

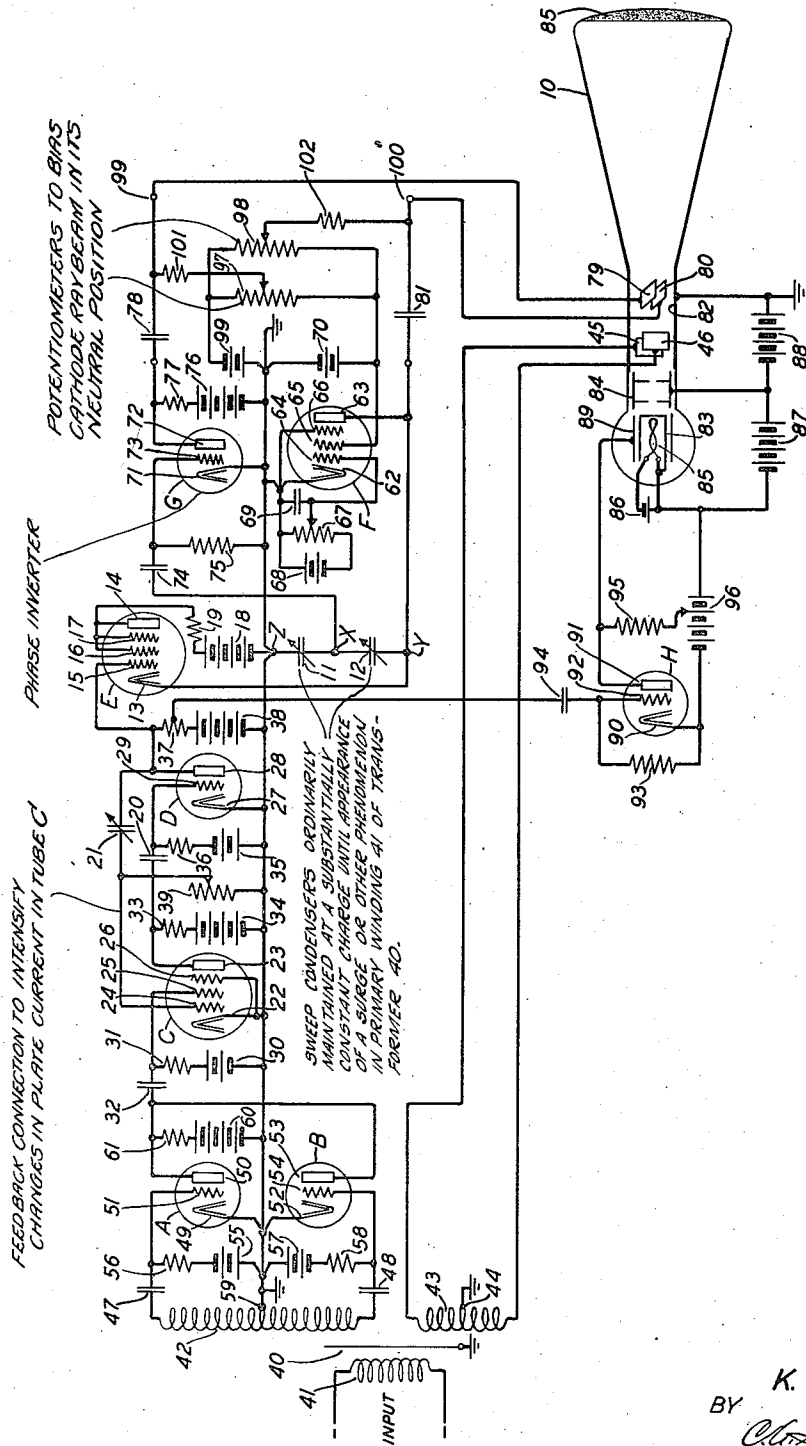
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CIRCUIT FOR CATHODE RAY TUBES

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CIRCUIT FOR CATHODE RAY TUBES

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This invention relates to electric circuits for and including electron discharge devices, and more specifically to sweep circuits for use with cathode ray tubes.

