Dec. 17, 1940. M. GEIGER 2,225,300

SAW-TOOTH GENERATOR

Filed June 9, 1938

Fig. 1

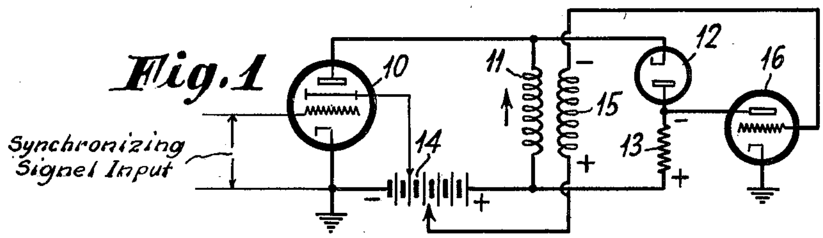


Fig. 2

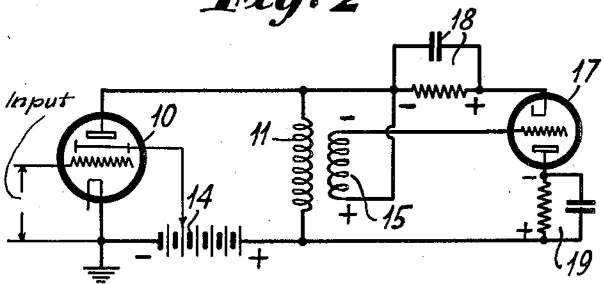


Fig. 3

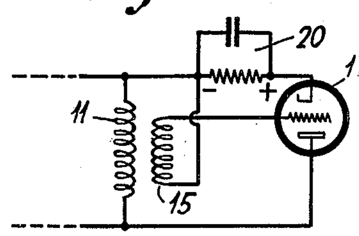


Fig. 4

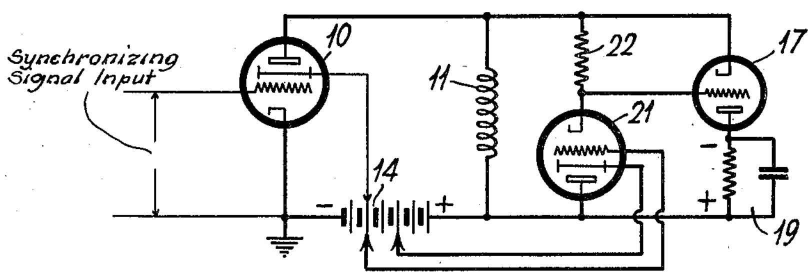
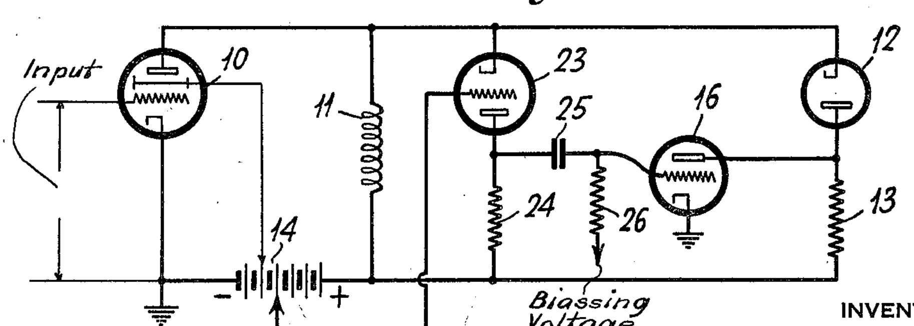


Fig. 5



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ATTORNEYS

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2,225,300

UNITED STATES PATENT OFFICE

2,225,300

SAW-TOOTH WAVE GENERATOR

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Application June 9, 1938, Serial No. 212,723
In Germany February 20, 1937

