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SAW-TOOTH WAVE GENERATOR

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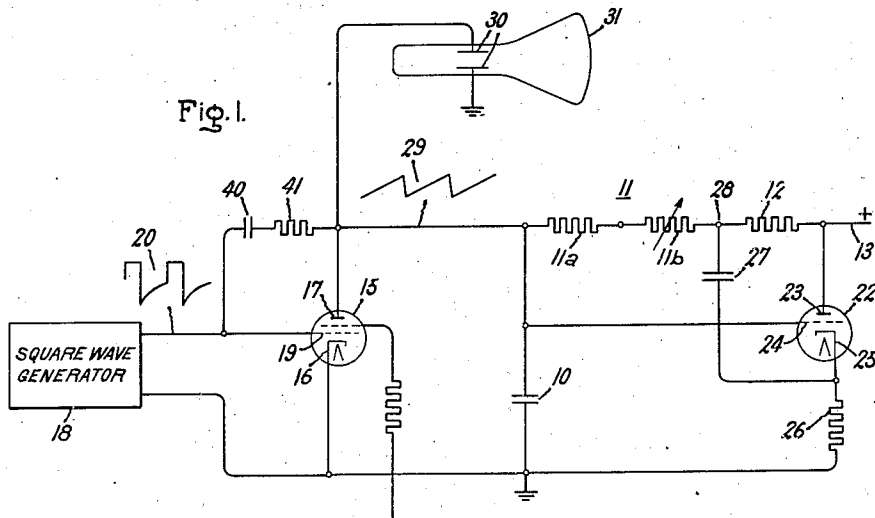
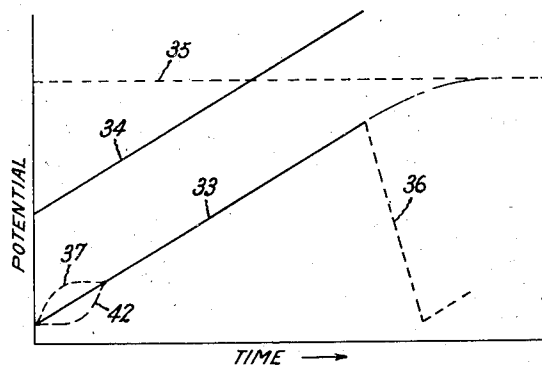


Fig. 2.



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SAW-TOOTH WAVE GENERATOR

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7 Claims. (Cl. 250—36)

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My invention relates to generators for producing non-sinusoidal waves, and particularly to such generators for producing voltage waves of saw-tooth form.

One frequently employed method for producing saw-tooth voltage waves is to provide a circuit including a resistance and a condenser in series and an arrangement for periodically shorting the condenser so that it is charged by current flowing through the resistance and is then discharged by the shorting arrangement. The voltage at the condenser terminal adjacent the resistance rises periodically at a rate depending upon the rate of charge and falls more or less abruptly depending upon the characteristics of the shorting circuit. In order to provide a linear rise in voltage it is necessary that the condenser be charged at a constant rate, and various arrangements have been proposed to maintain constant the current flowing to the condenser. One such arrangement includes an electron discharge device connected as a cathode follower amplifier having its control electrode coupled to the terminal of the condenser adjacent the resistance and having its cathode connected to an intermediate point on the resistance so that the voltage at that point is raised in accordance with the increase in voltage at the condenser terminal. The voltage drop across this portion of the resistance is thereby maintained substantially constant so that the rise in voltage of the saw-tooth wave is made linear. One difficulty with this type of generator is that the capacity effect of the electron discharge device may produce some distortion at the initial portion of the rise in saw-tooth voltage. Accordingly, it is an object of my invention to provide a generator for producing voltage waves of saw-tooth form including an improved arrangement for maintaining linear the rise in saw-tooth voltage.

It is another object of my invention to provide a saw-tooth wave generator comprising a condenser and resistance in series and including a cathode follower type of amplifier for maintaining constant the voltage drop in a portion of the resistance, and including an improved arrangement for preventing distortion of the initial portion of the saw-tooth wave due to capacity effects in the amplifier.