When cathode ray oscillographs are used to record lightning disturbances or other phenomena, some sort of a timing circuit is required to move the cathode ray beam across a fluorescent or phosphorescent screen or a photographically sensitized surface at one end of the tube in accordance with the passage of time after the phenomena is initiated. In one known circuit, a source of current operates through a resistance element to charge up a sweep condenser and to maintain the condenser charged until the appearance of a surge or other phenomenon, the condenser discharging through a screen grid tube linearly with respect to time upon the appearance of the surge or other phenomenon to be recorded or observed. This circuit possesses the disadvantage that if a second surge appears a very short interval of time after the first surge, the device is not operative to properly indicate or record the second surge. That is, for example, assuming that the interval between successive surges is less than one-tenth of a second, the circuit takes a certain longer period of time to reset, which period is dependent upon the time required to recharge the condenser through the resistance element, so the second surge is not properly indicated or recorded by the apparatus.

It is an object of this invention to provide a novel sweep circuit which does not have the disadvantage of the circuit mentioned above.

It is another object of this invention to provide a sweep circuit which is almost immediately effective upon the appearance of a surge or other impulse and which is almost immediately reset upon the disappearance of this surge or impulse so that it is in operative condition again for another surge or impulse even if this second surge occurs very shortly after the first surge.

Other and ancillary objects and features of this invention will be pointed out in the description which follows and in the appended claims.

In accordance with this invention a sweep circuit is provided, particularly for use with cathode ray oscillograph tubes which are designed to record or observe lightning disturbances or other phenomena comprising two sweep condensers, a source of potential and a high vacuum tube for quickly charging the condensers and maintaining them charged in the absence of a surge or other phenomenon to be recorded or observed, and two other high vacuum tubes (which will be

designated discharge actuating tubes) connected in a manner such that the plate of each tube is connected to the grid of the other through a condenser, so that a "lock-down" occurs between the two tubes when the surge appears, thus causing the plate current of the tube applying the grid bias to the charging tube to be greatly increased. This causes the grid of the charging tube to swing negative, thus transforming the tube into a high impedance which allows the constant current tube to discharge the two condensers linearly with respect to time through a constant current tube. The grid of still another tube (which will be called the phase-inverting tube) is controlled by the difference in potential across one of the two condensers, the capacity of the condenser being so chosen that the output voltage of the tube is of approximately the same magnitude and nearly 180 degrees out of phase with the actual voltage which appears across the two condensers. This gives a sweep which is substantially balanced with respect to ground. Two additional tubes (which will be designated the input tubes) are connected with their input circuits in push-pull and their output circuits in parallel to supply input voltage to the grid of one of the two discharge actuating tubes. Potentiometer resistances are connected to the output terminals of the sweep circuit to control the static condition of the spot on the luminescent screen of the cathode ray tube. Pulses appearing in the output circuit of one of the discharge actuating tubes are used to control the stopping and starting of the beam in the cathode ray tube.

In operation, the two sweep condensers are fully charged and maintained in this fully charged condition until the appearance of a surge or other phenomena in the circuit under observation by the action of the charging tube and a source of potential. Upon the appearance of this surge one or the other of the two input tubes becomes conducting and applies a pulse to one of the two discharge actuating tubes. The two discharge actuating tubes, being connected together as described above, "lock down" and supply a continuous negative pulse to the charging tube thus cutting off the flow of current through this tube and permitting the condensers to discharge through the constant current device linearly with respect to time. After the electron beam has been swept across the cathode ray tube, the discharge actuating tubes unlock very quickly and the sweep condensers begin to charge up again, this charging operation being almost instantaneous.

This circuit has the very desirable characteristics of (1) a very short time delay between the appearance of the surge which is to initiate the sweep and the beginning of the oscillograph record, (2) a rapid resetting of the circuit so that surges occurring at short intervals may be recorded or observed, (3) operation from surges of either polarity, and (4) releasing of the cathode ray tube electron beam only for the duration of the sweep. As a further advantage, all tubes used in this circuit are of the high vacuum type, thus permitting operation at very high frequencies and voltages, which would not be possible in circuits using gas-filled tubes.

The invention will be more readily understood from the following description taken in connection with the accompanying drawing forming a part thereof in which the single figure shows a sweep circuit for use with cathode ray oscillographs.

