May 29, 1951 K. SCHLESINGER 2,554,925

SAWTOOTH WAVE GENERATOR

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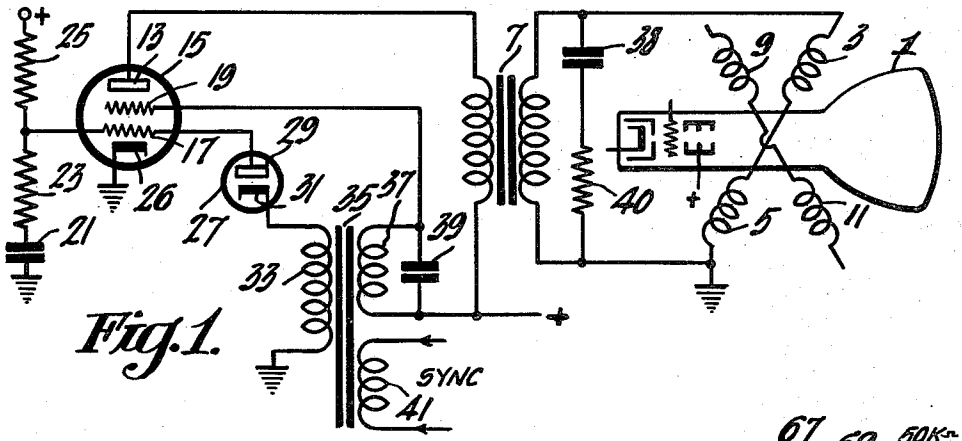


Fig. 1.

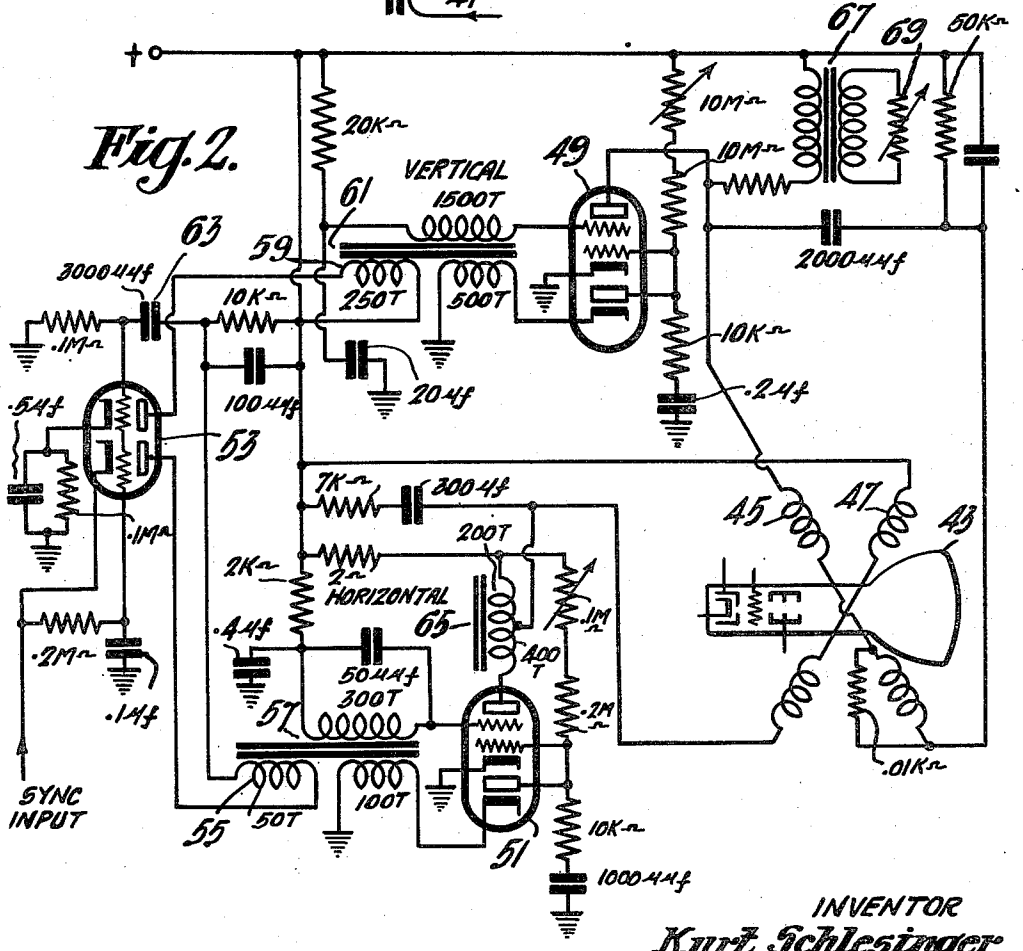


Fig. 2.