The features of my invention which I believe to be novel are set forth with particularity in the appended claims. My invention, itself, however, both as to its organization and method of operation together with further objects and advantages thereof may best be understood by reference to the following description taken in connection

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with the accompanying drawing in which Fig. 1 is a diagrammatic illustration of a saw-tooth wave generator embodying my invention and Fig. 2 is a curve showing the characteristics of operation of the generator of Fig. 1.

The saw-tooth wave generator illustrated in Fig. 1 comprises a condenser 10 and a resistance including series portions 11 and 12, the portion 11 being variable, connected in series with the condenser between the positive terminal of a source of direct current 13 and ground, the negative terminal of the source being grounded in the usual manner. The portion 11 of the resistance preferably comprises a fixed section 11a and a variable section 11b. The condenser 10 is thus charged through the resistance, and the potential across the condenser rises at a rate determined by the flow of current through the resistance. In order to produce a saw-tooth wave an electron discharge device 15 is provided for periodically shorting the condenser to discharge it, the device 15 having a cathode 16 connected to ground and an anode 17 connected to the terminal of the resistance 11 adjacent the condenser 10. It will readily be apparent that during the operation of the generator a saw-tooth voltage wave is produced at the anode 17. In order to make the device 15 alternately conducting and non-conducting and periodically discharge the condenser a square wave generator 18 is provided which is connected to a control grid 19 of the device 15. The square wave may be of the form indicated at 20 above the generator 18, it being essential that the negative-going edges of the wave have steep sides so that the initiation of the period of charge of the condenser will be sharply defined. It is also desirable that the positive half cycles be of square wave form to insure complete discharge of the condenser. It is essential for a purpose to be explained later that the negative half cycles have at least their leading edges steep, a wave of the form illustrated at 20 being satisfactory.

In order to maintain constant the charging rate of the condenser 10 an amplifier of the cathode follower type including an electron discharge device 22 is connected to maintain constant the voltage drop across the portion 11 of the resistance. The device 22 includes a cathode 25, a grid or control electrode 24 and an anode 23. The anode 23 is connected to the positive terminal of the direct current source 13 and the cathode 25 is connected through a relatively high cathode resistance 26 to ground. The control electrode 24 is connected to the anode 17 so that its potential

follows the voltage drop across the condenser 10. The cathode 25 is coupled through a large condenser 27 to the juncture 28 of the resistances 11 and 12. The condenser 27 has a capacity several hundred times greater than that of the condenser 10, and the time constant of the condenser 27 and its discharge circuit including the resistances 11 and 26 is much longer than that of the condenser 10 and its discharge circuit. Consequently the condenser 27 does not lose all of its charge when the device 15 is conducting, and some voltage remains across its terminals. It will now be apparent that as the voltage rises across the condenser 10 the increase in potential of the control electrode 24 results in an increase in the flow of current through the resistance 26 such that the potential of the cathode 25 rises and increases the potential of the juncture 28 at a rate dependent upon the rise in potential across the condenser 10. It follows that the potentials at the two ends of the series resistance 11 rise at the same rate so that the drop across the resistance is maintained constant and the current flowing through the resistance 11 to the condenser must, therefore, be constant and the rise in voltage across the condenser, linear. The voltage at the point 28 may, in fact, rise above that of the source 13, the charging current for the condenser 10 then being supplied from the condenser 27. The saw-tooth wave thus generated is indicated as appearing at 29 which is a point common to the anode 17, condenser 10 and resistance 11; this wave may be employed to excite deflecting plates 30 of a cathode ray tube or oscilloscope 31.

In Fig. 2 the rising portion of the saw-tooth wave which appears at point 29 in Fig. 1 is indicated at 33. This is the voltage existing across the condenser 10 at the lower potential terminal of the resistance 11. A straight line 34 which is substantially parallel to the line 33 represents the rise in potential at the juncture 28, the difference in potential between the lines 33 and 34 being the drop in potential across the resistance 11. The horizontal dotted line 35 represents the magnitude of voltage available at the point 13. The dotted line 36 represents the fall in potential during the discharge of condenser 10.