Referring more particularly to the drawing, the single figure shows a sweep circuit for a cathode ray oscillograph 10 in which only high vacuum tubes are employed. The circuit can be considered to be divided into five parts for the purposes of description although it is obvious that all of these parts cooperate to perform a unitary result. These five parts are (1) the charging circuit for the sweep condensers 11 and 12 comprising the tube E, the source 18 and the resistance 19, (2) the discharge actuating circuit for these condensers comprising the tubes C and D and the circuits therefor, (3) the arrangement for applying the pulse from the input transformer to the discharging circuit comprising the input tubes A and B, (4) the constant current device F for allowing the sweep condensers to discharge linearly with respect to time, and (5) the phase inverting arrangement comprising the tube G wherein the sweep potentials which are applied to the deflecting plates are balanced with respect to ground or other fixed potential.

The charging circuit comprises a pair of sweep condensers 11 and 12 connected in series, the capacity of which may be varied depending on the sweep speed desired and depending upon the desired distribution of the potentials between the condensers, a pentode tube E having a cathode 13, an anode 14, a control grid 15, a screen grid 16, and a suppressor grid 17, the last two grids being placed at anode potential so that in a sense the tube E operates as a triode, a source of potential 18 and the resistance element 19. In the absence of a surge or other phenomena in the input of the sweep circuit, the tube E is continuously conducting and the condensers 11 and 12 are charged up and maintained fully charged. The resistance element 19 is of the order of 1000 ohms, or even less, and it is thus not large enough to prevent the condensers 11 and 12, which may be of .007 microfarad to .02 microfarad and from .005 microfarad to .15 microfarad capacity, respectively, from being charged very quickly upon the occurrence of a flow of current in the anode-cathode path of the tube E. In certain cases resistance element 19 may be omitted if minimum charging time is a necessity.

The discharge actuating circuit for the sweep condensers 11 and 12 comprises tubes C and D which are interconnected in an interlocking arrangement by means of condensers 20 and 21. Tube C comprises a cathode 22, an anode 23, a control grid 24, a screen grid 25 and a suppressor grid 26, while tube D comprises a cathode 27, an anode 28 and a control grid 29. The circuit be-

tween the screen grid 25 and the cathode 22 of the tube C includes a battery 30 for positively biasing the grid 25 and a resistance element 31. This grid-cathode circuit is connected by means of a coupling condenser 32 (for example, of approximately .05 microfarad capacity) to the output circuit of the input tubes A and B, a description of which will be given more fully below. The circuit between the cathode 22 and the anode 23 of the tube C includes an anode resistance 33 and a source of anode potential 34. As mentioned above, the anode-cathode circuit of the tube C is coupled by means of the condenser 20 to the grid-cathode circuit of the tube D, this grid-cathode circuit including a biasing battery 35 and a resistance 36. The anode-cathode circuit of the tube D includes an anode resistance 37 and a source of anode potential 38. As explained above, there is a feedback connection between the anode 28 of the tube D and the control grid 24 of the tube C, this connection including the coupling condenser 21. A resistance 39 is used to control the time of "lock-down" of tubes C and D. The anode 28 of the tube D is connected to the grid 15 of the tube E for a purpose which will be described more fully below.

The input circuit to receive the surges from the circuit or line under observation includes a transformer 40 having a primary winding 41 and secondary windings 42 and 43. The secondary winding 43 has its mid-tap 44 connected to ground and its external terminals connected respectively to one set of electrostatic deflecting plates 45 and 46 of the cathode ray tube 10. The other set of deflecting plates 79 and 80, which plates are mounted at right angles to the plates 45 and 46, are connected respectively to the terminals 99 and 100 of the sweep circuit of this invention. By this arrangement the deflection in one direction is proportional to the intensity of the surge at the particular instant of observation, whereas the deflection in the other direction is proportional to the time elapsed since the occurrence of the surge.

