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ELECTRIC CIRCUIT

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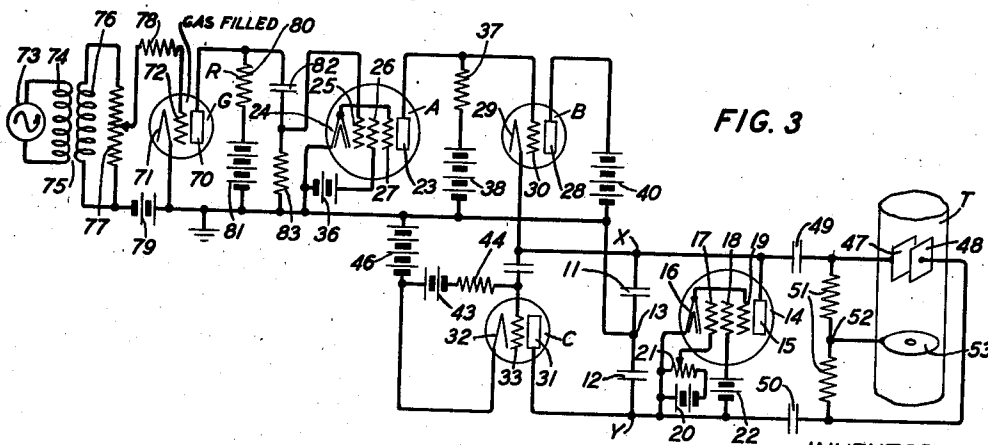
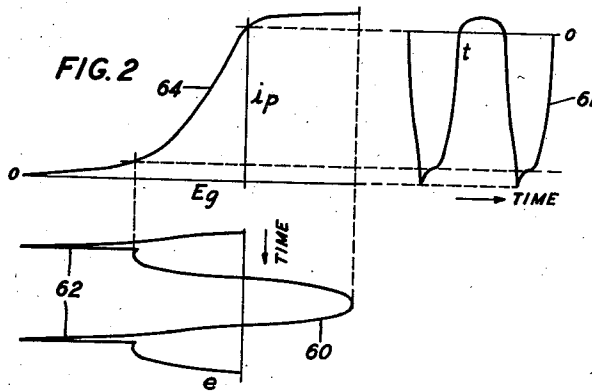
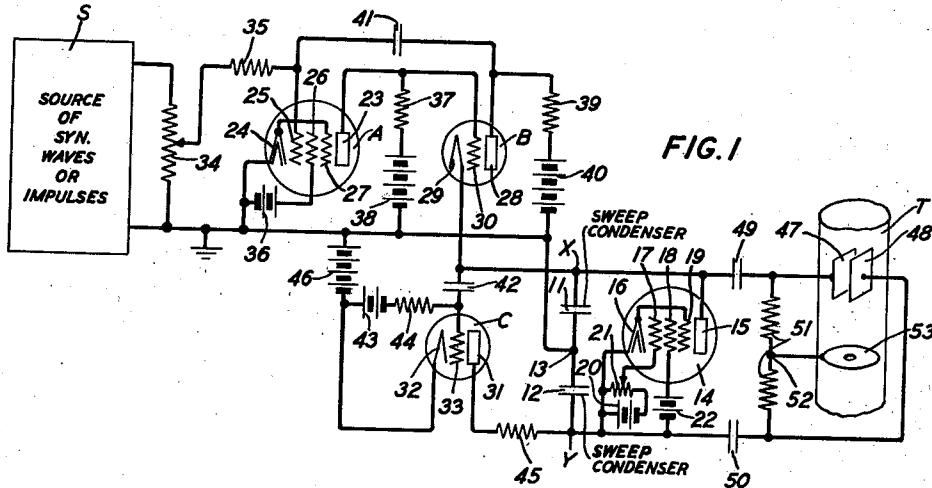


FIG. 3

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ELECTRIC CIRCUIT

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18 Claims. (Cl. 250—36)

This invention relates to electric condenser charging and discharging circuits and more specifically to sweep circuits suitable for television scanning.

