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SAW-TOOTH WAVE GENERATOR

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Fig. 1.

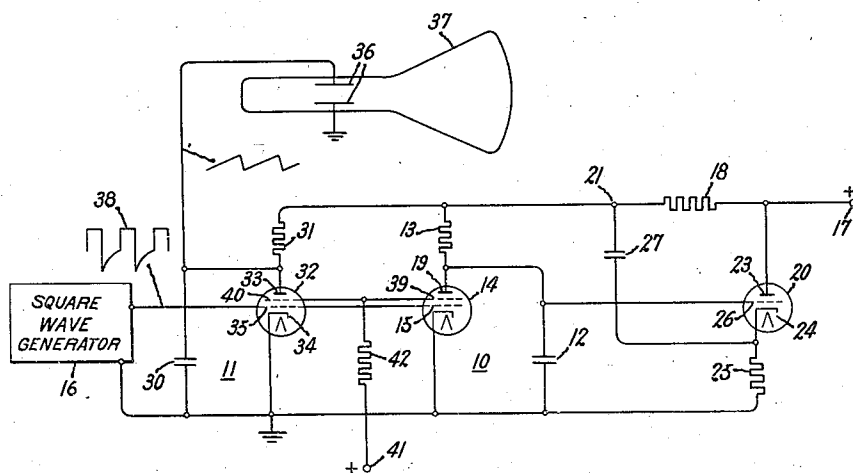
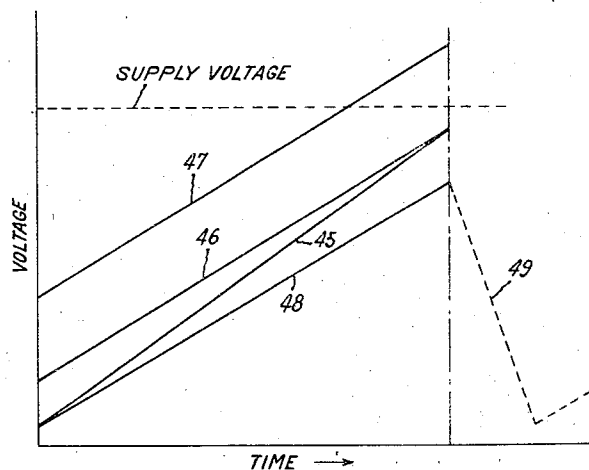


Fig. 2.



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SAW-TOOTH WAVE GENERATOR

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5 Claims. (Cl. 250—36)

1

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

Saw-tooth wave generators are commonly employed for exciting the deflecting plates of cathode ray devices such as the tubes employed in oscilloscopes and television receivers. One type of generator frequently employed includes a condenser and resistance connected in series across a source of direct current and provided with an arrangement for periodically shorting the condenser. The charging rate of the condenser determines the slope of the rise in voltage and it is, therefore, desirable to maintain the charging current constant so that the rise in voltage will be linear. One method which has been employed for this purpose is to provide an arrangement for maintaining the drop across the resistance constant during the rise in voltage. This may be accomplished by connecting an electron discharge device as a thermionic amplifier of the cathode follower type having its control electrode excited by the voltage across the condenser for boosting the voltage at the high potential terminal of the resistance at the same rate as the rise of the voltage across the condenser. It has been found, however, that because of the varying grid bias required for operating the cathode follower the rate of rise produced at the high potential terminal of the resistance is somewhat less than that across the condenser and consequently some nonlinearity may be introduced.

Accordingly, it is an object of my invention to provide a generator for producing 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 a resistance in series and including a cathode follower type of thermionic amplifier for maintaining constant the voltage drop in a portion of the resistance and including an improved arrangement for insuring complete linearity of the rise in saw-tooth voltage.

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 with the accompanying drawing in which Fig. 1 is a diagrammatic illustration of a saw-

2

tooth wave generator embodying my invention and Fig. 2 is a curve showing the operating characteristics of the generator of Fig. 1.

Briefly, the saw-tooth wave generator illustrated in Fig. 1 comprises two saw-tooth generating circuits arranged to generate saw-tooth voltages simultaneously, each of the circuits comprising a condenser and a resistance in series with a source of direct current and means for simultaneously charging and discharging the condensers. The rate of rise of voltage in the first generator circuit is greater than that in the other, and an electron discharge device connected as an amplifier of the cathode follower type is arranged to be responsive to the increase in voltage of the saw-tooth wave generated by the first generator and to increase the potential at the high potential ends of the resistances at a rate determined by the first generator. The constants of the circuits are selected so that this rate of rise is the same as the rate of voltage rise across the condenser of the second generator circuit. It will, therefore, be apparent that the voltage drop across the resistance of the second generator circuit is maintained constant and that the rise in saw-tooth voltage of the second generator is, therefore, linear.

