May 10, 1955 R. F. CASEY 2,708,240

SWEEP CIRCUIT

Filed April 26, 1952 3 Sheets-Sheet 1

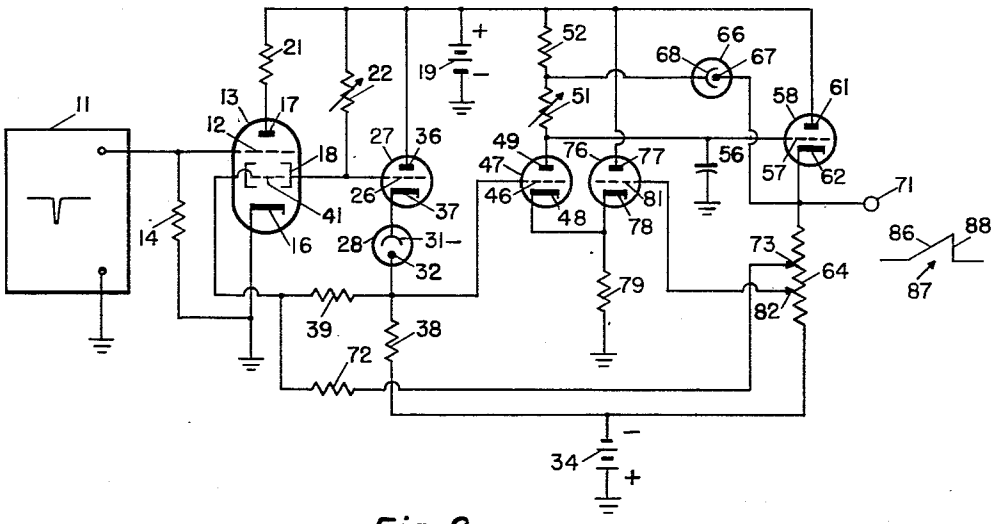



Fig. 2

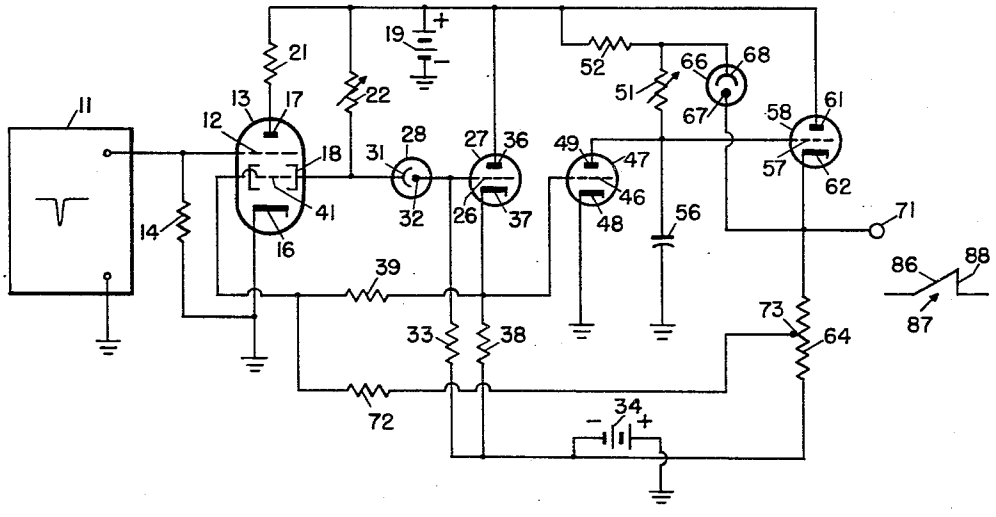



Fig. 1

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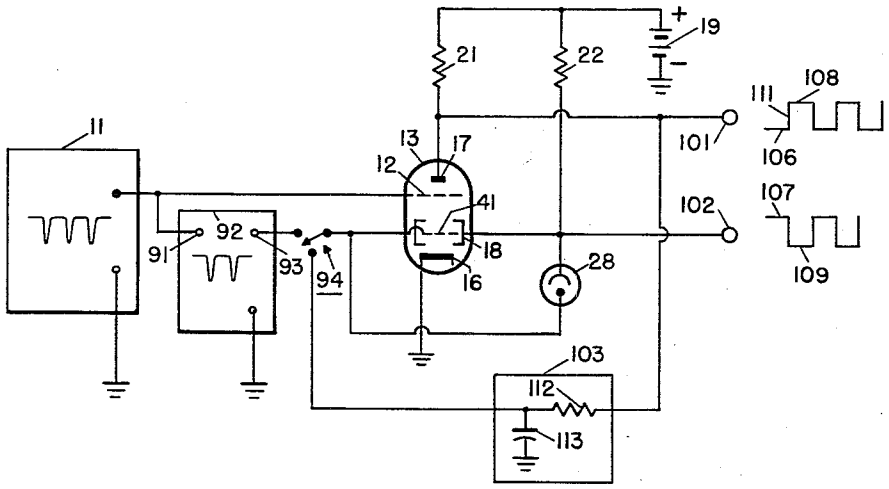



