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DRAWINGS ATTACHED

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(54) ELECTRON BEAM DEFLECTION CIRCUIT

(71) We, RCA CORPORATION formerly Radio Corporation of America, a Corporation organized under the laws of the State of Delaware, United States of America, of 30, Rockefeller Plaza, City and State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to electron beam deflection circuits and, in particular, to a deflection circuit wherein energy is transferred to a deflection winding by means of solid state semiconductor devices such as silicon controlled rectifiers.

The invention is particularly useful in connection with horizontal deflection circuits for television receivers and will be described further in connection with use in such apparatus.

Numerous circuit designs for completely transistorized television receivers either have been incorporated in commercially available receivers or have been described in detail in various technical publications. One of the most troublesome areas in such transistor receivers, from the point of view of reliability and economy, lies in the horizontal deflection circuits.

In an attempt to avoid the voltage and current limitations of transistor deflection circuits, a number of circuits have been proposed using the silicon controlled rectifier (SCR), a semiconductor device capable of handling substantially higher currents and voltages than transistors.

Most SCR deflection circuits heretofore proposed are of the retrace driven type wherein a single SCR is connected to a supply during the relatively short retrace portion of the deflection cycle. This replenishes the energy dissipated in an associated deflection yoke or winding during the trace portion of the cycle. The retrace driving circuit is gener-

ally of lower efficiency than the more conventional trace driven circuit commonly employed in vacuum tube or transistor deflection systems.

In the retrace driven circuit, a relatively high uni-directional current is passed through the SCR and associated deflection components during the retrace time.

A substantially linearly varying uni-directional deflection current is passed, for example, through a diode during trace. The resulting relatively high uni-directional current produces undesirable power losses in the resistive components associated with the deflection system.

In the conventional trace driven circuit, one or more active devices, which serves as a switch, conduct bidirectionally during the relatively long trace portion of the deflection cycle, replenishing energy in the yoke circuit during the latter half of trace and substantially reducing the direct current and associated power losses described above.

According to the present invention there is provided an electron beam deflection circuit for producing in a beam deflection winding sawtooth deflection current having alternate trace and retrace portions repetitive at a given recurrence rate, wherein a first source of electric energy capable of storing electric charge and said winding are connected in a first series combination having connected thereacross a first controllable switching means arranged to become bi-directionally conductive at a first predetermined timing with respect to said sawtooth current coupling said first source and said winding in a loop to generate said trace portion of said sawtooth current, a second source of electric energy shunted by a second controllable switching means and a coupling circuit comprising at least one reactive element linking said first and second controllable switches, said second controllable switching means being arranged to become conductive at a second predetermined timing with respect to said sawtooth

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current, causing energy stored in said coupling circuit means during each of said trace intervals when said second switching means is non-conductive to reverse the current flow through said first switching means towards the close of said trace interval and renders said first switching means non-conductive at the close of said trace interval to interrupt said current flow, whereupon energy is transferred from said coupling circuit during the ensuing retrace interval to said first series combination to replenish the energy losses therein during said preceding trace interval.

In the accompanying drawings:

FIGURE 1 is a schematic circuit diagram partially in block diagram form, of a television receiver embodying the invention; and

FIGURE 2 is a series of waveform diagrams (not drawn to scale) to which reference will be made in the explanation of the operation of the circuit of FIGURE 1.

Referring now to FIGURE 1 of the drawing, an embodiment of the invention will be described as it may be used in a typical television receiver. The television receiver includes an antenna 10 which receives composite television signals and couples the received signals to a tuner-second detector 11. The tuner-second detector 11 normally includes a radio frequency amplifier, a frequency converter for converting the radio frequency signals to intermediate frequency signals, an intermediate frequency amplifier and a detector for deriving composite television signals from the intermediate frequency signals. The television receiver further includes a video amplifier 12.

The amplified image-brightness-representative portion of the composite television signal produced by video amplifier 12 is applied to the control electrode (e.g. the cathode) of a television kinescope 13. The composite television signal is also applied from video amplifier 12 to a synchronizing signal separator circuit 14. The sync separator circuit 14 supplies vertical synchronizing pulses to a vertical deflection signal generator 15. Vertical deflection signal generator 15 is connected to a vertical deflection output circuit 16, terminals Y—Y' of which are connected to a vertical deflection winding 17 associated with kinescope 13.

