect to the axis of the gun arrangement and being axially disposed one after the other between the tubular anode member and the screen or target, and means including the second apertured diaphragm in said tubular anode member and said two cylindrical members for focussing an image of the aperture at said first apertured diaphragm upon said screen or target.

15. An electron gun arrangement for projecting a beam of electrons upon a screen or target comprising a cathode, a tubular anode member symmetrically arranged with respect to the axis of the gun arrangement, said tubular anode member having two apertured diaphragms therein, the first being disposed near the cathode and the second near the end of the tubular anode member remote from the cathode, means including a cylinder at least partially surrounding said cathode and negatively biased with respect thereto and an apertured diaphragm between said

cylinder and said tubular anode member for focussing electrons from said cathode on the aperture in the first of said diaphragms, means including a pair of modulating plates for moving the focal point of said electrons with respect to the aperture in the first diaphragm in a direction transverse to said axis, two cylindrical members each symmetrically arranged with respect to the axis of the gun arrangement and being axially disposed one after the other between the tubular anode member and the screen or target, and means including the second apertured diaphragm in said tubular anode member and said two cylindrical members for focussing the image of the aperture in said first apertured diaphragm upon said screen or target.

16. An electron gun arrangement for projecting a beam of electrons upon a screen or target comprising a cathode, a tubular anode member symmetrically arranged with respect to the axis of the gun arrangement, said tubular anode member having two apertured diaphragms therein, one being disposed near the cathode and the second near the end of the tubular anode member remote from the cathode, means including

a cylinder at least partially surrounding said cathode and negatively biased with respect thereto and an apertured diaphragm between said cylinder and said tubular anode member for focussing electrons from said cathode on the aperture in said first diaphragm in said tubular member, means including a pair of modulating plates for moving the focal point of said electrons with respect to the aperture in the first diaphragm in said tubular member in a direction transverse to said axis, two cylindrical members each symmetrically arranged with respect to the axis of the gun arrangement and being axially disposed one after the other between the tubular anode member and the screen or target, and means including the second apertured diaphragm in said tubular anode member and said two cylindrical members for focussing an image of the aperture in said first apertured diaphragm upon said screen or target, said apertured diaphragm member between said cylinder and tubular member, said tubular member and the second of said cylindrical members being placed at the same potential.

FRANK GRAY.