The secondary winding 42 is connected to the input circuit of tubes A and B through the coupling condensers 47 and 48 (for example, of one-tenth microfarad each). The tube A comprises a cathode 49, an anode 50 and a grid 51, while the tube B comprises a cathode 52, an anode 53 and a grid 54. Bias for the grid 51 of the tube A is supplied by means of a battery or other source of potential 55 and a resistance 56, while bias for the grid 54 of the tube B is supplied by means of a source of potential 57 and a resistance 58. The mid-point 59 of the secondary winding 42 is connected to the cathodes 49 and 52 and to ground. The input circuits of the tubes A and B are thus connected in push-pull. The output circuits of these tubes are connected in parallel inasmuch as they have a common source of anode potential 60 and a common anode resistance 61. The anodes 50 and 53 are connected together and the common terminal connected through the coupling condenser 32 to the screen grid 25 of the tube C.

For providing a linear discharge of the condensers 11 and 12 with respect to time when a surge appears in the primary winding 41 of the input transformer, the pentode tube F is provided. This tube, which comprises a cathode 62, an anode 63, a control grid 64, a screen grid 65 and a suppressor grid 66, is connected with its anode-cathode path directly across the condensers 11 and 12 in series. Biasing potential for the con-

trol grid 64 is provided by means of the potentiometer resistance 67 supplied with current from the source 68. A condenser 69 may also be connected between the control grid 64 and the cathode 62 for filtering purposes, if desired, although in some cases it is not necessary, especially when the source 68 comprises a battery. When the source 68 is a rectifier the condenser 69 may be required. Screen grid biasing potential is supplied by means of the source of potential 70. The suppressor grid is connected directly to the cathode 62. Because of the linear characteristic of the pentode tube, the discharge current through the tube tends to remain substantially constant despite the fact that the potential difference across the anode-cathode path decreases as the condensers 11 and 12 are discharging.

There has been described in the preceding paragraphs a charging circuit for the sweep condensers 11 and 12, a discharge actuating circuit for these condensers, an amplifying circuit for applying the pulses from an input transformer to the discharging circuit, and a circuit arrangement for permitting a linear discharge with respect to time. The potential difference between the points Y and Z, the external terminals of the condensers 11 and 12, is thus held substantially constant in the absence of a surge but this potential difference is linearly decreased upon the appearance of a surge. If the points Y and Z were connected to the plates 79 and 80, the sweep potentials would be unbalanced as point Z is grounded. It has been discovered that it is particularly advantageous to have the potentials of the sweep circuit balanced with respect to ground or some other fixed potential, this fixed potential being usually the potential of the last anode in the cathode ray tube. The circuit connection for causing the sweep voltages to be balanced will now be described.

For providing this balanced arrangement, the phase inverter tube G is used. Tube G comprises a cathode 71, an anode 72, and a control grid 73. The potential difference between the points X and Z, that is, the voltage across the condenser 11, is applied by means of the coupling condenser 74 (for example, of .06-microfarad capacity) to the grid-cathode circuit of the tube G, the resistance 75 being connected between the grid 73 and the cathode 71. The anode-cathode circuit of the tube G includes the source of anode potential 76 and the anode resistance 77. The anode 72 of the tube G is coupled by means of a coupling condenser 78 (for example, of .1-microfarad capacity) to the deflecting plate 79 in the cathode ray tube 10, the other plate 80 of the pair being connected through a coupling condenser 81 (also, for example, of .1-microfarad capacity) to the point Y which is the outside terminal of the sweep condensers 11 and 12. By means of this phase inverting tube G, the potential applied to the plate 79 is nearly opposite in phase to that applied to the plate 80. By properly proportioning the values of the capacities of the condensers 11 and 12, the potentials applied to the plate 79 at any time may be made substantially equal as well as opposite to that applied to the plate 80 at the same time, the potential of the anode 82 (ground) being the reference point. With this arrangement the average of the potentials applied to the plates 79 and 80 is always substantially equal to the potential of the last accelerating anode 82 which may be, for example, either a metal cylinder or the conducting coating on the inside walls of the

cathode ray tube 10. For simplicity, the anode 82 has been shown as a coating although it is to be understood that any other suitable anode structure can be used as well. Thus sweep voltages which are balanced with respect to the potential of the anode most closely adjacent the deflecting plates, are provided by this circuit.