Horizontal synchronizing pulses are derived from sync separator circuit 14 and are supplied to a phase detector 18, the latter also being supplied with a second signal related in time occurrence to the operation of a horizontal oscillator 19. An error voltage is developed in phase detector 18 and applied to horizontal oscillator 19 to synchronize the output of the latter with the horizontal synchronizing pulses. The output developed to horizontal oscillator 19 is supplied by means of a transformer 20 to a horizontal deflection

circuit 21 constructed in accordance with the principles of the present invention.

Deflection circuit 21 serves to produce, in a horizontal deflection winding 22, a sawtooth deflection current waveform having a trace portion and a retrace portion. In deflection circuit 21, a first source of electrical energy comprising a capacitor 23, across which there is developed a relatively constant voltage, is coupled to deflection winding 22 during the trace portion of the deflection cycle by means of a controllable bi-directionally conductive switching means 24.

Switching means 24 comprises the parallel combination of a silicon controlled rectifier (SCR) 25 and a damper diode 26, diode 26 being arranged to conduct current in a direction opposite to the direction of conduction of SCR 25. The deflection circuit 21 further comprises a second source of electrical energy including a relatively large inductor 27 coupled to a main B+ voltage supply (e.g. +150 Volts, not illustrated) provided in the television receiver. Reactive circuit means comprising the series combination of an inductor 28 and a capacitor 29 is coupled between inductor 27 and one terminal of switching means 24.

Circuit means comprising a winding 30 inductively associated with inductor 27, a resistor 31 and a capacitor 32 is coupled to the gate electrode of SCR 25 for rendering SCR 25 conductive during the trace portion of each deflection cycle as will be explained more fully below.

A second controllable bi-directionally conductive switching means 33 is coupled between the junction of inductors 27 and 28 and a point of reference voltage (i.e. ground). The switching means 33, like switching means 24, comprises the parallel combination of a silicon controlled rectifier (SCR) 34 and an energy recovery diode 35, diode 35 being arranged to conduct current in a direction opposite to the direction of conduction of SCR 34.

Circuit means are provided, as will be explained more fully below, for rendering switching means 33 conductive prior to the retrace portion of each deflection cycle. This latter circuit means comprises the transformer 20 which couples the output of horizontal oscillator 19 to the gate electrode of SCR 34.

A capacitive divider 36 having first and second capacitors 36a and 36b is coupled across the combination of capacitor 23 and deflection winding 22. The junction point of capacitors 36a and 36b is coupled to phase detector 18 to provide flyback or retrace pulses to phase detector 18 for controlling the operation of oscillator 19.

In the operation of the receiver shown in FIGURE 1, a television signal at radio frequency is received by antenna 10. The received signal is amplified, converted to an inter-

mediate frequency, further amplified and then detected by means of tuner-second detector 11. The image-representative portions of the signal are then amplified in video amplifier 12 and amplified video signals are applied to an electrode of kinescope 13. The detected television signal also is applied to synchronizing signal separator circuit 14. Sync separator circuit 14 separates the deflection synchronizing signals from the composite television signal and supplies vertical synchronizing signals to vertical deflection signal generator 15 and horizontal synchronizing signals to phase detector 18. Output pulses generated by vertical deflection signal generator 15 are supplied to vertical deflection output circuit 16 which, in turn, supplies a suitable sawtooth of current at field frequency to the vertical deflection winding 17 coupled across terminals Y—Y'.

Retrace pulses generated across capacitor 36b of divider 36, which are related in time occurrence to the signals generated by horizontal oscillator 19 (at a nominal frequency of 15,750 cycles per second for the United States of America) are applied to phase detector 18. The retrace pulses (or a waveform derived therefrom) are compared in phase detector 18 with the horizontal synchronizing pulses supplied from sync separator circuit 14. Phase detector 18 develops an error voltage which, in turn, is applied to horizontal oscillator 19 to control the oscillator phase and frequency.

The horizontal output pulses produced by oscillator 19 are shaped so as to provide positive pulses having, for example, a width of 3 to 7 microseconds, a repetition rate of 15,750 cycles per second and a predetermined time relationship, as will be pointed out more fully below, with respect to the horizontal blanking or retrace interval.

The positive pulses so formed are coupled to the gate electrode of silicon controlled rectifier 34 from the secondary winding of transformer 20. The silicon controlled rectifier 34, as will be described more fully below, initiates a sequence of events which results in producing the retrace portion of the horizontal deflection cycle each time a pulse is applied to its gate electrode.