In the operation of cathode ray tubes suitable for television scanning, the sweep circuits used have been generally of a form in which there is an unbalance, i. e., the instantaneous average of the potentials to ground generated by the sweep circuit and applied to the deflecting plates of a cathode ray tube does not substantially equal the potential to ground of the accelerating anode immediately preceding the deflecting plates in the cathode ray tube at all times. It has been found that this is the cause of the field on the screen on the cathode ray tube being somewhat wedge-shaped and so producing a distorted image, the reason therefor being that the velocity of the beam depends upon the average of the potentials applied to the sweep plate and hence the deflection in certain beam positions when this average is not substantially constant is greater or less than it should be. This unbalance also accounts for an unwanted intensity deviation and a loss of clear focus in parts of the image. These three manifestations are all due to the change in velocity of the beam. Various arrangements have heretofore been suggested for producing balanced sweep potentials. The present invention is directed to improvements in that type of circuit which produces balanced sweep potentials but in certain of its aspects is not limited to this use, as will be apparent from the following description and the appended claims.

In the embodiments of the invention herein chosen by way of illustration, two condensers are provided which are arranged in series relationship in the circuit to which they supply voltage, one of these condensers being charged under control of the other and substantially simultaneously therewith, both condensers then being discharged together in series to set up a voltage equal at all times to the sum of the voltages across the respective condensers. The common terminal of the condensers is preferably maintained at a fixed potential when the arrangement is used to generate sweep voltages for a cathode ray. In one specific embodiment hereinafter described, two high vacuum electron discharge devices have their respective input and output circuits interconnected so as to produce sharp output pulses for periodically and quickly charging the one of the condensers which controls the charging of the other. This control is effected by means of an electron discharge tube having the controlling

condenser in its input circuit and its controlled condenser in the output circuit thereof. A pentode tube is provided for discharging both of the condensers linearly with respect to time. The second condenser has produced across it a saw-toothed wave which is 180 degrees out of phase with respect to that across the first condenser, giving a voltage output across the condensers which is balanced with respect to the potential of their common terminal. The external terminals of the condensers are applied through coupling condensers to the respective plates of one set of deflecting plates of a cathode ray tube. Across these deflecting plates is connected a high resistance, the mid-point of which is connected to an anode of the cathode ray tube adjacent the deflecting plates. This arrangement produces a potential wave of the well-known saw-tooth wave form which is substantially balanced with respect to the potential applied to this anode.

In a second embodiment, the pulses for charging the condensers are produced in a separate gas-filled tube, thus eliminating the necessity for the back coupling between the two high vacuum electron discharge devices which were interconnected in the embodiment described above.

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

Fig. 1 shows a circuit for producing balanced sweep potentials in accordance with the invention;

Fig. 2 shows the shape of the pulses impressed on the grid of the tube used for charging the sweep condensers; and

Fig. 3 shows a modification of the circuit of Fig. 1.

Referring more particularly to the arrangement shown in Fig. 1 of the drawing, a sweep circuit is provided for producing balanced potentials of saw-tooth wave form for application to the deflecting plates of a cathode ray tube to cause, in cooperation with another sweep circuit of appropriate frequency, a cathode ray beam generated therein to scan in turn all of the elemental areas of a field of view of a screen or target. The circuit comprises two substantially equal condensers 11 and 12 connected in series, the common terminal 13 of which is connected to a fixed potential as, for example, ground. The term "condenser" as used in this specification is considered to be broad enough to describe the electrical action of any two conductors separated by a dielectric. Shunted across the con-

densers 11 and 12 is a suitable constant current device 14. This constant current device may be a saturated diode but it is preferably a pentode electron discharge device 14 having an anode 15, a cathode 16, a control grid 17, a screen grid 18 and a suppressor grid 19. Due to the extended linear portion of the anode voltage versus anode current characteristic of the pentode tube, the condensers 11 and 12 are discharged substantially linearly with respect to time through the constant current device 14. The control grid 17 of the pentode 14 is adjustably biased with respect to the cathode 16 by means of a source of potential 20 which is shunted by a voltage dividing resistance 21 from which adjustable connection is made to the grid 17. The screen grid 18 is positively biased with respect to the potential of the cathode 16 by means of the source of potential 22. The suppressor grid 19 is preferably placed at the same potential as that of the cathode 16.