The cathode ray tube 10 comprises a cathode 83, a first accelerating anode 84, and a second accelerating anode 82 which may comprise a metal cylinder or a conducting coating of Aquadag or other suitable material on the inside walls of the tube, for generating and focussing a beam of electrons into a fine spot upon the luminescent screen 85 which may be fluorescent or phosphorescent. This beam is deflected in a linear manner upon the appearance of a surge by means of the potentials generated by the sweep circuit described above and applied between the plates 79 and 80 and is deflected in a direction at right angles to the sweep direction by means of the pair of plates 45 and 46 to which the transformed surges from the secondary winding 43 are applied as described above. The cathode 83 may be heated by any suitable filament 85 to which is applied heating current from a source 86. The first accelerating anode 84 is placed at a positive potential with respect to the potential of the cathode 83 by means of a source of potential 87 and the second accelerating anode 82 is placed at a potential which is more positive than that of the first accelerating anode 84 by means of the source of potential 88. In practice, the second accelerating anode 82 is frequently placed at ground potential although in many cases it is desirable to place the cathode at ground potential.

Surrounding the cathode 83 is a cylindrical member 89 to which are applied potentials to control the intensity of and the starting and stopping of the beam of electrons in the cathode ray tube 10. Potentials are taken off from the resistance 37 in the output circuit of the tube D and are applied to the grid of a tube H, the principal purpose of which is to make the bias of the cylinder 89 remain substantially constant for a considerable range of the potential derived from resistance 37. Tube H comprises a cathode 90, an anode 91 and a control grid 92. A resistance 93 is connected between the grid 92 and the cathode 90 and a coupling condenser 94 (for example, having a capacity of about .5 microfarad) is used to couple the grid 92 of the tube H to the resistance 37 in the output circuit of the tube D. The anode-cathode circuit of the tube H includes an anode resistance 95 and a portion of the source of potential 96. The output circuit of the tube H is connected between the modulating or control element 89 and the cathode 83 for a purpose which will be described more fully hereinafter.

To control the static position of the beam on the fluorescent or phosphorescent screen 85 potentiometer resistances 97 and 98 are provided, each of which is connected across the sources of potential 99 and 70 connected in series. Inner terminals of the potentiometer resistances 97 and 98 are connected to the plates 79 and 80 by means of resistances 101 and 102 (each of the order of 1 megohm), respectively. By suitable adjustment, the position of the spot may be placed at one side of the screen or the other or any intermediate point thereof, as desired. In practice it seems best to bias the spot so that when a surge appears the visual record on the

screen starts at one side of the screen and works over towards the other side so that the whole area of the screen will be available for the record if necessary.

The operation of the cathode ray tube 10 and its associated circuits will now be described: Assume a condition wherein no surge appears in the primary winding 41 of the input transformer 40. In this condition tubes A and B are passing little or no current, tube C is passing current freely, tube D is passing little or no current, and tubes E, F and G are passing current. The passage of current through tube E charges up the sweep condensers 11 and 12 and maintains them charged until the appearance of a surge. Tube H is also passing current freely so that the modulating element 89 is biased by the battery 96 to such an extent that no beam current flows in the tube. Now assume that a change occurs in the external circuit such that a surge is impressed across the input terminals of the primary winding 41 of the transformer 40. Either tube A or tube B will pass current, depending upon whether the surge is positive or negative, which causes a drop in the corresponding anode potential. This, in turn, causes the screen grid of the tube C to swing in a negative direction which will decrease the plate current of the tube C causing the control grid 29 of the tube D to swing in a positive direction. The tube D then draws current which causes the control grid of the tube C to swing in a negative direction. By means of the feedback arrangement between the two tubes, a "lock-down" occurs with the plate current of the tube C zero or practically so and the plate current of the tube D is greatly increased.

The tube E is in series with the two condensers 11 and 12 which are bridged by the constant current tube F. Under normal conditions, that is, when no surge or other unusual phenomenon appears in the primary winding 41, the tube E is supplying enough current to keep the condensers 11 and 12 fully charged. The tube F, however, is continually discharging or attempting to discharge these condensers. When the plate of the tube D draws current the grid 15 of the tube E swings in a negative direction and transforms this tube into a high impedance which allows the tube F to discharge the two condensers 11 and 12 substantially linearly with respect to time. The grid of the tube G is controlled by a portion of the difference of potential across the two condensers, that is, by the voltage across the condenser 11, and as the sweep condensers 11 and 12 discharge, the plate current of the tube G decreases. The potential applied to the grid of the tube G is such (that is, the capacity of the condenser 11 is chosen so that its potential difference thereacross is such) that the output voltage of the tube G is substantially of the same magnitude and is nearly 180 degrees out of phase with the voltage which appears across the two condensers 11 and 12 connected in series. This gives a sweep voltage applied across the plates 79 and 80 which is substantially balanced with respect to ground; that is, with respect to the potential of the second accelerating anode 82, assuming the taps on the potentiometer resistances 97 and 98 are properly adjusted for this purpose.

