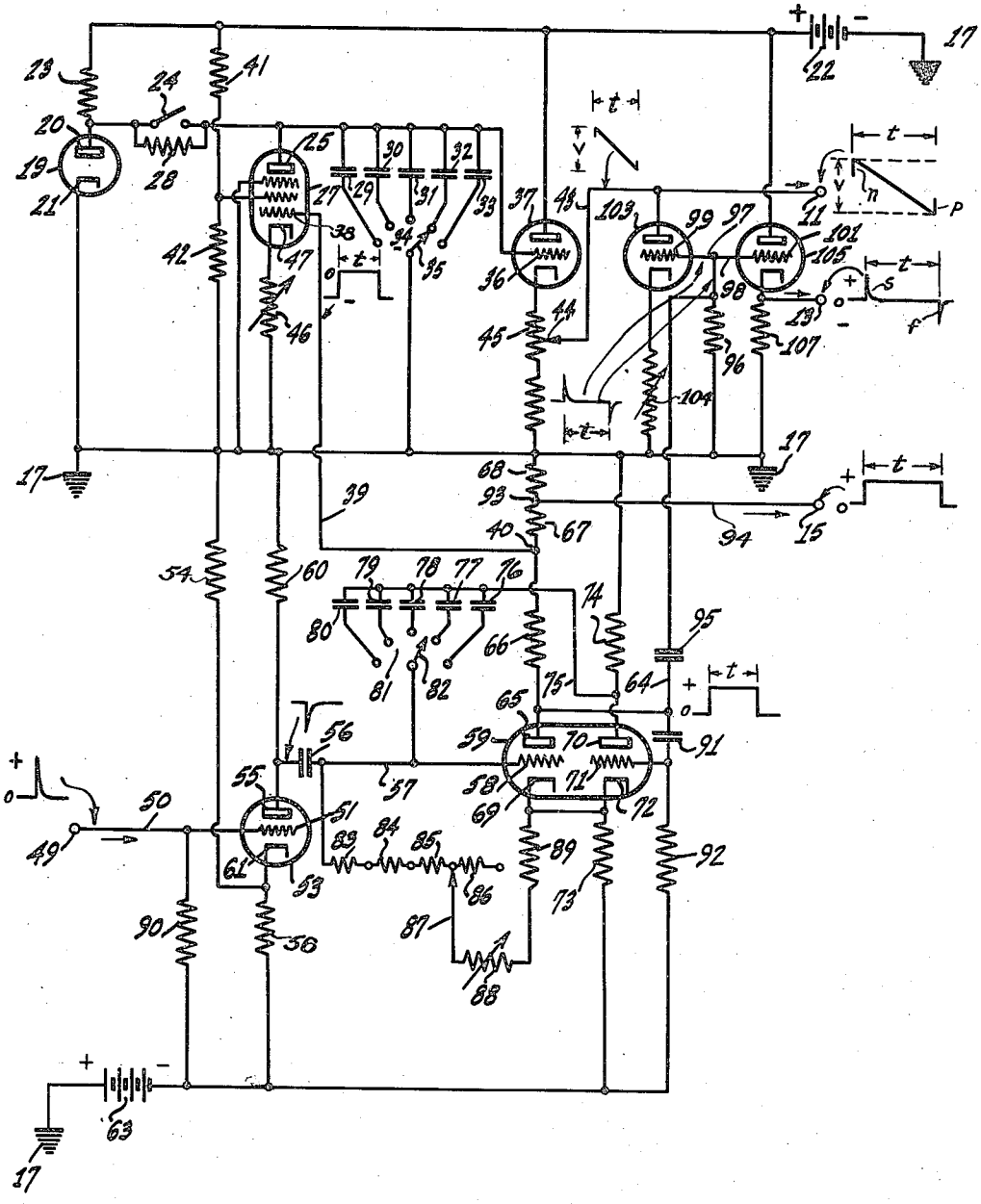
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CATHODE-RAY BEAM DEFLECTING CIRCUITS

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CATHODE-RAY BEAM DEFLECTING CIRCUITS

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This invention relates to electronic apparatus of the type particularly usable as a deflection generator. In its more specialized form, the invention relates to a deflection or sweep voltage generator, particularly useful for bringing about the deflection of a cathode ray beam along one axis of deflection, which is known as the time axis, so that transient phenomena, which are to be observed, may be applied to deflect the cathode ray beam in a mutually perpendicular direction. Deflection apparatus of this character thus provides for measuring or determining the time of an event or transient effect by virtue of the displacement produced thereby relative to the time axis along which the beam is deflected.