Fig. 4

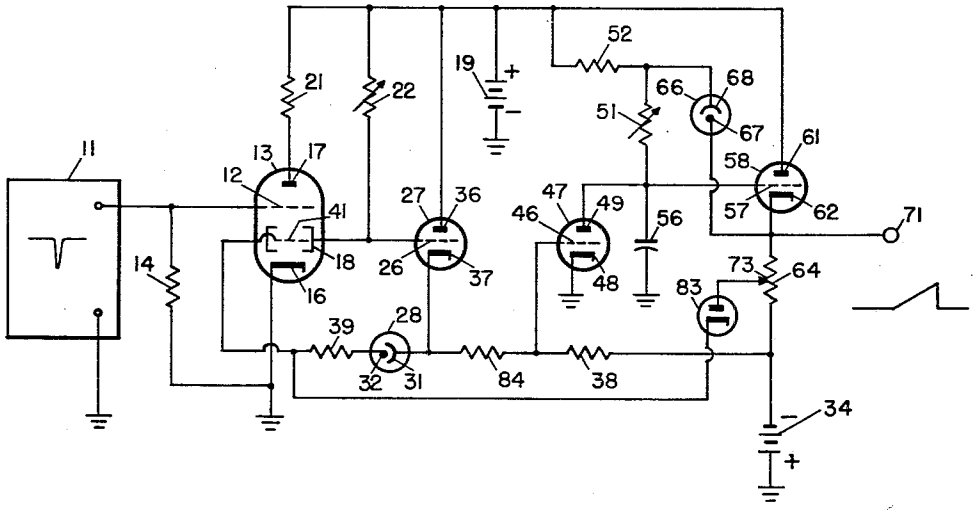



Fig. 3

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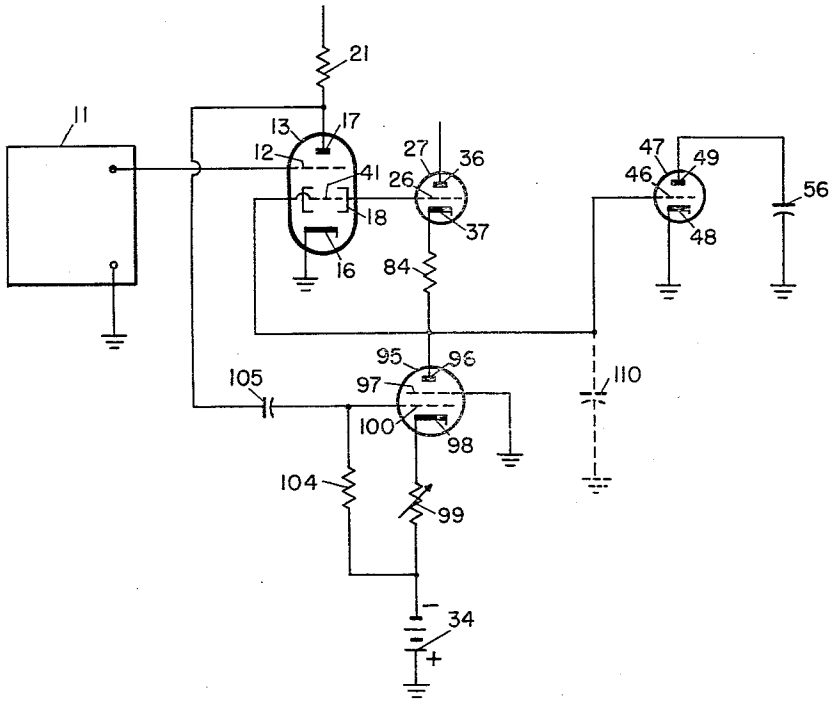



Fig. 5

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United States Patent Office 2,708,240 Patented May 10, 1955



2,708,240

# SWEEP CIRCUIT

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Application April 26, 1952, Serial No. 284,609

17 Claims. (Cl. 250—27)

This invention relates to electrical circuits and particularly to circuits for producing sawtooth voltage waves. Such waves are useful, for example, in causing an electron beam to scan a phosphor screen in a cathode-ray tube.