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SAW-TOOTH WAVE GENERATOR

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6 Claims. (Cl. 315—27)

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This invention relates to the generation of electrical voltages and currents of complex wave forms and more particularly it relates to the production of alternating currents and voltages of "sawtooth" and related wave forms for use in oscilloscopes, television systems and the like.

A most common type of sawtooth wave generator employs an inductive coupling between a control electrode and anode of an electron discharge tube for controlling the charge and discharge of a capacitive element. A typical sawtooth wave generator of this type is shown and described in the U. S. patent to Rhea, No. 2,165,815, issued July 11, 1939.

Circuits of this type generally have in common what may be called "feedback through an electron discharge tube." During the flyback or short slope time interval of the sawtooth wave, the circuit elements function like an oscillator which performs one-half of a complete cycle. During the long sweep phase, however, the tube is blocked and the system behaves like an ordinary class A amplifier for a sawtooth grid voltage.

Heretofore, certain disadvantages have appeared in the employment of sawtooth wave generators of the type referred to. First of all, the feedback condition of the circuit arrangements depends largely on adjustments in the deflector circuit and is greatly affected by alterations thereof.

Secondly, the yoke circuit has A. C. potential with respect to ground. This results in cross-talk between the two deflection circuits when a plurality of deflection circuits are closely associated with each other. This, of course, is undesirable, especially in connection with television scanning of the popular interlaced type. It also results in a slowing down of flyback (i. e., an increase in beam return time) when large capacities are encountered between the deflection coil and ground.

According to this invention, the aforementioned difficulties are substantially avoided by deriving the feedback energy from the auxiliary control electrode or the screen system of a power tetrode rather than from the plate of a tube.

It is possible, therefore, in the practice of this invention to isolate the deflector circuit from the feedback circuit. By employing the auxiliary control electrode or screen grid feedback arrangement, the system becomes more independent of variations of either frequency or amplitude of the deflection voltage or current.

A primary object of this invention is to provide an improved sawtooth wave generator.

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Other and incidental objects of the invention will be apparent to those skilled in the art from a reading of the following specification and an inspection of the accompanying drawing in which

Figure 1 illustrates by circuit diagram one form of this invention; and

Figure 2 illustrates also by circuit diagram another form of this invention employed, for example, as the scanning circuit of the television system.

Turning now to Figure 1, a cathode ray tube 1 has associated therewith deflection coils 3 and 5 which are connected to the secondary of transformer 7. Deflection coils 9 and 11 may, for example, be connected to another circuit arrangement for the provision of sawtooth waves, but for the purpose of explanation of the operation of this invention in one of its forms, no circuit connections will be illustrated as connected to deflection coils 9 and 11.

The primary of transformer 7 is connected to the anode 13 of electron discharge tube 15. Tube 15 contains a control electrode 17 and an auxiliary control electrode 19. Control electrode 17 is connected to condenser 21 through a resistance 23. A positive potential is connected to condenser 21 through resistances 25 and 23.

Control electrode 17 also has connected thereto a rectifier such as a diode 27 whose anode 29 is connected to control electrode 17 and whose cathode 31 is connected to winding 33 of transformer 35.

Auxiliary control electrode 19 is connected through winding 37 of transformer 35. Winding 37 contains an auxiliary condenser 39.

A synchronizing signal is applied to a third winding 41 of transformer 35.

In order to have a better understanding of how the circuit arrangement illustrated in Figure 1 operates, it is desirable to consider first of all the two phases of a sawtooth wave. The sawtooth wave may be broken down into two distinct time intervals. First of all, the sweep phase time interval and secondly, the flyback phase.