When the tube D passes current, a negative pulse is sent over the beam release circuit, that is, through the coupling condenser 94 to the tube H, which causes a positive pulse to be applied

to the modulating or control element 89, thus overcoming, in whole or in part, the negative bias due to the source 96 and allowing the formation of the electron beam.

While the condensers 11 and 12 are discharging through the tube F, this discharge being at an even or linear rate, the electron beam is caused to sweep across the surface of the screen 85. The beam is deflected in a direction at right angles to this sweep by the surge applied to the set of plates 45 and 46 by means of the secondary winding 43 of the transformer 40. This surge or phenomenon may be photographically recorded if desired; or, if a phosphorescent screen is provided, it may be observed directly.

As the condensers 11 and 12 become discharged, the cathode 13 of tube E tends to become less positive with respect to the grid 15 of this tube, and if the "lock-down" of tubes C and D were maintained indefinitely, tube E would eventually carry current due to the absence of a substantial control-grid bias. The time constant of the circuit involving condenser 21 and resistance 39 is adjusted so that the negative bias on control grid 24 of tube C required for "lock-down" is maintained just long enough for the sweep to be completed and not long enough for tube E to lose its control-grid bias. At the end of the sweep period, the currents and voltages in the "lock-down" circuit involving tubes C and D return quickly to the original values before the surge appears in the input transformer. The time constant of the circuit involving condenser 20 and resistance 36 is sufficiently long that it does not determine the sweep time. When these tubes C and D "unlock," a positive pulse is sent over the beam release circuit through the coupling condenser 94 which is changed into a negative pulse by the phase inverting action of the amplifier tube H to cause the modulating element 89 to swing in a negative direction and thus cut off the beam, the original negative bias of the battery 96 being effective to maintain the beam cut off.

The "lock-down" of the tubes C and D as well as the release or "unlocking" of these tubes is very rapid, by means of this arrangement, as soon as one sweep has been completed, the condensers 11 and 12 are practically instantaneously charged to full charge again and this charge maintained by the action of current flowing through tube E. It is thus ready for another surge.

While specific values of several of the various capacity and resistance elements have been stated in order to facilitate an understanding of the invention, it is to be understood that the invention is not limited to these specific values. It will also be obvious that while this sweep circuit has been described in connection with a cathode ray oscillograph for the recording or observing of voltage surges or other phenomena, various features thereof are not so limited but have other and/or broader applications which will be apparent from the appended claims.

What is claimed is:

1. A sweep circuit for use with cathode ray oscillographs for the indication of electrical disturbances of uncontrollable times of occurrence in an external circuit, comprising a condenser, a circuit in parallel with said condenser for providing a continuous discharge path therefor, means comprising an electron discharge device for suddenly charging said condenser to a predetermined potential difference and for main-

taining it charged at substantially that potential difference until the occurrence of an electrical disturbance in said external circuit, electron discharge means actuated by said electrical disturbance to render non-conducting said first electron discharge means to allow said condenser to discharge at a substantially linear rate through said parallel circuit.