Also, the invention in its form herein to be set forth, is essentially directed to a form of time sweep generator which is known as the single sweep variety. The invention essentially provides a deflection generator which causes the development of electrical fields which become effective to deflect a cathode ray beam developed within any appropriate cathode ray device and cause the cathode ray beam and its deflection to be initiated at a predetermined and selected time. The deflection then proceeds at a substantially uniform rate until the completion of one lateral traverse of the cathode ray beam relative to target area is accomplished. With this deflection having been brought about, provision is made for suppressing the cathode ray beam and conditioning it for subsequent traversals of the target in the event that further transient effects are to be observed. During the suppression period, the cathode ray beam is returned to its initial starting point by reason of the fact that the electrical field developed and which initiated the time sweep has been removed or is collapsed or returned to its original state.

Various forms of arrangements to effect deflection of a cathode ray beam relative to its target area have already been proposed in the art. The present invention, therefore, has as one of its primary objects that of providing simplified circuit arrangements to bring about the results and at the same time to provide an operating circuit and control which is highly efficient in its use due to the freedom of adjustment of both the time of the sweep and the rate of the sweep.

The invention herein to be set forth comprises essentially an oscillator circuit which is appropriately triggered under the control of a timing impulse. The timing impulse functions to initiate the cathode ray beam and, at the same time, to start the deflection and then brings about a

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turning off or suppression of the cathode ray beam following a complete deflection cycle. This result is brought about through the utilization of a relay tube circuit of the so-called "square wave" variety which operates under the influence of an initial triggering impulse at a rate determined by preselected time constants of circuit operation. The operation of the square wave relay tending to change the current flow in one of a pair of electric paths from a state of minimum current flow to maximum current flow, and vice versa, serves then to control the operation of the discharge tube serving to discharge a storage element across which a cathode ray beam deflection voltage has been built up. At the same time, the operation of the relay serves to develop a control pulse which through appropriate circuit elements brings about the formation of the cathode ray beam at the initiation of the deflection cycle due to operation of the discharge tube. Then, the termination of the effect of the pulse causes a suppression of the cathode ray beam following a completion of a single deflection path. The output from the square wave relay, as will be seen from a description following, has also as an additional function that of producing a voltage which can be added as an intensifying voltage effective on the cathode ray beam to increase the velocity at which it hits the target. This intensifies the effect of the cathode ray beam upon the impact target and is particularly desirable in the event that extremely short time duration sweep are employed because without intensification the beam sweep or trace might be very dim or even unobservable to the eye.

From the foregoing, it will be apparent that this invention has as another of its primary objects that of providing a single sweep time axis generator in which an automatically or even a manually produced initial controlling impulse serves not only to initiate the cathode ray beam but also serves simultaneously to control the beam initiation at the commencement of the sweep and beam suppression following the sweep. It is also an object of the invention to provide a single sweep time axis generator for bringing about the deflection of the cathode ray beam across the target where beam intensification effects, as the beam impacts the target, are brought about simultaneously with the beam initiation and under the influence of the same control pulse which initiates the operation.

Other objects of the invention are to provide a time axis generator of the single sweep variety which is relatively simple in its arrangement and

construction, which is efficient in its operation, which is easily set up, which comprises relatively few component parts, which is at all times simple in its operation and which, at the same time, overcomes many defects present in apparatus heretofore provided for such purposes.

Another object of the invention is to provide time markers on the sweep voltage, so that when two or more cathode ray tubes are operated by the same single sweep generator, the relative time positions of the different transients shown on each of them may be determined.

Other objects and advantages will become apparent when the invention is considered in conjunction with the accompanying drawing in which the single figure shows by way of illustration one suitable circuit improvement by which the invention may be practiced.

Referring now to the drawing for a further understanding of the invention, it may be assumed for purposes of illustration that the circuit herein to be described is particularly useful in conjunction with the so-called D. C. coupled amplifier. The circuit shown by the drawing essentially comprises the combination of a plurality of thermionic tubes appropriately arranged to provide three different types of output voltages which will be considered as being developed at the output terminal **11**, **13** and **15**. The graphical wave representatives adjacent the terminals exemplify the wave form thus produced.

The sweep voltage which is utilized to deflect a cathode ray beam developed within the cathode ray tube (not shown) so as to cause it to traverse the target thereof, may be assumed to appear between the output terminal **11** and ground **17**, for instance. As the invention has been illustrated, electrostatic deflection of the cathode ray beam will be assumed for reasons of simplicity, so that if reference is made to the curve shown adjacent the output terminal **11** it will be seen that the voltage represented as V, drops from a maximum to a minimum value within a time period *t* which will be assumed for purposes of illustration as the selected time sweep period.