In order to suddenly charge the condensers 11 and 12 periodically and substantially simultaneously, a vacuum tube arrangement comprising tubes A, B and C is employed. Tube A preferably comprises an anode 23, a cathode 24, a control grid 25, a screen grid 26 and a suppressor grid 27. The tube B preferably comprises an anode 28, a cathode 29 and a control grid 30, while the tube C preferably comprises an anode 31, a cathode 32 and a control grid 33. Each of the tubes A, B and C is preferably a high vacuum tube as is also, of course, the constant current device 14.

Included between the cathode 24 and the control grid 25 of the tube A is a potentiometer resistance 34 and a current limiting resistance 35. The screen grid 26 is preferably biased positively with respect to the cathode 24 by means of the source 36. The suppressor grid 27 is preferably connected directly to the cathode 24.

A source of synchronizing waves or impulses S is applied across the potentiometer resistance 34. This source S may be located at the transmitter or at the receiver and may take any of a number of well-known forms. In the preferred embodiment, however, the source S may comprise a vacuum tube oscillator for generating sine waves of scanning or framing frequency. If the circuit now being described is used in connection with a cathode ray tube at a receiving station, the frequency and phase of the source S will be synchronized with the scanning at the transmitting station by any well-known means.

Included in a circuit between the anode 23 and the cathode 24 of the tube A is an anode resistance 37 and a source of potential 38. The anode 23 is connected directly to the grid 30 of the tube B. Included in a circuit between the anode 28 and the cathode 29 of the tube B is a resistance 39, a source of potential 40 and the sweep condenser 11. The anode 28 is connected back to the control grid 25 of the tube A through a coupling condenser 41.

The terminal X of the sweep condenser 11 (the terminal not at ground potential) is connected through a coupling condenser 42 to the grid 33 of the tube C. Included in the circuit between the grid 33 and the cathode 32 of the tube C is a biasing source of potential 43 and a resistor 44. Included in the circuit between the anode 31 and the cathode 32 of the tube C is an anode resistance 45, sweep condenser 12 and a source of anode potential 46.

The changing potential across the sweep condensers 11 and 12 is applied to a pair of electro-

static deflecting plates 47 and 48 arranged in a cathode ray tube T of any suitable design in which balanced electrostatic deflection is used, a portion only of the tube T being shown. As an example of a satisfactory cathode ray tube for this purpose, reference may be made to an application of C. J. Davisson, Serial No. 118,277, filed December 30, 1936. A pair of coupling condensers 49 and 50 is utilized between the sweep condensers 11 and 12 and the deflecting plates 47 and 48. Connected across the deflecting plates 47 and 48 is a high resistance 51, of the order of several megohms, the mid-point 52 of which is connected to an anode 53. By this arrangement the potentials applied to the deflecting plates are at all times balanced with respect to the potential of the anode member 53 which may be any anode in the cathode ray tube about whose potential it is desired to balance the potentials applied to the deflecting plates. If desired, the potentials of the sweep plates may be balanced with respect to a fixed potential which is not the exact potential of any of the electrodes in the tube, in which event the deflecting plates serve as an electron lens member in addition to a deflecting means.