An object of the invention is to provide a generator for producing recurrent high-speed electrical signals, the rate of recurrence being variable by adjustment of a single time-constant circuit.

Another object of the invention is to provide a circuit for generating selectively recurrent or non-recurrent linear sawtooth waves having uniform characteristics and rapid retrace times.

A further object is to provide a circuit for generating push-pull square waves.

Another object is to provide a bi-stable square wave generator the repetition rate of which is controlled by a single time-constant circuit.

Other objects will be apparent.

In the drawings,

Figure 1 is a schematic diagram of a preferred embodiment of the invention;

Figures 2 and 3 are schematic diagrams of modifications of the circuit of Figure 1, incorporating features which provide increased stability of operation;

Figure 4 is a schematic diagram showing a modification of a portion of the circuit of Figure 1, which provides a push-pull square wave signal; and

Figure 5 is a schematic diagram of a circuit which may be incorporated in the circuits of Figures 1, 2 or 3 in order to increase the speed of operation.

In Figure 1, a source 11 of negative polarity synchronizing signals is connected to a second grid 12 of a timing tube 13 which preferably is of the type known as a "gated-beam" tube, such as the tube type No. 6BN6. This second grid is sometimes referred to as a "quadrature" grid. The second grid 12 is returned to ground through a resistance 14, and a cathode 16 is grounded. An anode 17 and a collector electrode 18 are connected, through load resistances 21 and 22, respectively, to a source 19 of voltage having positive polarity. The resistance 22 is preferably adjustable.

A control electrode 26 of a coupling tube 27 is connected to the collector element 18 through a constant-voltage device 28 shown as having an anode 31 and a cathode 32. The constant-voltage device 28 may be a gas-filled tube, a piece of thyrite, or the like. The control electrode 26 is also connected through a resistance 33 to a source 34 of voltage having negative polarity. An anode 36 is connected to the voltage source 19. A cathode 37 is connected through a resistance 38 to the voltage source 34 and also through a resistance 39 to a first grid 41 in the timing tube 13, and also to a control electrode 46 of a discharge tube 47, a cathode 48 of which is grounded.

An anode 49 of the discharge tube 47 is connected to the voltage source 19 through a variable resistance 51 and a fixed resistance 52. The anode 49 is also connected to a condenser 56 and to a control electrode 57 of an output tube 58 having an anode 61 connected to the source 19 of voltage, and a cathode 62 connected through a load resistance 64 to the source 34 of voltage. The cathode 62 of the output tube 58 is connected through a constant-voltage device 66 to the junction between the fixed resistance 52 and the variable resistance 51, a cathode 67 of the device 66 being shown connected to the cathode 62 and an anode 68 being shown connected to the junction. An output terminal 71 is connected to the cathode 62. A feedback resistance 72 is connected between a tap 73 on the load resistance 64 and the first grid 41 of the timing tube 13.

In the figures of the drawings, like parts are designated by like reference numerals. Figure 2 includes, in addition to the elements shown in Figure 1, a feedback tube 76 having an anode 77 connected to the voltage source 19, a cathode 78 connected to the cathode 48 of the discharge tube 47 and through a resistance 79 to ground, and a control electrode 81 connected to a tap 82 on the load resistance 64. The purpose of the feedback tube 76 is to increase the operating stability, as will be described hereinafter. In Figure 2, the constant-voltage device 28 is shown connected in series with the cathode 37 of the coupling tube 27, instead of in series with the grid 26 of this tube as is shown in Figure 1. The resistance 33 connected to the grid 26 of the coupling tube 27 in Figure 1, is omitted in Figure 2. The purpose of these latter changes is to provide suitable operating potentials for the tube elements.

In Figure 3, the feedback resistance 72 of Figure 1 is replaced by a diode rectifier device 83 having an anode connected to the tap 73 and a cathode connected to the first grid 41 of the timing tube 13. A resistance 84 is connected between the cathode 37 of the coupling tube 27 and the control electrode 46 of the discharge tube 47, for the purpose of obtaining proper operating voltages. The constant voltage device 28 is connected in the circuit in a manner similar to its connection shown in Figure 2.

The part of the circuit comprising the discharge tube 47, the condenser 56, the output tube 58, the constant-voltage device 66, and associated components, is more fully described in copending application Serial No. 284,611, by the same inventor and assigned to the same assignee.