It will be noted from the curve adjacent output terminal **13** that two impulses result during the time period *t*. These impulses are designated, for reasons of simplicity, by the letters *s*, representing start, and *f* representing finish. The impulses *s* and *f* serve to bring about a formation of the cathode ray beam in the cathode ray tube (not shown) at the start of the sweep period *t* and to suppress the same beam at the end or finish of the same sweep period. The output voltages which appear between the terminal **15** and ground **17** occur within the same time period *t* and comprise essentially a square topped positive pulse which persists throughout the assumed sweep period. This pulse is usually applied through a suitable beam control amplifier (not shown) to intensify the effect of the cathode ray beam upon its impacted target, particularly when extremely brief time sweep periods are utilized.

With the foregoing explanation of the objectives to be achieved by this invention, it will be seen that a system herein disclosed comprises a voltage regulator tube **19** including an anode element **20** and a cathode element **21**, with the cathode element connected to ground at **17**. The anode **20** connects to the positive terminal of a voltage source **22** of any desired variety, but conventionally represented as a battery having its negative terminal connected to ground **17**. The positive terminal of the battery

or other voltage source **22** connects to the anode of the voltage regulator tube **19** through the resistor **23**.

It accordingly becomes apparent that this voltage regulator tube **19** will supply a constant voltage (which, for purposes of illustration may be assumed to be 105 volts where the tube **19** is selected as being of the general type known as the VR–105) through the switch element **24** (assuming the switch to be closed) to the plate or anode **25** of a suitable discharge tube **27**. Likewise, the same positive voltage is applied through the same switch element **24** or through the shunting resistor **28** (in the event the switch **24** is open) to one plate terminal or element of a group of condenser elements **29**, **30**, **31**, **32** and **33**. The opposite terminal of each of these condensers connects to one contact of a switching unit, conventionally represented at **34**, so that when the contactor **35** rests upon any one selected terminal of the switch unit one terminal of a selected condenser in the group connects to ground **17** through the switch.

The same constant voltage is also supplied to the grid or control electrode **36** of a cathode follower connected tube **37**. This tube supplies its output through the connections, later to be explained, to the output terminal **11** so that, as will be apparent from what is to follow, a regulated voltage relative to ground appears at the terminal **11** when a voltage regulator tube **19** of the assumed VR–105 type is employed.

With the arrangement indicated, charging voltages are supplied to the condensers **29** through **33**, in accordance with the voltage developed across the voltage regulator tube **19**. The discharge tube **27** is usually of the pentode type and by way of illustration, may be considered as being of the 6SJ7 variety, although this type is selected primarily by way of illustration of one suitable type. The tube **27** is connected as a constant current tube and serves as the discharge medium for any of the condensers **29** through **33** which have been selected in accordance with the position of the switch contact **35** relative to the various terminals of the switch **34**.

The discharge tube **27** is normally maintained in a blocked state by way of the connection of its control grid **38** to a point of negative potential through conductor **39** to point **40** which is usually beyond the cut-off point of the tube. However, during the selected sweep time, the control grid **38** through the connection indicated, as will be later explained, is brought to a ground potential or zero potential, so that the tube **27** may discharge the selected condenser of the group **29** through **33** by permitting a current flow through the tube.

Suitable screen voltage is supplied to tube **27** through the connection to the source of voltage **22** by way of resistor **41**. The screen grid resistor **42** is connected between the screen grid and ground, as shown. Provided the tube **27** has a constant current characteristic, it will be appreciated that with current flowing through the tube the plate potential and also the potential of the upper terminal of the selected condenser **29** through **33** and the grid or control electrode **36** of the tube **37** will drop relative to ground uniformly during the selected time period *t* provided switch **24** is open. In this way, it will be appreciated that with the cathode follower connection of tube **37** that the voltage which is selected to appear in the conductor **43** connected through the variable tapping point **44** on the cathode resistor

45, can be made to follow the voltage at the control grid and can be made to match that of the D. C. deflection amplifier and produce a straight line sweep voltage, as indicated by the curve adjacent the terminal 11. With the voltage regulator tube 19 in operation and the slider 44 connected substantially as shown the maximum of the regulated voltage output is about 100 volts relative to ground but this voltage can be made to rise to even more than the assumed 105 volts for tube 19 when the slider 44 is moved up to the tube cathode.

So that the speed of the sweep, or, in other words, the rate of change of the sweep voltage, will be appropriately controlled, there is a potentiometer 46 connected between the cathode 47 of the tube 27 and ground. With this potentiometer 46 adjusted and the selector switch 34 so arranged as to select the appropriate condenser of the group 29 through 33, the rate of change of the sweep voltage may readily be established.

After one of the condensers of the group 29 through 33 has been discharged, by reason of the unblocking of the discharge tube 27, it will be observed that the discharge tube 27 will again block and the appropriate condenser 29 through 33 may again be caused slowly to charge through the relatively high resistor 28, or to receive the voltage across the regulator tube 19 through the switch element 24 providing it is in a closed position to short circuit resistor 28.