The circuit shown in Fig. 1 operates as follows: A synchronizing voltage is fed to the grid 25 of the tube A from the source S through the potentiometer 34. The steady grid potential of tube A caused by the current flowing in the grid-cathode circuit is adjusted to nearly zero with respect to the cathode 24 by making the resistance 35 high (of the order of 50,000 ohms). The amplitude of the synchronizing voltage is such that during the negative portion of the cycle, the grid potential is swung so far negative that the current flow ceases in the anode-cathode circuit. The anode 23 is then at the potential of the positive terminal of the anode source 38, which potential is positive with respect to ground. The grid 30 of the tube B is also at this potential. The cathode 29 of the tube B has been approaching ground potential at a rate determined by the discharge circuit of the sweep condenser 11 including the constant current tube 14. This rate is so adjusted that at the time when the grid of the tube B is suddenly made positive with respect to ground, the cathode 29 of the tube B is not very far from ground potential. A large current then flows from the source of potential 40 through the resistor 39 and tube B to suddenly charge up the condenser 11 so that the potential of the point X is highly positive with respect to ground. This initial large current produces a potential drop across the resistor 39 which is transmitted as a pulse through the coupling condenser 41 to the grid 25 of the tube A. This pulse tends to hold the tube A in its cut-off condition until current has ceased to flow through the resistor 39 to the sweep condenser 11, which occurs when condenser 11 is charged to its maximum potential.

This initially large charging pulse on the condenser 11 is transmitted likewise through the capacity 42 to the grid 33 of the tube C. This tube has been prevented from conducting current by a steady large negative grid potential applied from the source 43 through the resistor 44. A large charging pulse—positive in direction—starts current flowing in the cathode-anode circuit which charges the sweep condenser 12 so that point Y reaches a maximum negative potential with respect to ground. Tubes B and C then become inoperative since in each of them, the cathode and the anode are almost at the same

potential. Tube A can then leisurely return to its normal condition of conducting a maximum anode current which holds the grid 30 of the tube B a few volts positive with respect to ground, or at high negative potential with respect to its cathode 29. Condensers 11 and 12 are thus charged substantially simultaneously. They are then discharged through the constant current tube 14 at a constant rate in well-known manner.

The values of the condensers 11 and 12 are so chosen that the above charging operation is done in a very small fraction of the period of time allotted to a complete sweep cycle while the discharging operation takes the remainder of this period. The familiar saw-tooth form of potential appearing across the condensers 11 and 12—balanced with respect to ground by means of the common terminal 13—is then applied through the coupling condensers 49 and 50 to the deflector plates 47 and 48 of the cathode ray tube T.

Referring now to Fig. 2 of the drawing, curve 60 represents the voltage applied to the grid 25 of tube A while curve 61 represents the plate current of the same tube. Curve 64 represents the grid voltage versus plate or anode current of the tube A. The sharp pulses 62 in the negative half-cycle of the voltage applied to the grid of the tube A are caused by the pulse fed back from the tube B through the condenser 41 which drives the grid 25 even more negative and cuts off the current in tube A. The condenser 11 is entirely charged during the time when there is a minimum anode current in tube A. After it is entirely charged, tube A has lost its control until the charge on condenser 11 has decreased during the remainder of the saw-tooth cycle.

In the arrangement shown in Fig. 3 the pulses for charging the condensers 11 and 12 are produced in a separate gas-filled tube G, thus eliminating the necessity for the back coupling between the high vacuum electron discharge tubes A and B which were interconnected in the arrangement shown in Fig. 1. The elements of the circuit shown in Fig. 3 which correspond to those shown in Fig. 1 are designated by the same reference characters.

The gas tube G preferably comprises a tube of the "Thyratron" type comprising an envelope filled with gas and enclosing an anode 70, a cathode 71 and a grid 72. A source of synchronizing waves 73 of appropriate frequency is connected to the primary winding 74 of a transformer 75, the secondary winding 76 of which is connected to a potentiometer resistance 77. One of the fixed terminals of this potentiometer resistance 77 is connected through a source of potential 79 to the cathode 71 while an inner terminal of the resistance 77 is connected through a resistance 78 to the grid 72 of the gas-filled tube G. The resistor 78 is inserted to limit the grid-cathode current of the tube G as the main discharge path in the tube G should be confined to the anode-cathode circuit. Also by limiting the grid-cathode current, the intensity of any pulses, produced by the discharges through the anode-cathode circuit, which pulses are transmitted through the transformer 75 back to the source 73, is limited.