In Figure 4, the source 11 of negative-polarity synchronizing signals is connected to the second grid 12 of the timing tube 13, and also to an input terminal 91 of a source 92 of variable phase positive polarity trigger signals having an output terminal 93 which may be connected through a switch 94 to the first grid 41 of the timing tube 13. The load resistances 21 and 22 are connected between the voltage source 19 and the anode 17 and collector electrode 18 as has been described in connection with Figures 1, 2 and 3. The collector electrode 18 is connected through a constant-voltage device 28 to the first grid 41. The cathode 16 is grounded. A first output terminal 101 is connectel to the anode 17. A second output terminal 102 is connected to the collector electrode 18. A phase delay device 103 is connected between the anode 17 and the switch 94 so that it may be selectively connected to the first grid 41.

In the modified circuit of Figure 5, the cathode load resistance 38 of the coupling tube 27 shown in Figures 1, 2 and 3 is replaced with an electronic tube 95, preferably of the pentode type, having an anode 96 connected jointly to the resistance 84 and the control electrodes 41 and 46 of the tubes 13 and 47 respectively. A screen grid 97 is grounded. A cathode 98 is connected through a variable resistance 99 to the negative voltage source 34. A control electrode 100 is connected through a resistance 104 to the

voltage source 34, and through a capacitance 105 to the anode 17 of the timing tube 13. A stray capacitance 110 occurs in the circuit between ground and the elements of the tubes 13, 47 and 95.

Before describing the operation of the invention, it will be expedient to describe the function and operation of the timing tube 13. By connecting proper voltage to this tube, it is possible to cause the tube to have two stable states of operation. For the first stable state, both the first grid 41 and the second grid 12 are caused to have voltage polarities with respect to the cathode 16 such that electrons from the cathode 16 will flow through both grids to the positive-polarity anode 17, and thus a current will flow through the anode load resistance 21. In this first stable state, no appreciable amount of electrons from the cathode 16 flows to the collector electrode 18; hence, there is no appreciable current flowing through the collector load resistance 22, and thus the collector electrode assumes approximately the positive-polarity voltage of the source 19.

In the second stable state of the tube 13, the voltage of the first grid 41 is changed to be relatively negative in polarity with respect to its voltage for the first stable state. This voltage is usually negative with respect to the voltage of the cathode 16. Electrons from the cathode 16 will then flow directly to the collector electrode 18, and thus appreciable current will flow through the collector load resistance 22, and the collector potential will become relatively less positive. Under these conditions, no electrons from the cathode 16 will flow to the anode 17, irrespective of whether the second grid 12 is made to have a positive or a negative polarity. Hence, no appreciable current will flow through the anode load resistance 21 in the second stable state. The tube 13 effectively has two output electrodes; the anode 17 and the collector electrode 18.

The invention operates as follows: (refer to Figures 1 and 2). Normally the timing tube 13 will be in its first stable state, with current flowing to the anode and only a small amount flowing to the collector electrode. When a negative polarity pulse from the source 11 is applied to the second grid 12 of the timing tube 13, the electron current in the tube that was flowing to the anode, will now flow to the collector electrode 18, through the first grid 41. This causes current to flow through the collector load resistance 22, thereby causing the collector electrode 18 to quickly become relatively negative with respect to its original potential. The tube now is in a transition state, with electrons flowing from the cathode to the collector through the first grid.

The negative change in potential of the collector 18 is quickly transmitted, by alternative means in the two preferred embodiments of Figures 1 and 2, to the first grid 41 of the gated beam tube. In the circuit of Figure 1, the negative change in potential of the collector electrode 18 is transmitted through the constant-voltage device 28 to the control electrode 26 of the coupling tube 27. Since the tube 27 is connected in a cathode-follower circuit, the voltage on its cathode 37 will assume a relatively negative change in polarity, which change is applied through the resistance 39 to the first grid 41 of the timing tube 13.

In the circuit of Figure 2, the negative change in potential of the collector electrode 18 is directly applied to the grid 26 of the coupling tube 27. This causes the voltage of the cathode 37 to become relatively negative, this negative voltage change being transmitted through the constant-voltage device 28 and the resistance 39 to the first grid 41 of the timing tube 13.

When the first grid 41 of the timing tube 13 is thus quickly made relatively negative, current ceases to flow through it to the collector 18 and instead flows directly to the collector electrode 18. The tube 13 has thus quickly changed from its stable state through a transition state, and then to its second stable state, and will remain in this second stable state as long as the first grid



41 is maintained at a negative potential, irrespective of the polarity of voltage of the second grid 12. In the circuits described, the first grid 41 will remain at a negative potential, and the timing tube 13 will remain in its second stable state, until the first grid is made relatively positive in polarity by means of a feedback voltage applied thereto through the resistance 72, as will be described hereinafter.