8 Claims. (Cl. 250—36)

The invention is concerned with circuit organizations wherein, with a view to producing a linear rise of current in a choke-coil, a source of potential supply is applied to the choke-coil and is disconnected again therefrom after completion or termination of the rise of the current. Circuit arrangements which operate in accordance with this principle are known in the art of causing magnetic deflection by magnetic forces acting on the cathode-ray pencil in television tubes. However, circuit schemes of this kind as heretofore known have the disadvantage that the rise of the current proceeds in accordance with a straight-line law only initially, that is, in the early phase of the rise, and even then only under the condition that the potential is constant and stable, and, further, that the inner resistance of the voltage source is negligibly low, and that the resistance of the switch break is also constant. Since these assumptions are not always fulfilled in practice with sufficient accuracy, and as, moreover, the linear initial portion of the current rise curve is not always adequate, means and ways are suggested in the present invention which will so change the voltage acting at the coil as a function of the coil current that the voltage at the coil will decrease in the presence of a rapid rise of the coil current, and will increase for a low rise of the said current.

My invention will best be understood by reference to the figures in which

Fig. 1 shows one embodiment thereof,

Fig. 2 shows a second embodiment thereof,

Fig. 3 shows a modification of the arrangement of Fig. 2, and

Figs. 4 and 5 show still further embodiments of my invention.

The exemplified embodiment shown in Fig. 1 comprises a screen-grid tube 10, the deflector coil 11 of a cathode-ray tube, a rectifier 12, a resistance 13 and a source of plate potential supply 14. If the resistance 13 is assumed to be replaced by a source of D. C. voltage supply whose negative pole is united with the anode of the rectifier 12, then the circuit arrangement comprising the elements designated by 10—14 is known in the art. An auxiliary coil 15, a further tube 16 con-jointly with the resistance 13 according to the invention are arranged in the known circuit organization to the end of causing a steady change of the voltage acting at the coil in such a way that the rise of the current will be caused to obey a straight-line law.

In this figure there is shown a vacuum tube 10 having anode, cathode, control and screen electrodes. Connected serially in the anode-cathode circuit is an inductance coil 11 and shunted across the coil is the combination of a diode 12 and a serially connected resistor 13. The common terminal of the inductance 11 and resistance 13 is connected to the positive side of a plate supply battery 14, the negative terminal of which is grounded. Positioned immediately adjacent to coil 11 and coupled therewith is a second coil 15 which is serially connected with the control grid of a thermionic tube 16 having anode, cathode and grid electrodes. One terminal of the inductance coil 15 is energized through a lead which is connected with plate supply battery 14. The anode of the tube 16 is connected directly to the anode of the tube 12 and the cathode of tube 16 is grounded.

In order to explain more fully the operation of the circuit organization shown in Fig. 1, the circuit elements 15, 16, as well as the resistance 13 shall first be disregarded, and the supposition shall be made that in lieu of the resistance 13 a source of D. C. voltage supply is connected in a way as above stated in series with the rectifier 12. This circuit organization, as already pointed out, is known in the art and the same will then operate in such a way that for the production of the linear current rise the rectifier 12 is rendered conductive for current. This is effected for a period of time for which the current flowing in the coil 11 has a direction which conventionally flows from the positive terminal of the battery 14 to the anode of the tube 10 as a result of the fact that at the control grid of tube 10 is impressed a potential which will allow a flow of current through this tube. The plate current flows through the rectifier 12 and at the coil thus acts the voltage furnished from the source of D. C. voltage supply supposed to take the place of the resistance 13. If by suitable blocking voltage at the control grid of tube 10 the flow of current across this tube and the rectifier 12 is cut off, the coil will experience a half oscillation in such a way that the voltage acting thereon is inversed so that it thus resumes the polarity which it had during the linear rise of current, while incidentally surpassing the value of the voltage of the source of D. C. potential supply. Hence, the voltage acting at the coil is able to overcome the voltage which is to be assumed instead of the resistance 13 and to thus re-open or unblock the rectifier 12. Without the opening of tube 10 being required, the source of D. C. potential supply will thereafter be connected again through the rectifier 12 with the coil so that, in spite of the reversal of the sense of the current flow in the coil, the differential quotient of the coil current will again possess the same size and conventionally in such a direction as to flow from the positive terminal of the battery 14 to the anode of tube 10. However, before the coil current passes through the zero value a current must be initiated through the rectifier 12 by the opening of tube 10 since zero coil current could otherwise not be exceeded. Now, the circuit elements 13, 15 and 16 operate in such a way that during the linear rise of the current, at the auxiliary coil 15, there will arise a voltage of such polarity as to render the terminal thereof connected to tube 16 negative, and the terminal thereof joined to battery 14 positive, and this voltage acts as the regulator voltage for tube 16. In the grid circuit of the said tube 16 there thus acts a positive grid potential (namely, the voltage between the left-hand end of the plate potential source of supply 14 and its tap) in series with a negative grid biasing voltage, the latter being furnished from the auxiliary coil 15 in a manner as hereinbefore described. The size of the positive grid voltage must exceed that of the negative voltage so that, for a constant size of the negative grid voltage, a finite plate current is able to flow across the tube 16 by way of the resistance 13. This plate current results in a fall of potential across resistance 13 whereby the terminal thereof connected to the anode of tube 12 is rendered negative and the terminal connected to battery 14 is positive and which at the same time represents the voltage acting at coil 11 being constant in the known instance. If, then, the current in the coil 11 starts to rise more rapidly, the negative grid voltage experiences an increase, and the drop of potential across the resistance 13 as a result diminishes. However, this does not mean anything else but that the voltage decreases across the coil 11 and this, in turn, implies that also the slope or steepness of the current rise in this coil must diminish. If, on the contrary, the steepness of the current rise in the coil 11 decreases, this implies a reduction of the negative grid potential; hence, the positive grid potential predominates, and this results in an increase of the plate current of tube 16 and thus also of the drop of voltage across resistance 13. As a result there occurs thus a growth of potential at the coil 11, and this will also speed or accelerate the rate of current rise. It will thus be seen that no matter whether there is a tendency on the part of the coil current to either rise faster or less fast, there will instantaneously be caused a compensation of such tendency because of the fact that the voltage drop across resistance 13 is a function of the current rise through the coil.