Included in the anode-cathode circuit of the gas tube G is an anode resistance 80 and a source of potential 81. Also connected between the anode 70 and cathode 71 of the tube G is a condenser 82 and resistance 83. The resistance 83 is connected to the grid-cathode circuit of the tube A. The anode 23 of the tube A is connected

directly to the grid 30 of the tube B as in Fig. 1 but the anode 28 of the tube B is not connected back through a condenser to the grid 25 of the tube A as was the case in the arrangement shown in Fig. 1. Moreover, the resistance 39 in the anode-cathode path of the tube B and the resistance 45 in the anode-cathode path of tube C in Fig. 1 have been omitted in Fig. 3.

The arrangement shown in Fig. 3 operates in much the same manner as the arrangement shown in Fig. 1 with a few exceptions. Pulses are produced in the tube G, thus eliminating the necessity for the back coupling from the tube B to the tube A to produce pulses on the grid 25 by this feedback arrangement. In the arrangement shown in Fig. 3, the condenser 82 is charged through the resistor 80 to a potential which is sufficiently great to cause a discharge to occur through the gas-filled tube G when the synchronizing wave from the source 73, of the same frequency as the desired sweep wave, appears in the grid circuit of the tube G. This discharge current flowing through the resistor 83 produces a large negative potential with respect to ground on the grid of tube A.

The time of charging is determined by the product of the value of the capacity of the condenser 11 and the total resistance in series with it. In the circuit of Fig. 1, this resistance includes the anode-cathode resistance of the tube B and the resistor 39. In Fig. 1, the resistor 45 is added in series to the tube C and to the condenser 12 to make the charging time as nearly identical as possible with that of the circuit including the condenser 11, resistor 39 and tube B. If resistors 39 and 45 are removed, the charging time is decreased in the ratio which the value of one of these resistors bears to the previous total resistance.

This circuit arrangement preferably should allow the time of charging to be fixed by the tube and condenser combination for an optimum saw-tooth. The starting of the charge is determined by the synchronizing wave changed into a pulse and impressed on the control tube A. The duration of the charge, therefore, should be quite independent of this tube, which should be held in the "charge" condition until the actual charging is terminated by the condensers 11 and 12 reaching their maximum potential. The condensers then are indifferent to whatever happens to the control circuit until the potential has decreased by leaking through tube 14. Since resistor 83 in the pulse circuit partly determines the duration of the pulse, it is made of such value that this duration is a bit longer than the charging time of condenser 11. The need for resistors in the anode circuit of tubes B and C is therefore obviated because these resistors are not required to keep the tubes B and C in the charging condition (as in Fig. 1) and the charging time is thereby shortened.

If synchronizing pulses are received from another circuit, as from a pulse separation circuit for a standard RMA signal, these pulses must only be applied in a negative sense to the tube A and the circuit will operate exactly as above described. However, the circuit will not be self-running, that is, it will not generate saw-tooth pulses of a frequency determined by its own components (in the absence of synchronizing signals) if the back coupling condenser 41 (in Fig. 1) is left out or if the gas pulse generator of Fig. 3 is not included. In certain cases this self-running feature is very desirable.

In a specific instance where the arrangement described above was satisfactorily operated, the resistance 35 was 50,000 ohms, the resistance 37 was 500,000 ohms, the resistance 39 was 2,000 ohms, the resistance 44 was 100,000 ohms, the resistance 45 was 2,000 ohms and the resistance 51 was 10 to 20 megohms, the condenser 41 was .0001 microfarad, the condenser 42 was .0001 microfarad and each of the condensers 11 and 12 was .00025 microfarad, this circuit producing a sweep wave of 5,760 cycles. In the arrangement for 24 cycles the condensers 11 and 12 were each of .02 microfarad capacity and certain of the other circuit elements were correspondingly changed.