This charging of one of the condensers of the group will then condition the circuit for the next cycle of operation to be effected under the control of a triggering impulse such as that hereinabove assumed which may be impressed at the input control terminal 49. The input control pulse, as indicated by the waveform adjacent the input terminal point 49 is supplied by way of the conductor 50 to the control electrode or grid 51 of the tube 53. Tube 53 serves as an inverter tube and signal amplifier and supplies its output from the plate or anode 55 thereof through the coupling condenser 56 and conductor 57 to the grid or control electrode of the first (left hand portion) half of a relay tube 59. The tubes 53 and 59 and the circuit components associated therewith are connected to determine the time of sweep duration, or, in other words, serve to determine and establish the time period *t*. To this end, these tubes 59 and 53 have their plate or anode elements, such as 55 for the tube 53, connected to ground potential, at 17, through the resistor 60, for instance. The negative terminal or the cathode 61 of tube 53, for instance, is connected to the negative terminal of any suitable voltage source, such as that conventionally represented by the battery 63, which has its positive terminal connected to ground 17, as indicated.

The tube 59 is actually of the double triode variety, such as that known in the art as the 6SN7 type, for instance. Two completely separate tube envelopes containing the necessary electrodes, may be substituted for the single tube, where desired, and where the tube characteristics are substantially alike. The tube 59 has its electrode elements so connected as to follow the general type of heretofore developed square wave pulse or relay circuits and thus produces a positive square wave pulse, such as that represented by the square wave form immediately adjacent conductor 64, at the output plate or anode 65 of the first half of the relay tube 59, for instance. The anode 65 of the first half of the relay tube 59 connects to ground through the resistor elements

66, 67 and 68 which are serially connected. As above explained, the grid or control electrode 38 of the discharge tube 27 connects to the point 40 intermediate of the resistor 66 and 67 so that normally, while the plate circuit of the first half of the tube 59 is drawing current the point 40 is, nevertheless, sufficiently negative relative to the cathode potential of the tube 27 to bias the discharge tube to a cut-off state. This is because of the fact that in operation, as will become apparent from what is to follow, current is normally flowing through the first half of the relay tube 59. However, for a selected time period *t*, which can be made variable, the plate current flow through the first half of the tube 59, that is the plate current flow between the anode 65 and the cathode 69, is reduced to a zero value so that effectively the potential of the grid or control electrode 38 in tube 27 is brought to ground potential. The tube 27 then becomes conducting and acts to discharge that condenser of the group 29 through 33 which was selected by the switching contact arm 35 to be charged from the source 22.

The second (right hand) half of the relay tube 59 comprises also a plate or anode 70, a control electrode or grid 71 and a cathode 72, with the cathode 72 being connected to the negative terminal of the voltage source 63 by way of the cathode resistor 73 and the indicated conductor. The anode or plate 70 connects to ground through the plate resistor 74 and current is normally interrupted in this portion of the tube due to the current flow in the first half of the tube circuit. A conductor 75 connects one terminal of each of a group of condenser elements 76, 77, 78, 79 and 80 to ground 17 through the plate resistor 74. The opposite terminal of each condenser in this group connects to a contact point of a switch element, generally designated as 81. In accordance with the position of the switch arm 82 relative to the contact points, one condenser from the group may be selected to charge relative to the negative terminal of voltage source 63.

Between the grid electrode 58 and the cathode 69 of the first half of relay tube 59, a group of serially connected resistor elements 83, 84, 85 and 86 are provided. Any selected number of these resistors may be included in the grid circuit by virtue of the adjustment of the slide contactor 87 to the junction point at which these various resistors connect to one another. Also, there is provided a further adjustable resistor 88 connecting serially with a cathode resistor 89 so that in accordance with the selection of capacity and resistor units, the cycle of operation of the relay will be established in accordance with the well known time constant as provided by any one of the condensers and the selected amount of resistance. Then, when a triggering impulse (of wave form generally like that shown adjacent condenser 56) is impressed upon the control electrode 58 of the first half of the tube, the current flow in this half of the tube is interrupted. Simultaneously the right hand half of the tube is caused to conduct with a period of conduction being determined by the selected time constant of condensers and resistors in the grid circuit of the left hand half of the tube controlling the interruption cycle.