The exemplified embodiment shown in Fig. 2 differs from that in Fig. 1 in as far as the auxiliary coil 15 is included in the control-grid circuit of a tube 17 provided in lieu of the rectifier 12; if desired, the said control-grid circuit in addition may be supplied with a negative biasing potential furnished from the RC mesh. In lieu of the resistance 13, Fig. 1 there is provided another RC mesh 19 as known in a circuit arrangement Fig. 2, though without the coil 15, the RC mesh 18 and with a rectifier instead of tube 17.

In this figure the screen grid tube 10 has an inductance 11 connected serially with the anode thereof and a plate supply battery 14 has the positive terminal thereof connected to one terminal of the inductance 11, and the negative terminal thereof connected to the cathode, the latter being grounded. There is provided a second thermionic tube 17 having anode, cathode and control electrodes, the cathode of the tube being connected to the common terminal of the anode of tube 10 and the inductance 11 through a time constant circuit 18. A common terminal of the time constant circuit 18 is connected to the control grid of tube 17 through an inductance 15 which is positioned immediately adjacent the inductance 11 and is coupled therewith. The anode of tube 17 is connected to the common terminal of inductance 11 and plate supply battery 14 through a time constant circuit 19.

The circuit scheme Fig. 2 operates in this manner that, in the presence of a steep rise of the current in the coil 11 the grid potential of tube 17 is reduced, which, in turn, means an increase in internal resistance, so that a greater portion of the practically constant potential existent at the RC mesh 19 drops at the tube 17. But if the rise of the current in the coil 12 is too flat or slow, this results in a decrease of the voltage furnished from the auxiliary coil 15; hence, the grid potential of the tube 17 rises, its internal resistance diminishes, and at the coil 11 occurs an increase in the potential which, in turn, will cause the current in this coil to rise again with the desired slope.

Instead of the two distinct RC meshes 18 and 19, it would also be possible to use a joint RC mesh 20 as shown in Fig. 3 from which, by providing a suitable tap for the resistance such negative grid biasing voltage for tube as may be desired can be tapped.

The showing of Fig. 3 is essentially the same as that of Fig. 2 with the exception that the time constant circuit 19 of Fig. 2 which is connected to the anode of tube 17 and the common terminal of inductance 11 and plate supply battery 14 has been omitted.