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

What is claimed is:

1. A wave generator comprising a condenser, means for charging said condenser, a second condenser, means for charging said second condenser during substantially all the charging time of said first condenser comprising means responsive to the voltage across said first condenser due to the charge built up thereon, and means for discharging said condensers together in series so as to set up a voltage equal at all times to the sum of the voltages across said respective condensers.

2. A wave generator comprising a condenser, means for charging said condenser, a second condenser, means for charging said second condenser during substantially all the charging time of said first condenser comprising means responsive to the voltage across said first condenser due to the charge built up thereon, means for continuously maintaining one terminal of each condenser at the same fixed potential, and means for discharging said condensers together in series so as to set up a voltage equal at all times to the sum of the voltages across said respective condensers.

3. A saw-tooth wave generator comprising a condenser, means for quickly charging said condenser, a second condenser, means for charging said second condenser during substantially all the charging time of said first condenser comprising means responsive to the voltage across said first condenser due to the charge built up thereon, and means for relatively slowly discharging said condensers together in series at a substantially constant rate so as to set up a voltage equal at all times to the sum of the voltages across said respective condensers.

4. In a wave generator, a pair of condensers having a common terminal which is connected to a point of fixed potential and each having an outside terminal, means for charging one of said condensers, means responsive to the potential across said first condenser for substantially simultaneously charging the other of said condensers, and means for discharging the two condensers together, whereby a saw-toothed potential wave is produced between said outside terminals, which potential wave is balanced with respect to said point of fixed potential.

5. In combination, a condenser, a second condenser, each of said condensers having a terminal which is placed at a common fixed potential, and means for varying the charges on said condensers substantially simultaneously, said means comprising mechanism for varying the charge on one condenser in one direction, means

responsive to the voltage due to said variation in charge for varying the charge on said second condenser in the same direction, and a single electron discharge device for simultaneously varying the charge on said condensers in the opposite direction.

6. In combination, a condenser, a second condenser, each of said condensers having a terminal which is placed at a common fixed potential, means for quickly and substantially simultaneously charging said condensers, said means comprising mechanism for charging one condenser, and means responsive to the voltage across said first condenser due to said charge for charging said second condenser, and means for discharging said condensers.

7. In combination, a condenser, a second condenser, each of said condensers having a terminal which is placed at a common fixed potential, means for quickly and substantially simultaneously charging said condensers, said means comprising mechanism for charging one of said condensers, and means responsive to the voltage across said first condenser due to the charge built up thereon for charging said second condenser substantially simultaneously therewith, and means including a constant current device for discharging said condensers simultaneously and substantially linearly with respect to time.

8. In combination, a first condenser, a second condenser, each of said condensers having a terminal which is placed at a common fixed potential, high vacuum means for quickly varying the charge on said first condenser in one direction, and a high vacuum electron discharge device coupled to said high vacuum means and responsive thereto for quickly varying the charge on said second condenser in the same direction substantially simultaneously with the variation in charge on said first condenser.

9. In combination, two substantially equal condensers, means for connecting one terminal of each condenser to a terminal of the other condenser, means for connecting this common terminal to a point of fixed potential, a high vacuum electron discharge device having input and output circuits, a second high vacuum electron discharge device having input and output circuits, means for applying signals to the input circuit of said first electron discharge device, means for connecting the output circuit of said first electron discharge device to the input circuit of said second electron discharge device, means for connecting said first condenser in the output circuit of said second electron discharge device, a third high vacuum electron discharge device having input and output circuits, means for connecting the input circuit of said third electron discharge device to the output circuit of said second electron discharge device, and means for connecting said second condenser in the output circuit of said third electron discharge device, whereby said condensers are charged substantially simultaneously upon the appearance of a signal in the input circuit of said first electron discharge device.