It may be stated that the circuit arrangement shown in Figure 1 behaves during the sweep phase like an ordinary class A amplifier. Assume for the purpose of explanation that condenser 21 contains a charge such that control electrode 17 is negative with respect to its associated cathode 26. Condenser 21 is then discharged in the conventional manner through resistances 23 and 25. This results in a substantially linear rise in potential in a positive direction of control electrode 17, providing, of course, that the time constant of the resistance capacity

circuit involving resistances 23 and 25 and condenser 21 is made large, as compared to the total sweep period. During the beginning portion of the sweep phase, the voltage of the control electrode 17 is maintained at a level which is substantially negative with respect to its associated cathode 26, and therefore very little current flows in the tube 15. There is, however, a gradual increase in current through tube 15 during the sweep phase.

No current flows through diode 27 because anode 29 is maintained negative with respect to its associated cathode 31. The inter-electrode capacity of diode 27 may be considered as having a negligible effect at the frequencies of the sawtooth waves under consideration.

As soon as condenser 21 has discharged through resistances 23 and 25 sufficiently to cause anode 29 to become positive with respect to its associated cathode 31, a current will flow through diode 27 to cause the ungrounded plate of condenser 21 to go rapidly in a negative direction, or increase the potential stress across the plates of condenser 21 which we may consider charging the condenser.

The feedback in the circuit necessary to sustain oscillations is furnished by auxiliary electrode 19 through transformer 35. The coils 33 and 37 at the transformer 35 are so polarized that any increase in current by the auxiliary electrode 19 adds a positive voltage to cathode 31 of diode 27. It follows, therefore, that during the slow discharge of condenser 21 or the sweep phase of the oscillation, cathode 31 is caused to be more positive as a result of the gradual increase in current drawn by auxiliary electrode 19.

As the current through tube 15 approaches saturation of the tube 15, as a result of the approach of the potential of control electrode 17 to zero with respect to its associated cathode 26, the current flowing to auxiliary electrode 19 ceases to increase. At this point, as a result of the stopping of an increased current flow through winding 37 of transformer 35, the positive potential on cathode 31 added by transformer winding 33 of transformer 35 ceases, and diode 27 becomes conductive.

As soon as diode 27 becomes conductive and the potential of control electrode 17 drops in a negative direction, the current drawn by auxiliary electrode 19 rapidly decreases to cause through transformer 35 a more negative potential on cathode 31. This causes the short or retrace time interval. The cumulative effect thus produces an abrupt blocking of tube 15.

The detailed theory of operation of current generators for oscilloscope and television deflection is known to the art and is well described in literature such as, for example, an article entitled "Current oscillator for television sweep" by George Clifford Sziklai, published in "Electronics" for September 1946.

It may, however, be well at this point to refer briefly to the basic principles of operation of such an oscillator circuit in its production of sawtooth current variations for the accurate deflection of electron beams.

As a result of the action of the circuit shown in Figure 1 described immediately above, the quick change in current through transformer 7 resulting from the rapid discharge of condenser 21 and sudden blocking of tube 15 produces a sharp voltage pulse in transformer 7.

The effect of this sharp pulse in a transformer may be considered analogous to a circuit arrangement involving deflection coil 3 together with a battery and a switch, the switch being capable of high speed operation and able to withstand high voltages in its open position.

As the theoretical switch is first closed, the current through the deflection yoke 3 will increase linearly with time, according to

$$di/dt = E_B/L$$

where E_B is the voltage of the theoretical battery, and L is the inductance of the deflection yoke 3.

This condition exists until the time the theoretical switch is opened. The current stored in the inductance of the yoke 3 will then be discharged through its associated interturn capacity and any auxiliary capacity inserted in the circuit, such as condenser 38, in an oscillatory manner.

The solution for the equilibrium equation is

$$L\frac{di}{dt}+\frac{1}{C}\int i\,dt=0$$

$$i=\frac{-E_B}{L/C}\sin\frac{t}{LC}$$

If the theoretical switch is then closed again, the inductance returns its energy to the theoretical battery with a current linearly changing with time until approximately halfway up the long sweep phase, at which time there is a current equilibrium, and from there on, the theoretical battery will deliver current in a linear manner to the yoke again.