In the embodiment shown in Fig. 4 there is also provided a tube 17 in the sense of Figs. 2 and 3, and an RC mesh 19 in the sense of Fig. 2. In lieu of the auxiliary coil 15 there is here used a tetrode as well as a resistance 22, the series arrangement of these two element being connected in parallel relation to the coil 11.

In this figure a screen grid tube 10 has an inductance 11 connected directly to the anode of tube 10 and serially with plate supply battery 14, the negative terminal of which is connected to the cathode of tube 10, the latter being grounded. A screen grid tube 21 has the space discharge path thereof connected serially with a resistor 22 and this series circuit is connected substantially in parallel with inductance 11, the anode of the tube being connected to the common terminal of inductance 11 and plate supply battery 14, and the terminal of resistor 22 remote from the cathode of tube 21 is connected to the common terminal of the anode of tube 10 and inductance 11. The control electrode of tube 21 is variably biased by plate supply battery 14, as is the screen electrode of the same tube. A thermionic tube 17 having anode, cathode and one control electrode has the space discharge path thereof connected serially with a time constant circuit 19, the latter being connected directly to the anode of tube 21 and the cathode thereof being connected directly to the common terminal of inductance 11 and resistor 22. The control electrode of tube 17 is connected to the common terminal of tube 21 and resistor 22.

The circuit organization shown in Fig. 4

works in this manner that by suitable choice of the potential impressed upon the control and screen grids of tube 21, the operating point of the plate current-plate voltage characteristic is placed in the neighborhood of plate current saturation. If, then, the voltage at the coil should happen to rise, in other words, if the current through this coil increases its slope or steepness, this will be attended with an increase in the internal resistance of the tube 21, with the consequence that the grid potential of tube 17 diminishes. The voltage arising across the RC mesh 19 will drop across the inner resistance of tube 17 to a greater extent than before, and the voltage at the coil 11 is diminished as a result so that also the steepness of the current rise is lessened. But if, on the contrary, the voltage at coil 11 decreases, so that the steepness of current rise decreases, then tube 19 will be further opened with the result that through a rise of voltage across the coil 11 the rate of current rise is boosted again.

In the exemplified embodiment shown in Fig. 5, a tube 23 and a resistance 24 being connected in series with each other, are provided in parallel relation to the coil 11. Tube 16 corresponds to the tube Fig. 1 bearing the identical reference numeral, and resistance 13 corresponds to the resistance with the identical reference numeral therein provided. The grid circuit of tube 16 includes further a blocking condenser 25 and a resistance 26 which is united with a suitable biasing voltage.

The circuit arrangement of Fig. 5 is as follows: A screen grid tube 10 has the anode thereof serially connected with an inductance 11 and a plate supply battery 14, the negative terminal of the latter being connected to the cathode of the tube and the cathode being grounded. A series circuit comprising the space discharge path of a thermionic tube 23, this tube having anode, cathode and one control electrode, and a resistor 24 is connected in parallel with the inductance 11, the cathode of the tube being connected to the common terminal of the anode of tube 10 and the inductance 11, and the terminal of resistor 24 remote from the anode of tube 23 being connected to the common terminal of inductance 11 and plate supply battery 14. Also connected in parallel with the inductance 11 is a diode 12 and a resistor 13, the cathode of the diode 12 being connected to the cathode of tube 23. The bias for the control grid of tube 23 is supplied from the variable tap on the battery 14 connected to the control electrode thereof. A fourth tube 16 having anode, cathode and one control electrode, has the anode thereof connected to the common terminal of the anode of diode 12 and the resistor 13 and has the cathode thereof grounded. The control electrode of tube 16 is connected through a condenser 25 to the common terminal of the anode of tube 23 and the resistor 24. Connected directly to the control electrode of tube 16 is a resistor 26, the latter being grounded through an appropriate biasing means.

If in a circuit arrangement as shown in Fig. 5, the voltage acting at the coil undergoes a growth, this occasions a rise in the inner resistance of the tube 23 and thus also a rise of the grid potential of tube 16. The result is that a decrease of voltage across resistance 13 happens, and this means that also the rise of current at the coil 11 becomes less. If, inversely, the voltage at coil 11 diminishes, this means an increase of the inner resistance of tube 23; hence, the control grid potential of tube 16 rises, the drop of potential across resistance 13 and thus the rise of coil current are raised.