During the operation of the generator shown in Fig. 1 a slight pulse or distortion in a positive direction has been found to occur at the initial portion of the rise in voltage of the saw-tooth wave as indicated by the dotted hump or curve 37 of Fig. 2. This distortion or nonlinearity is believed to be caused by the plate to grid capacity of the device 22 which is in shunt relation to the resistances 11 and 12 in series and divides its charge with the condenser 10. In order to insure linearity of the initial portion of the rise in saw-tooth voltage the grid 19 of device 15 is coupled to the anode 17 by a condenser 40 and a resistance 41 in series so that at the end of the positive half cycle of the square wave when the grid 19 is driven sharply negative, a negative pulse or hump is produced at the anode 17 due to the charging of condenser 40. The capacity of the condenser 40 and the size of the resistance 41 may be selected so that a negative potential dip or distortion indicated at 42 in Fig. 2 offsets or counteracts the positive hump 37 and makes the voltage rise 33 completely linear by cancelling the effect of the grid-plate capacity of the device 22.

From the foregoing it is apparent that I have provided a simple and effective circuit for producing a linear saw-tooth voltage wave. By way of illustration only and not by way of limita-

tion there are listed below values of circuit constants which have been found to be suitable for the circuit of Fig. 1 when employed to excite the deflection plates of a cathode ray tube. The device 15 was a 6F6 pentode and the device 22 a 6J5 triode; the positive direct current source had a potential of 400 volts and the control grid of the device 15 was supplied with a square wave of substantially the form illustrated in Fig. 1. The other constants were as follows:

Resistance 11	ohms	180,000
Resistance 12	do	100,000
Resistance 26	do	100,000
Resistance 41	do	270,000
Condenser 10	mmfds	360
Condenser 27	mf	.5
Condenser 40	mmfds	68

While I have shown a particular embodiment of my invention, it will be understood that other modifications may be made without departing from the principles disclosed above. I do not, therefore, desire my invention to be limited to the particular embodiment shown and described and I intend by the appended claims to cover all modifications which fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An apparatus for generating voltage waves of saw-tooth form comprising an electron discharge device having an anode and a cathode and a control electrode, means for impressing on said control electrode an alternating voltage whereby said device is rendered alternately conducting and nonconducting, means connected in the anode circuit of said device for producing at said anode a saw-tooth voltage having a substantially linear rise while said device is non-conducting and a rapid fall while said device is conducting, said last mentioned means inherently producing a slight pulse in a positive direction at the initial portion of said rise, and means for producing a negative pulse at said anode during said initial portion of said rise to counteract said positive pulse and increase the linearity of said saw-tooth wave.

2. An apparatus for generating voltage waves of saw-tooth form comprising an electron discharge device having an anode and a cathode and a control electrode, means for impressing on said control electrode an alternating voltage having steep negative-going wave fronts whereby said device is rendered alternately conducting and nonconducting, means connected in the anode circuit of said device for producing at said anode a saw-tooth voltage having a substantially linear rise while said device is non-conducting and a rapid fall while said device is conducting, said last mentioned means inherently producing a slight pulse in the positive direction at the initial portion of said rise, and means responsive to the negative-going portion of said alternating voltage for producing a negative pulse at said anode during said initial portion of said rise to counteract said positive pulse and increase the linearity of said saw-tooth wave.

3. An apparatus for generating voltage waves of saw-tooth form comprising an electron discharge device having an anode and a cathode and a control electrode, means for impressing on said control electrode an alternating voltage whereby said device is rendered alternately conducting and nonconducting, said alternating voltage comprising positive half cycles and nega-

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tive half cycles having at least their leading edges steep, means connected in the anode circuit of said device for producing at said anode a saw-tooth voltage having a substantially linear rise while said device is non-conducting and a rapid fall while said device is conducting, said last-mentioned means inherently producing a slight pulse in a positive direction at the initial portion of said rise, and a condenser and resistance coupling connecting said control electrode and said anode for providing a negative pulse during said initial portion of said rise for counteracting said positive pulse to increase the linearity of said saw-tooth wave.