The negative voltage which appears at the junction between the resistances 38 and 39 as has been hereinbefore described, is applied to the control electrode 46 of the discharge tube 47, which normally is in a conducting state thereby normally maintaining the condenser 56 in a discharged condition. The discharge tube 47 is quickly made substantially non-conductive when its control electrode is rendered negative in voltage polarity, and the condenser 56 then begins to charge from the voltage source 19 through the resistances 51 and 52. As the condenser 56 charges, the voltage thereacross increases in a positive direction, and is applied to the control electrode 57 of the output tube 58, which is connected in a cathode-follower type of circuit having an output load resistance 64. As the voltage of the control electrode 57 becomes greater in a positive direction, the cathode 62 follows the change, and therefore a positively increasing voltage appears at the load resistance 64 and at the output terminal 71 as is indicated by the numeral 86 on the saw-toothed output signal 87. The constant-voltage device 66 functions to provide linearity of the output signal at the terminal 71 as is more fully described in the copending application to which reference is made hereinbefore.

The positive voltage appearing at the load resistance 64 is tapped off at the tap 73 and applied through the resistance 72 to the first grid 41 of the timing tube 13. When this voltage becomes sufficiently positive in value, electrons from the cathode 16 will flow through the first grid 41 and through the second grid 12 (which is no longer rendered negative by the signal source 11) to the anode 17 thereby returning the tube 13 to its first stable state. The collector electrode 18 now draws less current through its load resistance 22, and the voltage thereat changes in a positive direction to a value nearer that of the voltage source 19. This positive voltage at the collector electrode 18, is applied to the control electrode 26 of the coupling tube 27 and hence the voltage at the cathode 37 thereof changes in a positive direction, thereby rendering the discharge tube 47 conductive, whereupon the condenser 56 is quickly discharged therethrough. The output voltage 87 then ceases to increase, and quickly returns to its quiescent value, as indirected by the numeral 88. When used to provide deflection voltages for a cathode-ray tube, the positive portion 86 of the output signal 87 represents the active part of the electron beam sweep and the negative portion 88 represents the return trace of the electron beam sweep.

By adjustment of the collector load resistance 22, the invention can be used to provide either recurrent or non-recurrent sweep signals, in the following manner. If the collector load resistance 22 is made to have a sufficiently small value, the circuit will remain in its first stable state until triggered by the source 11 of synchronizing signals. That is, each synchronizing signal from the source 11 will produce a single sawtooth output signal in the manner described above. If the collector load resistance 22 is made to have a sufficiently large value, however, the sawtooth signal output can be made recurrent and a series of sawtooth output signals will be provided, even if no synchronizing signals are applied to the second grid 12 of the timing tube 13.

The recurrent sweep occurs in the following manner. When, at the end of a sweep, the discharge tube 47 is made conductive by applying a positive voltage to its control electrode, the condenser 56 discharges through this tube. When the condenser 56 has discharged suffi-

ciently, the anode of the discharge tube 47 will become relatively less positive in its voltage, whereupon the positive-polarity control electrode 46 will begin to draw current and the anode 49 will cease to draw current. At this moment, the output signal 87 has reached its quiescent or zero value at the bottom of the return-trace portion 88. The current to the control electrode 46 flows through the coupling tube 27 from the source 19 of voltage. Due to the effect of increased current flowing through the inherent resistance of the coupling tube 27, the voltage of the control electrode 46 of the discharge tube 47 will change in a negative direction. This negative voltage is applied through the resistance 39 to the first grid 41 of the timing tube 13 and thereby causes this tube to change into its second stable state whereby a new sawtooth output signal is generated. This procedure continues consecutively, thereby producing a continuous succession of sawtooth output wave forms. The recurrent operation may be synchronized by signals from the source 11. Certain other circuit elements also may be adjusted to selectively obtain recurrent or non-recurrent operation.

The coupling tube 27, in addition to its functions already described, performs the function of stabilizing the voltage at the control electrode 46 of the discharge tube 47, as follows. It will be noted that the positive output signal which is fed back through the resistance 72 to the first grid 41 of the timing tube 13, is also fed through the resistance 39 to the control electrode 46 of the discharge tube 47. Under certain conditions, this could cause an undesirable effect of making the tube 47 conductive prematurely whereas it is desirable, in the operation of the circuit, that the tube 47 should not become conductive until after the timing tube 13 changes to its first stable state via the feedback signal to its first grid 41.

The coupling tube 27 prevents this undesirable effect by acting as a voltage regulator for the feedback voltage at the control electrode 46. When the voltage at the control electrode 46 tends to change in a positive direction, the cathode 37 of the coupling tube 27 also tends to change in a positive direction. This tendency results in less current flowing through the coupling tube 27 whereby its cathode voltage tends to become more negative. These counteractive effects tend to stabilize the voltage at the control electrode 46 of the discharge tube 47 with respect to the output signal feedback voltage.