Referring to FIGURE 2, current and voltage waveforms at various points in the circuit of FIGURE 1 are shown as they appear during each deflection cycle. The trace portion of a deflection cycle is indicated as occurring during the time interval t_0 to t_1 while the retrace portion of the cycle occurs during the interval t_1 to t'_0 . Typically, the interval t_0 to t_1 is about 53 microseconds in duration while the interval t_1 to t'_0 is about 10.5 microseconds in duration for the standards used in the United States of America.

In the horizontal deflection circuit 21, the operation of the first or trace switching means

24 now will be considered. The trace switching means 24 is intended to operate to connect a constant voltage supply (capacitor 23) across deflection winding 22 throughout the trace portion of the deflection cycle. Specifically, beginning at the time t_0 (start of trace), the current in deflection winding 22 (waveform A) is at a maximum amplitude flowing in the direction within winding 22, from terminal X to terminal X'. The voltage across capacitor 29 (waveform E) passes through zero and reverses. As this voltage reverses at time t_0 , the diode 26 in the first or trace switching means 24 is biased for conduction, applying the substantially constant voltage (e.g. +50 volts) developed across capacitor 23 to the deflection winding 22.

As a result, during the first half of the trace portion of the deflection cycle (t_0 to t_1), the current in deflection winding 22 (waveform A) declines in a substantially linear manner towards zero, thereby supplying energy to capacitor 23. Capacitor 23 is chosen sufficiently large so that the voltage across such capacitor does not change appreciably. Approximately midway through the trace portion of the cycle (i.e. at time t_1), the current through deflection winding 22 (waveform A) reverses and switches from damper diode 26 to SCR 25. In preparation for this switching of current paths, SCR 25 is placed in a "standby" condition during the first half of trace by means of a gate signal (waveform G) provided via winding 30, resistor 31 and capacitor 32.

The manner in which the gate signal is produced will be explained below. The polarity of the portion of the gate signal occurring during trace is arranged to enable conduction in SCR 25 when the main (anode-cathode) conduction path is forward biased. This latter condition takes place approximately midway through trace (e.g. at t_1) so that deflection current is transferred from diode 26 to SCR 25 at that time. The deflection current in winding 22 then increases in a substantially linear manner during the latter half of trace as such current passes through SCR 25. Energy is extracted from capacitor 23 and transferred to deflection winding 22 during this interval.

In order to terminate the trace portion of the deflection cycle and initiate the retrace portion thereof, SCR 25 must be rendered non-conductive (turned off). An SCR may be turned off by reversing the direction of current flow in the main (anode-cathode) current path and by applying a reverse voltage to the anode-cathode junction for a sufficient interval to remove all stored charge carriers from such junction. In deflection circuit 21, the above operation should take place within disrupting the desired smooth transition from the substantially linear trace current to the reversal of direction thereof during retrace.

Approximately five microseconds before the end of the trace portion of each deflection cycle (i.e. at t_3) a horizontal output pulse (waveform H) produced by oscillator 19 is applied to the gate electrode of SCR 34 to initiate a sequence of events leading to the occurrence of the retrace portion of the deflection cycle. Specifically, when SCR 34 is triggered into conduction by oscillator 19, a closed circuit path comprising the first switching means 24, second switching means 33, inductor 28 and capacitor 29 is completed. The current in deflection winding 22 (waveform A) continues to increase linearly since switch 24 remains closed.

At the same time, substantial energy which, as will be explained below, previously has been stored in capacitor 29 is circulated in the above-mentioned closed circuit path at a resonant frequency determined by the combination of capacitor 29 and inductor 28. Initially, current (waveform D) flows in the closed circuit path in the forward direction through SCR 34 and in the reverse direction through SCR 25, the latter being possible since a substantial forward current (that of winding 22) also is flowing through SCR 25.

The resonant current, however, increases more rapidly than the deflection current so that, after a predetermined time interval (e.g. 2-3 microseconds) the net current flow through SCR 25 reverses (at t_4 in waveform C). SCR 25 is therefore turned "off". The resonant current, which continues to increase, then switches to diode 26 for a short interval until the deflection and resonant currents are again equal and current flow through switch 24 is thus interrupted. At that time, diode 26 and SCR 25 both are switched "off" (i.e. to high impedance state) thereby "disconnecting" winding 22 from the constant trace voltage supply (i.e. capacitor 23). The retrace interval commences at this time (t_5).