4. An apparatus for generating a voltage wave of saw-tooth form comprising an electron discharge device having an anode and a cathode and a control electrode, a condenser connected across said device between the input and output thereof, means for impressing an alternating potential on said control electrode for rendering said device alternately conducting and nonconducting, said alternating potential comprising positive half cycles having steep edges and negative half cycles having at least their leading edges steep, means connected in the anode circuit of said device for charging said condenser at a substantially constant rate to produce a saw-tooth voltage wave having a substantially linear rise at the anode of said device while said device is non-conducting and a rapid fall while said device is conducting, said last mentioned means inherently producing a positive hump of voltage in the initial portion of the charging period of said condenser, and means coupling the anode and control electrode of said device for producing a pulse of negative voltage for counteracting said positive voltage hump to increase the linearity of said rise of said saw-tooth voltage wave.

5. An apparatus for generating a voltage wave of saw-tooth form comprising an electron discharge device having an anode and a cathode and a control electrode, a resistance in the anode circuit of said device, a condenser connected in shunt across said device, means for impressing an alternating voltage wave on said control electrode for rendering said device alternately conducting and nonconducting whereby said condenser is alternately discharged and charged to produce a saw-tooth voltage wave at said anode, said alternating voltage comprising positive half cycles having steep edges and negative half cycles having at least their leading edges steep, means including a second electron discharge device for maintaining constant the voltage drop across a portion of said resistance adjacent said condenser to charge said condenser at a constant rate to tend to produce a linear saw-tooth voltage rise while said first device is nonconducting, said second device providing a capacity in shunt with said resistance whereby nonlinearity in a positive direction is produced in the initial portion of said saw-tooth voltage rise, and a coupling between the control electrode and the anode of said first device for providing a negative voltage to counter-

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act said positive nonlinearity and increase the linearity of said saw-tooth voltage rise.

6. An apparatus for generating voltage waves of saw-tooth form comprising an electron discharge device having an anode and a cathode and a control electrode, a resistance in the anode circuit of said device connecting said anode and a source of direct current, a condenser connected in shunt relation to said device, means for impressing an alternating voltage wave on said control electrode for rendering said device alternately conducting and nonconducting to produce a saw-tooth voltage wave at said anode, said alternating voltage comprising positive half cycles having steep edges and negative half cycles having at least their leading edges steep, means including a second electron discharge device having an anode and a cathode and a control electrode and having a resistance in its cathode circuit for maintaining constant the voltage drop across a portion of said anode circuit resistance adjacent said condenser, said anode of said first device being connected to the control electrode of said second device whereby a positive voltage hump is produced inherently on the initial portion of said saw-tooth voltage rise, and means including a condenser and a resistance coupling the anode of said first device and the control electrode thereof for feeding to said anode a negative voltage pulse to increase the linearity of said saw-tooth voltage rise.

7. An apparatus for generating voltage waves of saw-tooth form comprising a condenser and a first resistance connected in series across a source of positive potential, an electron discharge device having a cathode and an anode and a control electrode and connected across said condenser whereby said resistance is in the anode circuit of said device, means for impressing a square wave voltage on said control electrode to alternately render said device conducting and nonconducting whereby a saw-tooth voltage is produced across said condenser, means including a second electron discharge device having an anode and a cathode and a control electrode and connected in shunt to said first device and said first resistance for maintaining constant the voltage drop across a portion of said first resistance adjacent said condenser, a second resistance in the cathode circuit of said second device, a condenser for coupling the cathode of said second device and the higher potential end of said portion of said first resistance, a connection between the anode of said first device and the control electrode of said second device whereby the grid anode capacity of said second device is connected in shunt to said portion of said resistance and produces a positive hump at the initial portion of said saw-tooth wave, and a condenser and resistance coupling the anode of said first device and the control electrode thereof for providing a negative hump to offset said positive hump and provide linearity of said initial portion of said saw-tooth wave.

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