2. In combination, a cathode ray tube comprising means for generating a beam of electrons, means for controlling the initiation and the stopping of said beam of electrons, two pairs of deflecting plates, a screen, a transformer having one primary winding and two secondary windings, said primary winding adapted to be connected to an external circuit in which occurs the electrical changes to be indicated on said screen, a sweep condenser having two external terminals and an inner terminal, means for grounding one external terminal of said sweep condenser, a circuit in parallel with said condenser for providing a continuous discharge path therefor, means for suddenly charging said sweep condenser to a predetermined potential difference and for maintaining it charged at substantially that potential difference in the absence of an electrical change in said external circuit, means including two interconnected electron discharge devices for blocking said charging means upon the occurrence of an electrical change in said external circuit to cause said condenser to discharge through said parallel circuit, means responsive to the current through one of said two interconnected electron discharge devices for generating a pulse upon the occurrence or completion of an electrical change in said external circuit to control the starting and stopping of said electron beam in said cathode ray tube by means of said controlling means in said tube, means for connecting said second secondary winding to one pair of deflecting plates, means for connecting the ungrounded terminal of said sweep condenser to one plate of the second pair of deflecting plates, and means for connecting the inner terminal of said condenser through a phase inverting device to the second plate of said second pair of deflecting plates.

3. In combination, a cathode ray oscillograph for the indication of disturbances of uncontrollable times of occurrence in an external circuit, comprising means for generating a beam of electrons, means for controlling the initiation of and the stopping of said beam of electrons, two pairs of electrostatic deflecting plates, and a screen, a transformer having a primary and two secondary windings, said primary winding being adapted to be connected to said external circuit, a first electron discharge device having input and output circuits, a second electron discharge device having input and output circuits, means for connecting the input circuits of said electron discharge devices in push-pull manner to one of said secondary windings, a third electron discharge device having input and output circuits, a fourth electron discharge device having input and output circuits, means for connecting the output circuit of said first and second electron discharge devices in parallel to the input circuit of said third electron discharge device, means for connecting the output circuit of said third electron discharge device to the input circuit of said fourth electron discharge device, means for connecting the output circuit of said fourth electron discharge device to the input circuit of said third electron discharge device, means for con-

necting the output circuit of said fourth electron discharge device to said means for initiating and stopping the beam in said cathode ray oscillograph, a condenser having two external terminals and an inner terminal, means including a fifth electron discharge device having input and output circuits, the output circuit of which is connected in series with said condenser for suddenly charging said condenser in the absence of an electrical disturbance in said external circuit to a predetermined potential difference, means for connecting the input circuit of said fifth electron discharge device to the output circuit of said fourth electron discharge device, and a sixth electron discharge device having an anode, a cathode and at least one grid, means for connecting the anode-cathode path of said sixth electron discharge device to the external terminals of said condenser to cause said condenser to discharge substantially linearly with respect to time, a seventh electron discharge device having input and output circuits, means for connecting the inner terminal and one of the external terminals of said condenser to the input circuit of said seventh electron discharge device, means for connecting the output circuit of said seventh electron discharge device to the plates of one pair of the deflecting plates of said oscillograph, means for connecting the anode of said sixth electron discharge device to the other one of the plates of said pair of plates, and means for connecting said second secondary winding to the respective plates of said second pair of deflecting plates.

4. A sweep circuit for use with cathode ray oscillographs for the indication of disturbances of uncontrollable times of occurrence in an external circuit, comprising a condenser, means comprising an electron discharge device for suddenly charging said condenser to a predetermined potential difference and for maintaining it charged at substantially that potential difference until the occurrence of a disturbance in said external circuit, an electron discharge constant current device having a cathode, an anode and a grid, the anode-cathode path of which is connected across said condenser, and electron discharge means actuated by said disturbance to render non-conducting said first electron discharge means to cause said condenser to discharge through said constant current device at a substantially linear rate.

5. A sweep circuit for use with cathode ray oscillographs for the indication of disturbances of uncontrollable times of occurrence in an external circuit, comprising a condenser, a circuit in parallel with said condenser for providing a continuous discharge path therefor, means comprising an electron discharge device for suddenly charging said condenser to a predetermined potential difference and for maintaining it charged at substantially that potential difference until the occurrence of a disturbance in said external circuit, and means for blocking said charging means upon the occurrence of said disturbances to allow said condenser to slowly discharge at a substantially linear rate through said parallel circuit.