Operation of this character is commenced by the application of the positive voltage pulse at the input terminal 49 applied to the grid or control electrode 51 of the inverter tube 53. This tube 53 is normally biased to a cut-off state by the action of the current flow through resistor 54 and the

cathode resistor 56 where current flows from ground to the negative terminal of battery 63. This causes the cathode 61 to become slightly positive relative to the grid 51. The input signals are applied across the grid resistor 90 so that the tube is responsive only to strong positive pulses impressed thereon. In this way, noise pulses will not be applied to the grid 58 of the first half of the relay 59 to cause interference with operation. The pulse which is developed and applied at the input terminal 49, may be supplied by way of an impulse generator or other type of pulse producer (not shown) or by the application of a positive potential (also not shown) developed by manually closing a control switch. The manner of generating the pulse applied at the input terminal is wholly immaterial to an understanding of this invention. However, it will be appreciated that due to the interference produced within the tube 53, the pulse provided and applied by way of conductor 57 is of negative plurality and serves to block the first half of the relay tube. The condensers 76 through 80 are connected so that the capacity and resistance combination establishes the desired time constant during which the blocking effect on the first half of the tube 59 becomes effective. It will be appreciated that if the first half of the tube 59 blocks the voltage effective at the plate 65 will immediately rise so that the point 40, for instance, is effectively at ground and the discharge tube 27 is unlocked. Simultaneously, the rise in voltage effective at the plate 65 is passed to the second half of the tube by way of the condenser 91 which serves promptly to cause the second half of the tube to draw current. The discharging of the condensers 76 through 80 through the resistors holds the left half of the tube blocked. The grid resistor 92 for the right half of the tube 59 is of a relatively high value.

Not only is the relay tube 59 utilized in this manner to control the operative periods of the discharge tube 27, but also it will be seen that the current flow through the first half of the tube 59, when interrupted for the period determined by the time constant circuit of the condenser selected from the group 76 through 80 and the various resistors above enumerated, produces the effect of an increase in potential at the point 93 which is passed along the conductor 94 to the output terminal point 15 to produce the waveform already indicated as being adopted to be supplied to the beam control amplifier to bring about an intensification of the cathode ray beam in the controlled tube (not shown).

Likewise, the output waveform represented adjacent the conductor 64 is passed through a differentiating circuit comprising the relatively small condenser 95 and the resistor 96 to provide a differentiated pulse indicated adjacent the conductors 97 and 98 connecting the grid or control electrodes 99 and 101 of the tubes 103 and 105. It will be observed that the differentiated pulse that appears in the conductor 97 is impressed upon the grid or control electrode 99 to cause at the commencement of the pulse, an instantaneous increase in current flow through the tube.

The tube 103 may be regarded, for illustrative purposes, as being one of the so-called 6J5 type. Under such circumstances, the tube is provided with a cathode resistor 104 which is preferably made variable. The tube is arranged normally to pass but a very small amount of current which is increased momentarily at the commencement of a pulse. Changes in the value of the resistor will vary the magnitude of the timing pulses n and p, later to be more particularly referred to, which become available at the output terminal 11. The current flowing through the tube 103 will momentarily be blocked at the end of a pulse applied by way of the conductor 97 due to the negative section of the differentiated wave indicated. Accordingly, the effective resistance of the cathode circuit of the tube 37 is momentarily decreased for an instant at the beginning of the time period t but is increased proportionally for a corresponding period at the end of the said time period t. The result is that a negative pulse, such as that represented at n (for negative) on the wave form adjacent to the terminal 11 is produced to mark the beginning of the time period t and a short positive pulse, represented at p (for positive) is produced at the end of the time period t. Thus, the pulse p will mark the end of the sweep period.

Likewise it was explained that the same differentiated pulse is applied to the grid or control electrode 101 of the tube 105 which derives its plate voltage from the source 22. When the positive differentiated pulse representing the start of the control effect is received upon the grid, it is reproduced as the small pulse s at the terminal 13, in that it is developed across the cathode resistor 107 of the tube 105 which is connected as a cathode follower. The negative portion of the differentiated pulse appears as the negative pulse shown at f opposite the terminal 13 and indicates the finish or completion of the cycle of operation at the end of the time period t.

A pulse of this character may then be applied to a relay tube (not shown) of the same general character as that described by the tube 59 which will serve to control the initiation of the cathode ray beam concurrently with the production of the start pulse s, and it will then suppress the cathode ray beam with a tripping of the relay at the time corresponding to the completion or finish of the square wave pulse which is represented at f in the wave shown opposite terminal 13.

It thus becomes apparent that by the adjustment of the tapping point for the condensers of the group 29 through 33 and an adjustment of the cathode resistor 46 of the discharge tube 27, it is possible to vary the speed of sweep of the cathode ray. Similarly, an adjustment and selection of one of the condensers 76 through 80 and a selection of the resistance elements 83 through 86 and a variance of the resistor 88 makes it possible to vary the time during which the sweep action takes place in that the time constant of operation of the circuit is thus determined and established. These adjustments, it will be observed, are brought about independently of one another and cause the beam deflection and control to be brought about once and only once for any single impressed triggering impulse applied at the input terminal 49 to control any one operation.

For the purpose of illustration only, and in order particularly to explain the operation of the invention, it will be assumed that each of the voltage sources 22 and 63 is of the order of about 250 volts. The various tube types proposed have hereinabove been set forth. No resistance values are of absolutely critical nature but purely by way of illustration and example the following resistances are proposed.