The time interval (t_4 to t_5) during which current passes through diode 26 is arranged to be of sufficient duration to permit the removal of all stored carriers in SCR 25 thereby insuring that SCR 25 will remain "off" until the required standby trigger is applied to its gate electrode during the trace portion of the succeeding deflection cycle.

During retrace, switch 33 acts to couple the reactive components comprising inductor 28, capacitor 29 and deflection winding 22 in a series resonant circuit. Capacitor 23, because of its large value, may be neglected in this discussion. The resonant period of the three components is selected to be twice as long as the desired retrace interval. Therefore, the current in deflection winding 22 will pass through one-half cycle of oscillation, thereby accomplishing the desired reversal of direction of such current and the consequent retrace of the electron beam in kinescope 13.

Since SCR 34 is a unidirectionally conduc-

tive device, diode 35 is coupled across SCR 34 to render switching means 33 bidirectionally conductive, thereby permitting the reversal of deflection current. When the current through switch 33 reverses (i.e. at t_6), SCR 34 is rendered non-conductive. The duration of the flow of current through diode 35 (about half of retrace time) is more than adequate to insure removal of all carriers from SCR 34 thereby insuring proper turnoff of SCR 34.

The energy exchange relationships which exist during retrace and immediately thereafter are of particular interest and will now be discussed, including the manner in which energy is stored in capacitor 29 preparatory to initiating retrace.

At the beginning of retrace (t_5), the currents in deflection winding 22 (waveform A) and inductor 28 (waveform D) are substantial and equal (any difference is rapidly eliminated since both components are in series at this time). Such currents are representative of energy stored in these inductive components. At the same time, since the current in inductor 28 and capacitor 29 has decreased from its peak value (waveform D) and some voltage exists across capacitor 29 (waveform E), it is evident that capacitor 29 also stores some energy at the beginning of retrace.

When switch 24 is opened (at t_5), the energy stored in deflection winding 22 and inductance 28 is transferred into capacitor 29 during the first half of retrace and then all of the energy stored in capacitor 29, including that which was stored at the beginning of retrace, is returned to the deflection winding 22 and inductance 28 during the second half of retrace. At the end of retrace, there is substantially no energy stored in capacitor 29.

During the entire retrace interval, and immediately preceding such interval (i.e. including t_5 to t_6), the second switching means 33 is closed, thereby coupling inductance 27 directly across the B+ voltage supply. During this time, the current in inductor 27 increases in a substantially linear manner resulting in the storage of substantial energy in inductor 27.

At the end of retrace (at t_6), diode 26 is once again forward biased as the voltage across deflection winding 22 completes substantially one-half cycle of oscillation. As diode 26 is switched "on", the current in deflection winding 22 again returns to the linearly varying waveform. At the same time, the residual energy stored in inductor 28 (see waveform D) is transferred rapidly (t_6 to t_7) to capacitor 29 via diodes 26 and 35. At the end of this last-mentioned energy transfer, diode 35 (and therefore switch 33) opens. It should be noted that switch 33 has remained closed during the interval t_5 to t_6 . Inductor 27 then commences to discharge into capacitor 29 via the trace switch 24 (see voltage wave-

form E). Sufficient energy is transferred into capacitor 29 from inductor 27 during the interval t_1 to t_3 to replenish circuit losses occurring during the preceding deflection cycle. This energy is then supplied by capacitor 29 primarily to winding 22 during retrace as was mentioned above.

The gating signal (waveform G) applied to SCR 25, which was described in general terms above, is produced in the following manner: The voltage across inductor 27 and therefore the voltage across inductor 30, is in the form of a square wave with transitions occurring near the beginning (i.e. at t_1) and near the end (i.e. t_3) of trace as the switches 33 and 24 change state (see waveform F). After filtering in the network comprising resistor 31 and capacitor 32, the square wave is modified for application to the gate electrode of SCR 25 to provide a wave having relatively slowly increasing and slowly decreasing portions. As was mentioned above, the polarity of the major portion of the wave occurring during trace is selected to enable conduction

in SCR 25 when the main (anode-cathode) path of SCR 25 is forward biased.

The gating signal applied to SCR 25 may, of course, be derived in several different ways. For example, this gating signal may be provided by oscillator 19 just as the gating signal applied to SCR 34 is provided.

In order to permit adjustment of the operating time intervals, components in the circuit (e.g. inductor 28) may be made variable.