6. A sweep circuit for use with cathode ray oscillographs for the indication of disturbances of uncontrollable times of occurrence in an external circuit, comprising a condenser, a circuit in parallel with said condenser for providing a continuous discharge path therefor, means comprising an electron discharge device for suddenly charging said condenser and maintaining it

charged until the occurrence of a disturbance in said external circuit, a transformer having a primary winding and a secondary winding, two electron discharge devices having input and output circuits, means for connecting the input circuits of said two electron discharge devices in push-pull connection to the secondary winding of said transformer, means including two interconnected electron discharge devices for blocking said charging means upon the occurrence of said change to allow said condenser to discharge through said parallel circuit, and means for connecting in parallel the output circuits of the two electron discharge devices having their input circuits connected in push-pull to said means for blocking said charging means.

7. A sweep circuit for use in cathode ray oscillographs for the indication of disturbances of uncontrollable times of occurrence in an external circuit, comprising a condenser, a circuit in parallel with said condenser for providing a continuous discharge path therefor, means comprising an electron discharge device for suddenly charging said condenser and maintaining it charged until the occurrence of a disturbance in said external circuit, two electron discharge devices having input and output circuits, means for connecting the input circuits of said electron discharge devices in push-pull, and means for connecting the output circuits of said electron discharge devices in parallel, means including said two discharge devices to render non-conducting said first electron discharge means on the occurrence of said disturbance to allow said condenser to discharge at a substantially linear rate through said parallel circuit.

8. In combination, a cathode ray tube comprising means for generating a beam of electrons, means for controlling the initiation and the stopping of said beam of electrons, two pairs of electrostatic deflecting plates, a sweep circuit connected to one of said pairs of deflecting plates, said sweep circuit comprising a condenser, means for charging said condenser and means including two interconnected electron discharge devices for blocking said charging means upon the occurrence of an electrical charge in an external circuit which changes are to be indicated by said cathode ray oscillograph, and means responsive to the current through one of said two interconnected electron discharge devices for generating a pulse upon the occurrence of said electrical change to control the starting and stopping of said electron beam of said cathode ray tube by means of said controlling means in said tube.

9. In combination, a condenser, a circuit in parallel with said condenser for providing a continuous discharge path therefor, means for charging said condenser, means for blocking said charging means to allow said condenser to discharge through said parallel circuit, and means including an electron discharge device for inverting the phase of a portion only of the difference in potential across said condenser.

10. In combination, a cathode ray tube having an anode and a pair of deflecting plates, a sweep

circuit substantially balanced with respect to ground, means for connecting the anode of said cathode ray tube to ground, a pair of coupling condensers for coupling the two terminals of said sweep circuit, respectively, to the plates of said pair of deflecting plates, a source of potential having two external terminals and an inner terminal, the inner terminal of said source being connected to ground, a potentiometer resistance connected across said source of potential, said potentiometer resistance having an inner terminal, means for connecting the inner terminal of said first potentiometer resistance through a high resistance to one of said deflecting plates, a second potentiometer resistance connected across said source of potential, said potentiometer resistance having an inner terminal, and means for connecting the inner terminal of said second potentiometer resistance through a second high resistance element to the other of said pair of deflecting plates.

11. In combination, a condenser having two external terminals and an inner terminal, means for charging said condenser, means for discharging said condenser, means for blocking said charging means upon the occurrence of an electrical change in an external circuit to allow said condenser to discharge through said discharge means, a cathode ray tube having a pair of electrostatic deflecting plates, a phase inverting electron discharge device, means for connecting one of the external terminals of said condenser to a point of fixed potential, means for connecting the other external terminal of said condenser to one plate of the pair of deflecting plates, and means for connecting the inner terminal of said condenser through the phase inverting device to the second plate of said pair of deflecting plates.

12. In combination, a condenser, means for varying the charge on said condenser in one direction, a second charge varying means for varying the charge on said condenser in the opposite direction, means for blocking said second charge varying means to allow said condenser to vary its charge in the first direction, means for inverting the phase of at least a portion of the difference of potential across said condenser, and means for utilizing at least a portion of the difference of potential across said condenser and also at least a portion of the potential obtained by said phase inversion to control the deflection of an electron beam.

13. In combination, a condenser, a constant current device in circuit with said condenser for discharging said condenser, a source of potential in circuit with said condenser for supplying charging current thereto while it is being discharged through said constant current device to hold said condenser at a substantially constant charge, and means for applying a pulse for rendering the impedance of the charging circuit substantially infinite whereby the condenser is permitted to discharge substantially linearly with respect to time through said constant current device.

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