Resistance elements	Value
28	10 megohms.
45	5,000 ohms.
46	1 megohm.
60	10,000 ohms.
66	25,000 ohms.
67	1,000 ohms.
68	500 ohms.
73	18,000 ohms.
74	25,000 ohms.
83 to 86	each 1 megohm.
88	1 megohm.
89	35,000 ohms.
92	5 megohms.
96	100,000 ohms.
104	15,000 ohms.
107	5,000 ohms.

It is proposed that the condensers in the groups 29 through 33 and 76 through 80 be selected so that they are of approximately the following sizes: 1.0; 0.1; 0.01; 0.001 and 0.00025, respectively.

From these values, it will be appreciated that it is easily possible to provide at the output terminal 11 control voltages with a possible variation in the time period t from about 10 microseconds up to and including 2.5 seconds. Of course, other components and variations of operations may readily be provided where changes fall clearly within the general nature of the foregoing disclosure.

Having now described the invention, what is claimed and desired to be secured by Letters Patent is the following:

1. Electronic apparatus for developing cathode ray beam deflection voltages which comprises a combination of a storage means and means for charging the same from a source of voltage, normally inoperative discharge means for discharging, with operation, the storage means to develop substantially linear output voltages therefrom for producing electrical fields for deflecting said beam, a thermionic relay system and a resistance and capacity circuit connected thereto for producing substantially square wave voltage outputs of time duration measured substantially by the time constant of the capacity and resistance means, means for initiating an operation of the said relay under the influence of an applied control pulse, a connection between the said relay and the said discharge means for rendering the said discharge means operative at a time coincident with the initiation of the said square wave pulse and for a time duration coincident with the duration of said square wave pulse so that in accordance with the receipt of control impulses serving to trigger the said relay output voltages to produce electrical fields to deflect a cathode ray beam along a single path of deflection are initiated, and means for controlling the rate of discharge of the storage means to control the speed at which the said linear voltage output is varied between maximum and minimum values.

2. Electronic apparatus for developing cathode ray beam deflection voltages which comprises a combination of storage means across which a voltage is adapted to be developed in a direction to increase toward a maximum and discharge means for discharging the storage means and thereby developing a voltage wave of substantially linear configuration which is adapted for producing electrical fields for deflecting said beam, means for controlling the rate of discharge of the storage means to control the speed at which the said linearly changing voltage is varied between maximum and minimum values, means comprising a thermionic relay tube and a resistance and capacity circuit connected thereto for producing substantially square wave voltage outputs of time duration measured substantially by the time constant of the capacity and resistance means, means for controlling the said relay under the influence of an applied control pulse to initiate the controlled time duration square wave pulses, and a connection between the said relay and the said discharge means for rendering the said discharge means operative at a time coincident with the initiation of the said square wave pulse and for a time duration coincident with the duration of said square wave pulse so that in accordance with the receipt of control impulses serving to trigger the said relay output voltages to produce electrical fields to deflect a cathode ray beam along a single path of deflection are initiated.

3. Electronic apparatus for developing voltages to produce electrical fields to deflect a cathode ray beam which comprises, in combination, a capacity element and means for charging the element from a source of voltage, discharge means for discharging the capacity means, with operation, for developing substantially linearly changing output voltages which vary in the direction between maximum and minimum for producing the electrical fields for deflecting said beam, relay means for producing substantially square wave voltage outputs of selected time duration, means for controlling the said square wave relay means under the influence of an applied control pulse to initiate the controlled time duration square wave pulses, a connection between the said relay and the said discharge means for rendering the said discharge means operative at a time coincident with the initiation of the said square wave pulse and for a time duration coincident with the duration of said square wave pulse so that in accordance with the receipt of control impulses serving to trigger the said relay output voltages to produce electrical fields to deflect a cathode ray beam along a single path of deflection are initiated, means for controlling the rate of discharge of the storage means to control the speed within which the said linearly changing voltage is varied in its change in the direction between maximum and minimum values, and means for separately and independently controlling each of the means to control the speed at which the linearly changing voltage is produced and to control the time of duration of said voltage wave.