10. In combination, two substantially equal condensers, means for connecting one terminal of each condenser to a terminal of the other condenser, means for connecting this common terminal to a point of fixed potential, a high vacuum electron discharge device having input and output circuits, a second high vacuum electron discharge device having input and output circuits, means for applying signals to the input

circuit of said first electron discharge device, means for connecting the output circuit of said first electron discharge device to the input circuit of said second electron discharge device, means for connecting said first condenser in the output circuit of said second electron discharge device, means for feeding back energy from the output of said second electron discharge device to the input circuit of said first electron discharge device, phase inverting means, and means for connecting said second condenser in the output circuit of said electron discharge device through said phase inverting means whereby the charge on the first condenser varies substantially simultaneously with the variation in charge on the second condenser.

11. In combination, two substantially equal condensers, means for connecting one terminal of each condenser to a terminal of the other condenser, means for connecting this common terminal to a point of fixed potential, a high vacuum electron discharge device having input and output circuits, a second high vacuum electron discharge device having input and output circuits, means for applying pulses to the input circuit of said first electron discharge device, means for connecting the output circuit of said first electron discharge device to the input circuit of said second electron discharge device, means for connecting said first condenser in the output circuit of said second electron discharge device, a third electron discharge device having input and output circuits, means for connecting the input circuit of said third electron discharge device to the output circuit of said second electron discharge device, means for connecting said second condenser in the output circuit of said third electron discharge device, whereby said condensers are charged substantially simultaneously upon the appearance of a pulse in the input circuit of said first electron discharge device, and means including a constant current device for discharging said condensers substantially linearly with respect to time between pulses.

12. In combination, a first condenser, a second condenser, means for placing a terminal of each of said condensers at the same fixed potential, and means for charging said condensers quickly and substantially simultaneously comprising a first high vacuum electron discharge device having an anode, a cathode and a grid, a second high vacuum electron discharge device having an anode, a cathode and a grid, and a third electron discharge device having an anode, a cathode and a grid, means for connecting a source of signals between said cathode and grid of said first electron discharge device, means for connecting the anode of said first electron discharge device to the grid of said second electron discharge device, means for connecting said first condenser in circuit between said anode and said cathode of said second electron discharge device, means for connecting the cathode of said first electron discharge device to said point of fixed potential, means for connecting said cathode of said second electron discharge device to the grid of said third electron discharge device, means for connecting the cathode of said third electron discharge device through a source of potential to said point of fixed potential, and means for connecting the anode of said third electron discharge device through said second condenser to said point of fixed potential.

13. In combination, a first condenser, a second condenser, means for placing a terminal of each

of said condensers at the same fixed potential, and means for charging said condensers quickly and substantially simultaneously comprising a first high vacuum electron discharge device having an anode, a cathode and a grid, a second high vacuum electron discharge device having an anode, a cathode and a grid, and a third electron discharge device having an anode, a cathode and a grid, means for connecting a source of signals between said cathode and grid of said first electron discharge device, means for connecting the anode of said first electron discharge device to the grid of said second electron discharge device, means for connecting said first condenser in circuit between said anode and said cathode of said second electron discharge device, means for connecting the anode of said second electron discharge device to the grid of said first electron discharge device, means for connecting the cathode of said second electron discharge device to the grid of said third electron discharge device, and means for connecting the second condenser in circuit between said anode and said cathode of said third electron discharge device.

14. In combination, a first condenser, a second condenser, means for placing a terminal of each of said condensers at the same fixed potential, means for charging said condensers quickly and substantially simultaneously comprising a first high vacuum electron discharge device having an anode, a cathode and a grid, a second high vacuum electron discharge device having an anode, a cathode and a grid, and a third electron discharge device having an anode, a cathode and a grid, means for connecting a source of signals between said cathode and grid of said first electron discharge device, means for connecting the anode of said first electron discharge device to the grid of said second electron discharge device, means for connecting said first condenser in circuit between said anode and said cathode of said second electron discharge device, means for connecting the cathode of said second electron discharge device to the grid of said third electron discharge device, and means for connecting the second condenser in circuit between said anode and said cathode of said third electron discharge device whereby said condensers are charged substantially simultaneously upon the appearance of a signal in the input circuit of said first electron discharge device, and means including a constant current device for discharging said condensers substantially linearly with respect to time between signals applied to the grid of said first electron discharge device.