The invention is of practical value not only for the production of saw-tooth-shaped currents of the kind required for the magnetic deflection of cathode-ray pencils for television work, but also for so-called image converter tubes. These tubes comprise a photo-cathode and a luminescent or mosaic screen, and the photo-cathode may be projected or imaged by electron optic ways and means upon the said luminescent screen or mosaic screen, and they may be operated in such a manner, as previously suggested in the art, that of an object moved at a uniform rate of speed a migrating or shifting photo-optic image is produced upon the photo-cathode, while by suitable deflection of the pencil of electron rays a static luminescent or charge pattern or image is produced upon the mosaic screen.

Moreover, the invention may be utilized in practice also independently of whether after completion of the linear rise of current the coil 11 undergoes a free half-cycle alone or in conjunction with a capacity connected in parallel with it or whether, say, by means of a counteracting voltage applied to the coil a still faster change of the current is obtained than that which would correspond to the natural period of the coil or to the resonant circuit formed by the coil and the paralleled condenser.

What I claim is:

1. Saw-tooth wave generator comprising means for storing electromagnetic energy, means for storing energy in said storage means, and means for applying a compensating voltage to said storage means, said compensating means being adapted to generate a compensating voltage in accordance with the rate of change of current in the electromagnetic storage means.

2. An electric generator comprising means for storing electromagnetic energy, means for storing energy in said storage means, and means for applying a compensating voltage to said storage means, said compensating means being adapted to generate a compensating voltage in accordance with the rate of change of current in the electromagnetic storage means.

3. A saw-tooth wave generator comprising means for storing electromagnetic energy, means for storing energy in said storage means, a unilateral conductor connected substantially in parallel with said energy storage means, means for deriving a corrective potential from a portion of the energy in said storage means, and means for impressing said corrective potential on to a current carrying electrode of said unilateral conductor.

4. A saw-tooth wave generator comprising means for storing electromagnetic energy, means for storing energy in said storage means, a diode, a resistor connected in the anode-cathode circuit of said diode, said diode and said resistor forming a circuit which is connected in parallel with said energy storage means, a thermionic vacuum tube having anode, cathode, and at least one control electrode, means for connecting the anode of said thermionic tube to said resistive means, and means for impressing a portion of the energy in said electromagnetic storage means onto a control electrode of said thermionic tube.

5. A saw-tooth wave generator comprising electromagnetic energy storage means, means for storing energy in said storage means, a therm-

ionic tube having anode, cathode and at least one control electrode, at least one time constant circuit connected in the anode-cathode circuit of said thermionic tube, said anode-cathode circuit and said time constant circuit comprising a series circuit which is connected substantially in parallel with said energy storage means, and means for impressing a portion of the energy of said electromagnetic storage means onto a control electrode of said thermionic tube.

6. Apparatus in accordance with claim 5 wherein a second time constant circuit is connected in the control electrode-cathode circuit of said thermionic tube.

7. A saw-tooth wave generator comprising electromagnetic energy storage means, a first thermionic vacuum tube having anode and cathode electrodes, a resistor connected in the anode-cathode circuit of said tube, said anode-cathode circuit and said resistor comprising a series circuit which is connected substantially in parallel with said electromagnetic energy storage means, a diode, a second resistive member connected in the anode-cathode circuit of said diode, said anode-cathode circuit of said diode and said second resistance forming a series circuit which is connected substantially in parallel with said electromagnetic energy storage means, a second thermionic vacuum tube having anode, cathode and at least one control electrode, means for impressing the anode current of said second thermionic vacuum tube onto at least a portion of said second resistance, and means for impressing variations in the anode-current of said first vacuum tube onto the control electrode of said second thermionic vacuum tube.

8. The method of linearly storing and discharging electromagnetic energy which comprises the steps of storing electromagnetic energy and simultaneously developing a potential bearing a definite relationship to the rate of change of storing of said energy and correcting for irregularities in the linearity of the storing and discharging of energy in accordance with the value of the potential bearing the definite relationship to the rate of change of storing said electromagnetic energy.

MAX GEIGER.