In the embodiment shown in Figure 2, the feedback tube 76 provides additional stability for the discharge tube 47, as follows: As has been stated above, there is an undesirable tendency for the voltage of the control electrode 46 of the discharge tube 47 to change in a positive direction due to the feedback of the output signal. The feedback tube 76 counteracts this tendency by applying a counteracting feedback voltage to the cathode 48 of the discharge tube 47. The output voltage from the tap 82 is fed to the control electrode 81 of the feedback tube 76, and is thereby cathode-coupled to the cathode 48 of the discharge tube 47. This novel arrangement causes the voltage at the cathode 48 to change substantially the same amount and in the same direction of polarity as the control electrode 46 thereof, as far as the feedback voltage of the output signal is concerned. Therefore, there is no possibility of the discharge tube 47 becoming conductive prematurely before the timing tube 13 is actuated into its first stable state.

In the circuit of Figure 3, the diode rectifier 83 functions to delay the feedback of the output signal to the first grid 41 of the timing tube 13 until the signal is of sufficient magnitude to actuate the grid 41 and return the timing tube 13 to its first stable state. Thus, there is no danger of the feedback signal actuating the discharge tube 47 before it is of sufficient magnitude to actuate the first grid 41 of the timing tube 13. The delay in the feedback signal may be controlled by adjustment of the tap 73 on the load resistance 64.

The various novel stabilization means, above described, cause the grid 41 of the timing tube 13 to be actuated before the grid 46 of the discharge tube 47 becomes actuated, both at the time when the negative sweep-actuating signal is applied to these grids, and also when the positive return-sweep-actuating feedback signal is applied to these grids. This feature is particularly desirable for the following reasons: In a conventional circuit having a signal source connected to control electrodes of two tubes, a positive signal will actuate a first one of these tubes before it actuates the second tube, depending on the grid and cathode biases of the tubes. A negative signal, however, will actuate the second tube before it actuates the first tube. Such a conventional arrangement lacks the required stability for a sweep circuit such as is here described. In the novel stabilization circuits herein described, the two tubes involved, i. e., the switching tube 13 and the discharge tube 47, are biased so that a negative signal will actuate the switching tube first; and the stabilizing circuits, hereinbefore described, cause the switching tube to again be the first actuated by a positive signal, after which the discharge tube is actuated.

The recurrent sweep rate may be adjusted by means of the variable resistance 51. This sweep rate may also be varied by adjusting the values of the condenser 56, the voltages 19 and 34, and the tap 73 on the output resistance 64. The source 11 of synchronizing signals may be employed to obtain synchronization of the sweep circuit.

It is to be noted that the constant-voltage tube 28, shown in different positions in the figures of the drawing in order to provide proper operating voltages for the tubes, could be replaced by a resistance if desired. However, since the signal from the collector element 18 is coupled through the constant voltage device 28 to the first grid 41, a resistance at this point would reduce the amount of signal thus coupled. Therefore, a constant-voltage device is preferable at this point in order to transmit the full magnitude of this coupling signal, and at the same time provides proper operating voltages.

The circuit of Figure 4 functions as follows: The timing tube 13 is normally in its first stable state with current flowing to the anode 17 through its load resistance 21 and with a relatively small amount of current flowing to the collector electrode 18 through its load resistance 22; thus the anode 17 and output terminal 101 will have a relatively negative polarity of voltage 106 and the collector electrode 18 and its output terminal 102 will have a relative positive polarity of voltage 107.

When the source 11 of synchronizing signals renders the second grid 12 negative, the tube 13 changes into its second stable state, because of the feedback provided through the constant voltage device 28 as has been explained above. In this second stable state, the anode 17 draws no current and thus the anode and its output terminal 101 have a relatively positive voltage 108; the collector electrode 18 now draws current through its load resistance 22 and hence this electrode and its output terminal 102 have a relatively negative polarity of voltage 109. The tube 13 will tend to remain in its second stable state even though the negative synchronizing signal is removed from its second grid 12, as long as the first grid 41 is maintained at a relatively negative potential.