15. In combination, a pair of substantially equal condensers, a terminal of each of which is connected to a point of the same fixed potential, and means for substantially simultaneously charging said condensers, said means comprising a gas-filled grid-controlled electron discharge device having an input and an output circuit, means for connecting a source of signals to the input circuit of said gas-filled discharge device, a third condenser, means for charging said third condenser, a resistance, means including said gas-filled electron discharge device for discharging said third condenser through said resistance, a high vacuum electron discharge device having input and output circuits, means for connecting said resistance in the input circuit of said high vacuum electron discharge device, means for connecting the output circuit of said first elec-

tron discharge device to the input circuit of said second electron discharge device, means for connecting said first condenser in the output circuit of said second electron discharge device, 5
 5, a third electron discharge device having input and output circuits, means for connecting the output circuit of said second electron discharge device to the input circuit of said third electron discharge device, and means for connecting said 10
 10, second condenser in the output circuit of said third electron discharge device.

16. In combination, a pair of substantially equal condensers, a terminal of each of which is connected to a point of the same fixed potential, and means for substantially simultaneously charging said condensers, said means comprising a gas-filled grid-controlled electron discharge device having an input and an output circuit, means for connecting a source of signals 20
 20, to the input circuit of said gas-filled discharge device, a third condenser, means for charging said third condenser, a resistance, means including said gas-filled electron discharge device for discharging said third condenser through said 25
 25, resistance, a high vacuum electron discharge device having an input and an output circuit, means for connecting said resistance in the input circuit of said high vacuum electron discharge device, a second high vacuum electron discharge 30
 30, device, means for connecting the output circuit of said first electron discharge device to the input circuit of said second electron discharge device, means for connecting said first condenser in the output circuit of said second electron discharge 35
 35, charge device, a third electron discharge device having input and output circuits, means for connecting the output circuit of said second electron discharge device to the input circuit of said third electron discharge device, means for connecting said second condenser in the output circuit of said third electron discharge device 40
 40, whereby said condensers are charged substantially simultaneously upon the appearance of a signal in the input circuit of said gas-filled electron discharge device, and means including a 45
 45, constant current device for discharging said

pair of condensers substantially linearly with respect to time between signals applied to the input circuit of said gas-filled electron discharge device.

17. In combination, a first condenser, a second condenser, means for connecting a terminal of each of said first and second condensers to the same point of fixed potential, and means for charging said condensers, said means comprising a source of pulses, a first electron discharge device having an anode, a cathode and a grid, means for connecting the grid of said first electron discharge device to said source of pulses, means for connecting said first condenser in the anode-cathode circuit of said first electron discharge device, a second electron discharge device having an anode, a cathode and a grid, means for connecting the grid of said second electron discharge device to the cathode of said first electron discharge device, and means for connecting said second condenser in the anode-cathode circuit of said second electron discharge device.

18. In combination, a first condenser, a second condenser, means for connecting a terminal of each of said first and second condensers to the same point of fixed potential, means for charging said condensers, said means comprising a source of pulses, a first electron discharge device having an anode, a cathode and a grid, means for connecting the grid of said first electron discharge device to said source of pulses, means for connecting said first condenser in the anode-cathode circuit of said first electron discharge device, a second electron discharge device having an anode, a cathode and a grid, means for connecting the grid of said second electron discharge device to the cathode of said first electron discharge device, and means for connecting said second condenser in the anode-cathode circuit of said second electron discharge device, and means including a constant current device for discharging said condensers substantially linearly with respect to time between pulses applied to the grid of said first electron discharge device.

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