In a theoretically perfect circuit where no resistance is encountered and if a perfect switch could be provided, no external energy would be required to provide a sawtooth current, however, this is not true in practice.

In comparing the above theoretical explanation to the circuit operation of the circuit shown in Figure 1, the time interval of the gradual increase in current of tube 15 may be considered that time interval during which a theoretical battery is connected to deflecting yoke 3. The time interval during which the theoretical switch is open may be compared to the time interval occupied during the discharge of condenser 21.

In circuits of this type used today, there is usually provided a damping arrangement such as condenser 38 and resistance 40, or preferably there is employed a diode or triode for damping purposes, as is well known in the present television art.

If the natural frequency of the transformer 35 is too high, the time interval during which the ungrounded plate of condenser 21 is driven in a negative direction through conduction of the diode is too short. As a consequence, the amount of differential change in the potential at condenser 21 is insufficient, and the amplitude of the sawtooth wave output is small.

Correct operation of the circuit may be assured either by "tuning down" transformer 35 through a separate condenser 39, as indicated in Figure 1, or by providing sufficient inductance in the circuit with the result that the natural period of the transformer 35 under load conditions approaches the desired flyback period.

The resistor 23, which may be termed a peaking resistor, connected in series with the sweep condenser 21, is provided in order that the diode 27 does not have to operate into an extremely small impedance and in order that the desired current wave form be present in transformer 7. The value of the resistance 23 can best be adjusted experimentally, but it may be of the order of, for example, about 10,000 ohms. If, however, the resistor 23 is made too large, the charge feed-

back is throttled and the A. C.-D. C. efficiency of the generator decreases.

Although there are alternate ways of synchronizing the system illustrated in the circuit diagram in Figure 1, the synchronizing pulses may be applied to winding 41 of transformer 35, as indicated in Figure 1. Alternatively, negative voltage pulses may be introduced across a small impedance in the cathode circuit of the tube 15. In the form of the invention shown, however, the synchronizing is done inductively in both directions using coil 41 to introduce pulse energy into the feedback transformer 35. This synchronizing energy may, for example, be derived from a conventional separator circuit which derives its energy from a composite video signal of a television system.

Turning now to Figure 2, there is shown by way of example employment of this invention in a complete deflector system employed for the reproduction of television images. An image reproducing tube 43 contains two sets of deflection coils 45 and 47 which may, for example, be the vertical and horizontal deflection coils, respectively, of the type well known in the television art.

In the circuit arrangements shown in Figure 2, dual purpose tubes 49 and 51 are employed, each of which contain a tetrode and a diode. Such a tube is known commercially as the 117L7/GT. Here again, the type tube is merely illustrative and it is not intended that this invention should be limited to its use.

The synchronizing signal input is applied to tube 53 which, as illustrated, may take the form of a dual triode such as the 6F8 type tube.

The synchronizing signal which should be applied in a negative direction causes the lower section of tube 53 to provide a horizontal synchronizing signal to winding 55 of transformer 57.

The vertical synchronizing pulse is obtained through the upper section of tube 53 and applied to winding 59 of transformer 61.

Sync separation is reasonably well understood in the television art, and it is believed unnecessary to go into further detail regarding its derivation for the synchronization of the circuit arrangements shown, except perhaps to mention that condenser 63 and its associated circuit elements act to permit the upper section of tube 53 as illustrated to pass only the vertical synchronizing pulses to winding 59 of transformer 61.

The operation of the horizontal and vertical sections of the circuit shown in Figure 2 is substantially the same as shown and described in connection with the circuit diagram illustrated in Figure 1 above. It will be noted, however, that no transformer is provided in the output circuit of the vertical deflector and that in the horizontal deflection portion of the circuit, transformation is obtained by tapping down on an output inductance 65. Operation without transformation in the output circuit is generally satisfactory if approximately 750 turns are employed in the vertical deflection coils 45 of the yoke, and approximately 250 turns are employed in the horizontal deflection coils 47.

A quicker retrace time may be obtained by reducing the yoke inductance and increasing the power input.

Circuit damping is furnished through transformer 67 by the employment of a variable resistance 69.

Although values of resistances and capacities are given, together with tube types and turns of transformer and inductance windings, it is not intended that this invention should be limited to the values given.