4. Electronic apparatus for developing voltages suitable for producing electrical fields to produce deflection of a cathode ray beam which comprises, in combination, a capacity element having means to charge said element from a substantially constant voltage source and a thermionic discharge means for discharging said capacity element at selected periods to produce substantially linearly changing output voltages adapted for producing electrical fields for deflecting said beam, a thermionic relay tube, variable resistance and capacity means connected thereto for producing substantially square wave voltage outputs of a duration which is measured substantially by the time constant of the capacity and resistance means, means for initiating an operation of the said relay under the influence of an applied control pulse, means for rendering the said discharge means operative to discharge the capacity coincidently with the initiation of the said square wave pulse and for establishing the duration period of operation of the discharge

means as coincident with the duration of said square wave pulse, so that with the receipt of each control impulse serving to trigger the said relay output voltages which serve to bring about a deflection of a cathode ray beam along a single path of deflection or initiated, resistive means for controlling the current flow through the discharge means at operative periods thereby to vary the rate of discharge of the storage means to control the speed at which the produced voltage change occurs, thermionic tube means connected to supply the linear output voltages from the storage means as varied by the dischange means to an output terminal, means for additively combining with said output voltages auxiliary voltages to mark the commencement and termination of the deflection period, and means to vary the rate of voltage change and the time of duration of the voltage change.

5. Electronic apparatus for developing cathode ray beam deflection voltages which comprises a combination of a capacitor and means for charging said capacitor to increase the voltage thereacross and discharge means for removing the charge on the capacitor and thereby for developing a substantially linearly changing voltage which varies in magnitude between maximum and minimum and is adapted for producing electrical fields for deflecting said beam, means for controlling the rate of discharge of the capacity means to control the rates at which the said sawtooth voltage is varied between maximum and minimum values so as thereby to control the beam deflection speed, means comprising a thermionic relay tube and a resistance and capacity circuit connected thereto for producing substantially square wave voltage outputs of time duration measured substantially by the time constant of the capacity and resistance means, means for controlling the said square wave relay under the influence of an applied control pulse to initiate the controlled time duration square wave pulses, a connection between the said relay and the said discharge means for rendering the said discharge means operative at a time coincident with the initiation of the said square wave pulse and for a time duration coincident with the duration of said square wave pulse so that in accordance with the receipt of control impulses serving to trigger the said relay output voltages to produce electrical fields to deflect a cathode ray beam along a single path of deflection are initiated, a first thermionic tube connected to supply the produced substantially linearly changing output voltage from the storage means to an output terminal, a second thermionic tube connected in parallel with the output circuit of the first-named thermionic tube, a differentiating circuit comprising a series connected capacity and a shunt resistor connected across the input of the second-named thermionic tube and adapted to receive the developed square wave output pulses from the relay and to differentiate said pulses in such a manner as to provide a control pulse of one polarity on the input of the second thermionic tube at a time coincident with the initiation of the square wave pulse and a pulse of the opposite polarity on the input of said tube at a time coincident with the termination of said square wave pulse, whereby the output current from the said first-named tube is modified at the commencement and termination of the discharge cycle and a voltage pulse to mark the commencement and termination of the said cycle is superimposed upon the output of the said first-named tube.

6. Electronic apparatus for developing voltages to produce electrical fields to deflect a cathode ray beam which comprises the combination of a plurality of individually selectable capacity means, means for charging said capacity means, a thermionic discharge element connected to discharge at least one of said capacity means, upon operation, for developing substantially linearly changing voltage outputs, resistance means for controlling the rate of discharge of the capacity means, means comprising a thermionic relay tube and a selectably variable resistance and capacity circuit connected thereto for producing substantially square wave voltage outputs of a time duration measured substantially by the time constant of the selected capacity and resistance means, means for controlling the said relay under the influence of an applied control pulse to initiate the controlled time duration square wave pulses, a connection between the said relay and the said thermionic discharge means for rendering the said discharge means operative at a time coincident with the initiation of operation of the said square wave pulse and for a duration of operation coincident with the duration of said square wave pulse so that in accordance with the receipt of control impulses serving to trigger the said relay substantially linearly changing output voltages to produce the electrical fields required to deflect a cathode ray beam along a single path of deflection are initiated, a first thermionic tube connected to supply the linearly changing output voltage from the storage means to an output terminal a second thermionic tube connected in parallel with the output circuit of the first-named thermionic tube, a differentiating circuit comprising a series connected capacity element and a shunt connected resistor element connected across the input of the second-named thermionic tube and adapted to receive the developed square wave output pulses from the relay and to differentiate said pulses in such manner as to provide a control pulse of one polarity on the input of the second thermionic tube at a time coincident with the initiation of the square wave pulse and a pulse of the opposite polarity on the input of said tube at a time coincident with the termination of said square wave pulse, whereby the output current from the said first-named tube is modified at the commencement and termination of the discharge cycle and a voltage pulse to mark the commencement and termination of the said cycle is superimposed upon the output of the said first-named tube, and means for modifying and varying the time constant circuit connected with the said relay whereby the time duration of the square wave pulse developed is modified and the resultant cathode ray beam deflection is caused to take place within selected time limits.