The timing tube 13 is returned to its first stable state by applying a positive-polarity trigger signal to its first grid 41. The circuit shows alternative means, selectable by the switch 94, for applying a positive-polarity trigger signal to the first grid 41. When the switch 94 is arranged to connect the positive-polarity trigger source 92 to the first grid 41, the circuit operates as follows: The positive-polarity trigger source 92 provides trigger pulses which are applied to the first grid 41 in a controlled phase with respect to the negative-polarity trigger signals applied to the second grid 12 by the source 11. If it is desired to obtain square wave signals at the output terminals 101 and 102, the phase of the positive-polarity signals of the source 92 should be such that these positive-polarity sig-

nals will occur halfway between the negative-polarity pulses produced by the source 11. Other output wave shapes at the terminals 101 and 102 may be produced by varying this phase relationship.

When the switch 94 is arranged to connect the phase delay device 103 to the first grid 41, the circuit operates as follows: When the tube 31 is changing to its second stable state and the voltage at the output terminal 101 is changing in a positive direction as indicated by the numeral 111, this positive signal is delayed by the delay device 103 and is then coupled to the first grid 41. When the first grid 41 is thus rendered positive in polarity, the tube 13 returns to its first stable state. The phase delay device 103 may comprise a series-connected resistance 112 and a shunt-connected capacitance 113, as shown in Figure 4.

The circuit of Figure 4 will generate a square or rectangular output wave each time a negative trigger pulse is applied to its second grid 12. By applying continuously repetitive negative-polarity trigger signals to the second grid 12, a continously repetitive push-pull rectangular-wave output signal may be obtained at the output terminals 101 and 102. The exact shape of the output signal may be varied by adjusting the phase delay of the positive trigger source 92, or of the phase delay device 103 such as by varying the value of the resistance 112 or of the capacitance 113.

The embodiment shown in Figure 5, comprising the load tube 95 and associated components, functions to partially overcome the undesirable effects of the stray capacitance 110, which is inherent in the circuit. When a positive or negative signal is applied to the control electrode 46 of the discharge tube 47 from the collector electrode 18 through the coupling tube 27, the stray capacitance 110 tends to absorb the high-frequency components of the leading edge of the signal, so that the signal is delayed in building up to its operating level at the control electrode 46.

The load tube 95 provides a cathode load for the coupling tube 27. The load tube 95 also speeds up the operation of the discharge tube 47, as follows: When ever a positive or negative signal is generated at the collector electrode 18 of the timing tube 13, a corresponding signal of opposite polarity is generated at the anode 17, as has been explained with reference to Figure 4 of the drawing. This signal from the anode 17 is coupled through the condenser 105 to the control electrode 100 of the load tube 95, where it is amplified and phase-inverted and fed from the anode 96 to the control electrode 46 of the discharge tube 47 in phase with the signal which is coupled to the control electrode 46 from the collector electrode 18 of the timing tube 13. The amplified in-phase signal at the anode of the load tube 95, speeds the build-up time of signals at the control electrode 46, thus counteracting the adverse effect of the stray capacitance 110. The amplification of the tube 95 is controlled by the variable resistance 99. In the circuit of Figure 5, the constant-voltage device 28 shown in Figures 1, 2 and 3, is not employed, since the value of the resistance 84 is relatively small compared to the comparatively high resistance of the load tube 95, and hence only a small amount of signal is dissipated in the resistance 84 which acts as a voltage divider in combination with the plate resistance of the load tube 95.

An important feature of the invention is that the repetition rate of the output sweep signal depends upon, and may be varied by adjustment of, a single time-constant circuit, viz. the time constant of the resistance 51 and capacitance 56. Other types of high-speed sweep circuits, such as multivibrator switching circuits, operate in accordance with two time-constant circuits.

The novel sweep circuit of the present invention achieves reliable, convenient and economical control over the repetition rate, by means of a single variable time-constant circuit. The repetitive switching of the switching tube 13 occurs in accordance with the voltage level of the output signal, and thus switching rate ultimately depends upon the single time-constant circuit which controls the rate-of-rise of the output sawtooth sweep signal.

While preferred embodiments of the invention have been described, modifications thereof will be apparent to those skilled in the art, and yet will fall within the scope of the invention.

The true scope of the invention is defined in the following claims.

What is claimed is:

1. A sawtooth-wave generator comprising a tube of the gated-beam type having a cathode, a first grid, a collector electrode, a second grid and an anode; a first source of voltage connected to said anode, a second source of voltage, a first impedance connected between said second voltage source and said collector electrode, a source of synchronizing signals connected to said second grid, a saw-tooth wave forming condenser, a third source of voltage, a second impedance connected between said third voltage source and said sawtooth wave forming condenser, a discharge device connected in parallel with said sawtooth wave forming condenser and containing a control electrode, means electrically connecting said collector electrode to said first grid and to said control electrode, utilization means connected to said sawtooth wave forming condenser to utilize a sawtooth wave produced therein, and means connected to apply said sawtooth wave to said first grid.