High voltage generation circuitry (not illustrated) for development of the high voltage required by the ultor electrode of kinescope 13 may be associated with deflection circuit 21 in a variety of ways. Illustratively, the primary winding of a high voltage flyback transformer may be effectively shunted across switching means 24, with stepped-up flyback pulses, derived from a secondary winding of the transformer, applied to a high voltage rectifier to develop the unidirectional ultor potential.

A circuit of the type shown in FIGURE 1 utilizing the following component values has been built and tested to operate satisfactorily.

50	deflection winding 22	1.1 millihenries
	capacitor 23	1 microfarad
	SCR 25	RCA Type TA 2688
	diode 26	General Instrument Type RG100G
	inductor 27	40 millihenries
55	inductor 28	150 microhenries
	capacitor 29	0.015 microfarads
	SCR 34	RCA Type TA2688
	diode 35	General Instrument Type RG100G

WHAT WE CLAIM IS:—

1. An electron beam deflection circuit for producing in a beam deflection winding sawtooth deflection current having alternate trace and retrace portions repetitive at a given recurrence rate, wherein a first source of electric energy capable of storing electric charge and said winding are connected in a first series combination having connected thereacross a first controllable switching means arranged to become bi-directionally conductive at a first predetermined timing with respect to said sawtooth current coupling said first source and said winding in a loop to generate said trace portion of sawtooth current, a second source of electric energy shunted by a second controllable switching means and a coupling circuit comprising at least one reactive element linking said first and second controllable switches, said second controllable switching means being arranged to become conductive at a second predetermined timing with respect to said sawtooth current, causing energy stored in said coupling circuit means during each of said trace intervals when said second switching means is non-conductive to reverse the current flow through said first switching means towards the close of said trace interval and renders said first switching

means non-conductive at the close of said trace interval to interrupt said current flow, whereupon energy is transferred from said coupling circuit during the ensuing retrace interval to said first series combination to replenish the energy losses therein during said preceding trace interval.

2. A deflection circuit as claimed in claim 1 wherein said first switching means comprises the parallel combination of a first controlled rectifier having anode, cathode and gate electrode and a diode having an anode and cathode coupled respectively to said cathode and anode of said first controlled rectifier, and wherein triggering signals applied between said gate electrode and another electrode of said first controlled rectifier at said first timing renders said first controlled rectifier conductive.

3. A deflection circuit as claimed in claim 2 wherein deflection current flow during the first half of the trace portion of said sawtooth is through said first diode and said first controlled rectifier is conductive during the latter half of the trace portion.

4. A deflection circuit as claimed in any one of the preceding claims wherein said second controllable switching means comprises the anode-cathode path of a second controlled

form E). Sufficient energy is transferred into capacitor 29 from inductor 27 during the interval t_1 to t_2 to replenish circuit losses occurring during the preceding deflection cycle. This energy is then supplied by capacitor 29 primarily to winding 22 during retrace as was mentioned above.

The gating signal (waveform G) applied to SCR 25, which was described in general terms above, is produced in the following manner: The voltage across inductor 27 and therefore the voltage across inductor 30, is in the form of a square wave with transitions occurring near the beginning (i.e. at t_1) and near the end (i.e. t_2) of trace as the switches 33 and 24 change state (see waveform F). After filtering in the network comprising resistor 31 and capacitor 32, the square wave is modified for application to the gate electrode of SCR 25 to provide a wave having relatively slowly increasing and slowly decreasing portions. As was mentioned above, the polarity of the major portion of the wave occurring during trace is selected to enable conduction

in SCR 25 when the main (anode-cathode) path of SCR 25 is forward biased.

The gating signal applied to SCR 25 may, of course, be derived in several different ways. For example, this gating signal may be provided by oscillator 19 just as the gating signal applied to SCR 34 is provided.

In order to permit adjustment of the operating time intervals, components in the circuit (e.g. inductor 28) may be made variable.

High voltage generation circuitry (not illustrated) for development of the high voltage required by the ultor electrode of kinescope 13 may be associated with deflection circuit 21 in a variety of ways. Illustratively, the primary winding of a high voltage flyback transformer may be effectively shunted across switching means 24, with stepped-up flyback pulses, derived from a secondary winding of the transformer, applied to a high voltage rectifier to develop the unidirectional ultor potential.

A circuit of the type shown in FIGURE 1 utilizing the following component values has been built and tested to operate satisfactorily.