7. Electronic apparatus for developing cathode ray beam deflection voltages which comprises a combination of a capacity element and means to charge said element to develop an electrical charge therein, a thermionic discharge means for discharging said stored charge and thereby developing substantially linearly changing output voltage which varies in the direction from maximum to minimum and which is adapted for producing electrical fields for deflecting said beam, resistive means for controlling the current flow through the discharge means thereby to vary the rate of discharge of the capacity means to control the time within which the produced sawtooth

voltage is changed between maximum and minimum amplitude, a thermionic relay tube and a controllable resistance and capacity network connected thereto for producing substantially square wave voltage outputs of a duration which is measured substantially by the time constant of the capacity and resistance means, means for controlling the said relay under the influence of an applied control pulse to initiate a controlled time duration square wave pulse substantially concurrently with the control pulse, a connection between the said relay and the said discharge means for rendering the said discharge means operative to initiate a discharge of the charged capacity at a time coincident to the initiation of the said square wave pulse and for establishing the duration of operation of the discharge means so as to be coincident with the duration of said square wave pulse, so that with the receipt of each control impulse serving to trigger the said relay output voltages which serve to bring about a deflection of a cathode ray beam along a single path of deflection are initiated, a first thermionic tube connected to supply the sawtooth output voltage from the storage means as varied by the discharge means to an output terminal, a second thermionic tube connected in parallel with the output circuit of the first-named thermionic tube, a differentiating circuit comprising a series connected capacity and a shunt connected resistor connected across the input of the second-named thermionic tube and adapted to receive the developed square wave output pulses from the relay and to differentiate said pulses in such manner as to provide a control pulse of one polarity on the input of the second thermionic tube at a time coincident with the initiation of the square wave pulse and a pulse of the opposite polarity on the input of said tube at a time coincident with the termination of said square wave pulse whereby the output current from the said first-named tube is modified at the commencement and termination of the discharge cycle and a voltage pulse to mark the commencement and termination of the said cycle is superimposed upon the output of the said first-named tube, a third thermionic tube having its input circuit connected in parallel with the input of said second-named tube and connected to receive voltage impulses approximately identical to those supplied to the input of the second-named thermionic tube, an output circuit for said tube, the last-named tube having an output terminal whereat voltage pulses of a polarity serving to initiate a cathode ray beam are developed coincident with the commencement of the discharge voltage and a voltage pulse of the opposite polarity is developed coincident with the termination of discharge to suppress the developed cathode ray beam, and means for developing a second square wave voltage output from the said relay to provide a control voltage for intensifying the developed cathode ray beam.

8. Electronic apparatus for developing cathode ray beam deflection voltages which comprises a combination of a capacity element and means to charge said element to develop voltages thereacross and a thermionic discharge means for discharging said capacity and developing thereby substantially linearly changing voltages which change in the direction between maximum and minimum and which are adapted for producing electrical fields for deflecting said beam, resistive means for controlling the current flow through the discharge means thereby to vary the rate of discharge of the capacity means to control the speed at which the produced voltage is changed between maximum and minimum amplitude, a thermionic relay tube and a controllable resistance and capacity network connected thereto for producing substantially square wave voltage outputs of a duration which is measured substantially by the time constant of the capacity and resistance means, means for controlling the said relay under the influence of an applied control pulse to initiate the controlled time duration square wave pulses substantially concurrently with the control pulse, a connection between the said relay and the said discharge means for rendering the said discharge means operative to initiate a discharge of the charged capacity at a time coincident to the initiation of the said square wave pulse and for establishing the duration of operation of the discharge means so as to be coincident with the duration of said square wave pulse, so that with the receipt of each control impulse serving to trigger the said relay output voltages which serve to bring about a deflection of a cathode ray beam along a single path of deflection are initiated, a first thermionic tube connected to supply the substantially linearly changing voltage from the storage means as varied by the discharge means to an output terminal, a second thermionic tube connected in parallel with the output circuit of the first-named thermionic tube, a differentiating circuit comprising a series connected capacity and a shunt connected resistor connected across the input of the second-named thermionic tube and adapted to receive the developed square wave output pulses from the relay and to differentiate said pulses in such manner as to provide a control pulse of one polarity on the input of the second thermionic tube at a time coincident with the initiation of the square wave pulse and a pulse of the opposite polarity on the input of said tube at a time coincident with the termination of said square wave pulse whereby the output current from the said first-named tube is modified at the commencement and termination of the discharge cycle and a voltage pulse to mark the commencement and termination of the said cycle is superimposed upon the output of the said first-named tube, a third thermionic tube having its input circuit connected in parallel with the said second-named tube and connected to receive voltage impulses approximately identical to those supplied to the input of the second-named thermionic tube, and an output circuit for said tube, the last-named tube having an output terminal whereat voltage pulses of a polarity serving to initiate a cathode ray beam are developed coincident with the commencement of the discharge voltage and a voltage pulse of the opposite polarity is developed coincident with the termination of discharge to suppress the developed cathode ray beam.

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