2. The device in accordance with claim 1, in which said utilization means comprises a cathode-follower circuit having an input electrode connected to said sawtooth wave forming condenser and a cathode load impedance connected to said first grid.

3. The device in accordance with claim 1, in which a constant-voltage device is connected in series between said collector electrode and said first grid.

4. The device in accordance with claim 1, in which said means electrically connecting said collector electrode to said first grid and to said control electrode comprises a cathode-follower circuit having an input electrode connected to said collector electrode and a cathode connected to said first grid and control electrode.

5. The device in accordance with claim 4, in which a load impedance is connected to said cathode of said cathode-follower, comprising an electronic tube having an anode connected to the junction of said cathode of said cathode-follower and said control electrode and said first grid, and containing a control grid, a capacitance between said junction and ground, an a capacitor connected between said control grid and said anode of said tube of the gated-beam type.

6. The device in accordance with claim 1, in which a resistor is connected between said first grid and said control electrode.

7. The device in accordance with claim 1, in which said first impedance is variable to provide selectively recurrent or non-recurrent sweeps.

8. The device in accordance with claim 1, in which said discharge device contains a cathode; an electrical impedance connected in series with said cathode of said discharge device; and a feedback tube having an anode connected to a source of voltage, a control grid connected to said sawtooth wave utilization circuit, and a cathode connected to said cathode of said discharge device.

9. The device in accordance with claim 1, in which said connection between said collector electrode and said first grid and control electrode comprises an electronic tube having an anode connected to a source of voltage, a control grid connected to said collector electrode, and a cathode connected to said control electrode; and a resistor connected between said control electrode and said first grid.

10. The device in accordance with claim 1, in which

a diode member is connected in series between said utilization circuit and said first grid.

11. The device in accordance with claim 1, in which the value of said first impedance is sufficiently small so that the device generates a single electric signal when actuated by a single one of said synchronizing signals.

12. The device in accordance with claim 1, in which the value of said first impedance is sufficiently large so that the device generates recurrent electric signals.

13. A rectangular-wave generating circuit comprising a tube of the gated-beam type having a cathode, a first grid, a collector electrode, a second grid and an anode; a first impedance, a source of voltage connected through said impedance to said anode, a second impedance, a source of voltage connected through said second impedance to said collector electrode, an electrical signal transferring connection between said collector electrode and said first grid, a source of negative trigger signals connected to said second grid, and a source of positive trigger signals connected to said first grid.

14. The device in accordance with claim 13, including means to derive said positive trigger signals in accordance with said negative trigger signals.

15. An electrical circuit comprising a tube of the gated-beam type having a cathode, a first grid, a collector electrode, a second grid, and an anode, a first source of voltage connected to said anode, a second source of voltage, an impedance connected between said second voltage source and said collector electrode, a source of synchronizing signals connected to said second grid, a signal input terminal, means connected thereto for generating a positive going sawtooth wave voltage, said means having an output terminal, means electrically connecting said collector electrode to said first grid and to said input terminal, and means electrically connecting said output terminal to said first grid.

16. A rectangular-wave generating circuit comprising a tube of the gated-beam type having a cathode, a first grid, a collector electrode, a second grid and an anode; a first impedance, a source of voltage connected through said impedance to said anode, a second impedance, a source of voltage connected through said second impedance to said collector electrode, an electrical signal transferring connection between said collector electrode and said first grid, a source of negative trigger signals connected to said second grid, a source of positive trigger signals connected to said first grid, and a constant voltage device connected between said collector electrode and said first grid.

17. A rectangular-wave generating circuit comprising a tube of the gated-beam type having a cathode, a first grid, a collector electrode, a second grid and an anode; a first impedance, a source of voltage connected through said impedance to said anode, a second impedance, a source of voltage connected through said second impedance to said collector electrode, an electrical signal transferring connection between said collector electrode and said first grid, a source of negative trigger signals connected to said second grid, and a source of positive trigger signals connected to said first grid, said source of positive trigger signals comprising a phase-delay device connected between said anode and said first grid.

**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 2,060,095 | Mathes | Nov. 10, 1936 |
| 2,143,397 | White | Jan. 10, 1939 |
| 2,228,084 | Murcek | Jan. 7, 1941 |
| 2,275,016 | Koch | Mar. 3, 1942 |
| 2,404,919 | Overbeck | July 30, 1946 |
| 2,456,029 | Snyder, Jr. | Dec. 14, 1948 |
| 2,469,031 | Canfora | May 3, 1949 |

FOREIGN PATENTS

| | | |
|---|---|---|
| 620,585 | Great Britain | Mar. 28, 1949 |