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	capacitor 23	1 microfarad
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	diode 26	General Instrument Type RG100G
	inductor 27	40 millihenries
	inductor 28	150 microhenries
55	capacitor 29	0.015 microfarads
	SCR 34	RCA Type TA2688
	diode 35	General Instrument Type RG100G

WHAT WE CLAIM IS:—

1. An electron beam deflection circuit for producing in a beam deflection winding sawtooth deflection current having alternate trace and retrace portions repetitive at a given recurrence rate, wherein a first source of electric energy capable of storing electric charge and said winding are connected in a first series combination having connected thereacross a first controllable switching means arranged to become bi-directionally conductive at a first predetermined timing with respect to said sawtooth current coupling said first source and said winding in a loop to generate said trace portion of sawtooth current, a second source of electric energy shunted by a second controllable switching means and a coupling circuit comprising at least one reactive element linking said first and second controllable switches, said second controllable switching means being arranged to become conductive at a second predetermined timing with respect to said sawtooth current, causing energy stored in said coupling circuit means during each of said trace intervals when said second switching means is non-conductive to reverse the current flow through said first switching means towards the close of said trace interval and renders said first switching

means non-conductive at the close of said trace interval to interrupt said current flow, whereupon energy is transferred from said coupling circuit during the ensuing retrace interval to said first series combination to replenish the energy losses therein during said preceding trace interval.

2. A deflection circuit as claimed in claim 1 wherein said first switching means comprises the parallel combination of a first controlled rectifier having anode, cathode and gate electrode and a diode having an anode and cathode coupled respectively to said cathode and anode of said first controlled rectifier, and wherein triggering signals applied between said gate electrode and another electrode of said first controlled rectifier at said first timing renders said first controlled rectifier conductive.

3. A deflection circuit as claimed in claim 2 wherein deflection current flow during the first half of the trace portion of said sawtooth is through said first diode and said first controlled rectifier is conductive during the latter half of the trace portion.

4. A deflection circuit as claimed in any one of the preceding claims wherein said second controllable switching means comprises the anode-cathode path of a second controlled



- rectifier having anode, cathode and gate electrode, said anode-cathode being poled for conduction through said reactive circuit means and said first switching means in a direction
5 opposite to the direction of conduction of deflection current through said first switching means at the end of said trace portion, triggering signals applied at said second timing between said gate electrode and another of said
10 electrodes of said second controlled rectifier thereby to render it conductive.
5. A deflection circuit as claimed in claim 4 wherein said coupling circuit means resonates with the series combination of said deflection winding and said first source of electric energy during the retrace portion when
15 said second and first switching means are respectively conducting current and not conducting current, said resonance causing a reversal of current flow to said second switching means rendering said second controlled rectifier non-conductive.
6. A deflection circuit as claimed in claim 5, wherein the natural resonant period of the combination of said deflection winding and said coupling circuit means is selected to be substantially twice as great as the interval of said retrace portion.
7. A deflection circuit as claimed in claim
30 5, wherein said coupling circuit means comprises a first inductive element and a second capacitive element in a second series combination.
8. A deflection circuit as claimed in claim
35 7, characterised in that the resonant period of said second series combination is selected with respect to the interval between initiation of conduction in said second switching means and commencement of retrace to cause said
40 reversal of current flow through and said interruption of current flow in said first switching means within said last-named interval.
9. A deflection circuit as claimed in any one of claims 4, 5, 6, 7 and 8 wherein said
45 second switching means further comprises a second diode having anode and cathode coupled respectively to the cathode and anode of said second controlled rectifier.
10. A deflection circuit as claimed in any
50 one of the prior claims wherein said conduction of said second switching means extends during a portion of the latter half of said trace portion and throughout said retrace portion.
11. A deflection circuit as claimed in any one of the previous claims wherein said first source of electrical energy comprises a first voltage supply and said second source of electrical energy comprises a supply of current
60 during the interval said second switching means is not conducting.
12. A deflection circuit as claimed in claim 11 wherein said first voltage supply comprises a relatively large capacitor for storing sufficient charge to maintain a relatively constant voltage across said deflection winding during
65 said trace portion of said sawtooth current.
13. A deflection circuit as claimed in either of claims 11 or 12 wherein said current supply comprises the series combination of a second voltage supply and an inductor in the magnetic field of which energy is stored when
70 said second switching means is closed to be released as continuing current flow to said reactive circuit means when said second switching means is open.
14. An electron beam deflection circuit constructed and operating substantially as described with reference to the accompanying
80 drawings.

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