Having thus described the invention, what is claimed is:

1. A signal generator comprising in combination an electron discharge tube having a cathode, an anode, a control electrode and at least one auxiliary electrode, a transformer having a plurality of windings, a connection between a point on a first winding of said transformer and said auxiliary electrode a power supply terminal for said auxiliary electrode, a direct current connection from another point on said first winding and said power supply terminal, a serially connected resistance and capacity, said resistance connected to a point of positive potential and said condenser connected to a point of fixed potential a rectifier connected in series with another winding of said transformer, said rectifier and the latter mentioned winding of the transformer connected between a point on said resistance and a point of fixed potential a connection between said control electrode and a point on said resistance, the connections of said transformer being polarized to impose a potential in series with said rectifier in the direction of greater rectifier conductivity upon a decrease in auxiliary electrode current, and an output circuit connected between said anode and cathode.

2. An oscillator comprising an electron discharge tube having a cathode, an anode, a control electrode and at least one auxiliary electrode, a transformer having a plurality of windings, one end of each of said windings being connected to a point of fixed potential, a connection between a point on a first winding of said transformer and said auxiliary electrode, a serially connected rectifier resistance and condenser connected in series with a second winding of said transformer, a connection between said control electrode and said resistance, the connections of said transformer being polarized to impress across said rectifier a potential in the direction that said rectifier is non-conductive in response to an increase in auxiliary electrode current, and an output circuit connected between said anode and cathode.

3. A signal generator comprising in combination, an electron discharge tube having at least an anode, a cathode and a first and second control electrode, a transformer having at least a primary and secondary winding, a diode having an anode and cathode, connections for placing said diode in series with said secondary winding between said first control electrode and said cathode, the diode anode and cathode being so connected to permit electron flow therethrough only in the cathode-anode direction, a resistance and capacitance connected in series to form a combination between said first control electrode and said cathode, means for applying a unidirectional charging potential to said capacitance for charging the first control electrode terminal of said capacitance in a positive direction relative to said cathode at a predetermined rate, a biasing circuit connected between said second control electrode and said cathode, said circuit including a potential source for establishing said second control electrode positively with respect to said cathode, connections placing said transformer primary in series with said biasing circuit with such winding polarity to induce a non-conduc-

tively polarized secondary voltage in series with said diode in response to an increase in said second control electrode current, and an output circuit connected between said anode and said cathode.

4. Apparatus according to claim 3 wherein said unidirectional charging means comprises a resistance connected between a source of charging potential, positive with respect to said cathode, and said first control electrode.

5. A sawtooth deflection circuit for driving an electromagnetic deflection yoke winding comprising in combination, an electron discharge tube having at least an anode, a cathode and a first and second control electrode, a transformer having at least a primary and secondary winding, a diode having an anode and cathode, connections for placing said diode in series with said secondary winding between said first control electrode and said cathode, the diode anode and cathode being so connected to permit electron flow therethrough only in the cathode-anode direction, a resistance and capacitance connected in series to form a combination between said first control electrode and said cathode, means for applying a unidirectional charging potential to said capacitance for charging the first control electrode terminal of said capacitance in a positive direction relative to said cathode at a predetermined rate, a biasing circuit connected between said second control electrode and said cathode, said circuit including a potential source for establishing said second control electrode positively with respect to said cathode, connections placing said transformer primary in series with said biasing circuit with such winding polarity to induce a non-conductively polarized secondary voltage in series with said diode in response to an increase in said second control electrode current, a source of positive anode biasing potential referenced to said discharge tube cathode, an electromagnetic impedance matching device having primary and second terminals, connections placing said matching device primary between said discharge tube anode and said positive biasing source, and connections placing said deflection yoke winding across said matching device secondary.

6. Apparatus according to claim 5 wherein one terminal of said deflection yoke is connected by a low impedance path to said discharge tube cathode.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,165,815	Rhea	July 11, 1939
2,212,202	Faudell et al.	Aug. 20, 1940
2,254,031	Faudell	Aug. 26, 1941
2,284,337	Mulert et al.	May 26, 1942
2,358,297	Bedford	Sept. 19, 1944

FOREIGN PATENTS

Number	Country	Date
425,035	Great Britain	Mar. 4, 1935