Referring now to Fig. 1 the saw-tooth wave generator illustrated comprises a first saw-tooth wave generating circuit 10 and a second saw-tooth wave generating circuit 11. The circuit 10 includes a condenser 12 and a resistance 13 connected in series and an electron discharge device 14 connected in shunt to the condenser 12 and including a control electrode 15 which is supplied with a square wave voltage from a suitable generator 16. The electron discharge device when excited by the square wave becomes alternately conducting and nonconducting so that the condenser 12 is charged from a suitable source of direct current 17 through a resistor 18 and a resistor 13 when the device 14 is nonconducting and is discharged through the device 14 when the device is conducting. A saw-tooth voltage is thus produced at the anode 19 of the device 14 and across the condenser 12. In order to make the rise in saw-tooth voltage across condenser 12 linear it is necessary that the charging current be maintained constant, and to accomplish this an electron discharge device 20 is connected as a cathode follower amplifier to increase the voltage at the junction between the resistors 13 and 18 indicated at 21, and at a rate dependent upon the voltage rise across the condenser 12. The voltage drop across the

3

resistor 13 is maintained constant by operation of the amplifier and the current flowing through the condenser is, therefore, constant and the voltage rise linear. The device 20 includes an anode 23 connected to the source 17, a cathode 24 connected to ground through a relatively high resistance 25 and a control electrode 26 connected to the juncture between the upper terminal of the condenser 12 and the anode 19 at the lower potential end of resistance 13. The cathode 24 is coupled to the point 21 through a condenser 27, the capacity of which is much greater than that of the condenser 12. It will be evident that, as the voltage across the condenser 12 rises, the potential of grid 26 rises and the flow of current through the resistance 25 increases so that the drop across resistance 25 increases and raises the potential of the point 21 at a rate determined by the rise in potential across the condenser 12.

The rise in potential at the point 21 produced by the device 20 is at a somewhat lower rate than the rise in potential across the condenser 12 because the grid or control electrode bias required by the device 20 decreases as the current through the device increases. Some slight nonlinearity due to the change of the drop across the resistance 13 is, therefore, produced in the voltage across the condenser 12.

In order to provide a saw-tooth wave which is truly linear the generating circuit 11 is provided which comprises a condenser 30 and a resistance 31 connected in series with each other and in parallel with the generator 10, the higher potential end of the resistance 31 being connected directly to the point 21. The generator 11 is provided with an electron discharge device 32 including an anode 33, a cathode 34 and a control electrode 35. The control electrode 35 is excited from the square wave generator 16 simultaneously with the control electrode 15 of the device 14, and saw-tooth waves are, therefore, produced simultaneously and in synchronism by the two generators. The condenser 30 and resistance 31 are selected to have values of capacity and resistance respectively such that the rate of rise of voltage across the condenser 30 at the anode 33 is the same as the rate of rise produced at the point 21 by operation of the device 20. Both ends of the resistance 31, therefore, increase in potential at the same rate and the drop across the resistance remains constant so that the charging current flowing to the condenser 30 through the resistance 31 is constant and the saw-tooth wave produced by the generator 11 is truly linear.

The output of the generator of Fig. 1 may be taken from the anode of the device 32 and coupled to deflecting plates 36 of a cathode ray tube or device 37. It is desirable that the wave produced by the generator 11 be a square wave having steep sides and flat topped positive half cycles as indicated at 38 which assures accurate timing of the saw-tooth wave and substantially complete fall in voltage during the discharge of the saw-tooth wave across condensers 12 and 30. The negative half cycles of the wave 38 need not be of square form, the form shown at 38 being satisfactory.

The devices 14 and 32 are provided with screen grids 39 and 40, respectively, which are connected to a suitable direct current source 41 through a resistance 42.

The operating characteristics of the generator shown in Fig. 1 are illustrated in Fig. 2 where the increase in potential is plotted against time.

4

The curve 45 represents the voltage produced across the condenser 12 and impressed on the control electrode 26. The curve 46 represents the potential at the cathode 24, the difference between the curves 45 and 46 representing the bias of the electrode 26. The curve 47 represents the potential at the point 21 produced by operation of the device 20 and the line 48 represents the rise in saw-tooth voltage produced during the charging of the condenser 30 at the output of the generator 11, the dotted line 49 representing the fall in voltage when the condenser 30 is discharged.

From the foregoing it will be apparent that I have provided a relatively simple and effective apparatus for producing saw-tooth waves of truly linear form, and although I have shown a particular embodiment of my invention, other modifications which do not depart from the principles disclosed will readily be apparent to those skilled in the art. I do not, therefore, desire my invention to be limited to the particular modification shown and described and I intend in the appended claims to cover all modifications 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 a voltage wave of saw-tooth form comprising a first saw-tooth wave generator including a condenser and resistance connected in series across a source of direct current whereby said condenser is charged, means for discharging said condenser periodically to produce a saw-tooth wave across said condenser, a second generator for producing a saw-tooth wave in synchronism with the saw-tooth wave produced by said first generator and having a rate of rise of voltage greater than that of the saw-tooth wave produced by said first generator, and means responsive to the rise of voltage in said second generator for producing an increase of voltage at the higher potential terminal of said resistance at a rate equal to the rate of rise across said condenser whereby the rate of flow of current through said resistance is constant and the rise in potential of the saw-tooth wave produced by said first generator is linear.

2. An apparatus for generating a voltage wave of saw-tooth form comprising a first circuit including a condenser and a resistance connected in series across a source of direct current whereby said condenser is charged, means for periodically discharging said condenser to produce a saw-tooth voltage across said condenser, means including a thermionic amplifier of the cathode follower type having its control electrode energized by the voltage across said condenser for increasing the voltage at the high potential end of said resistance at substantially the same rate as the rise in potential across said condenser, a second circuit including a condenser and a resistance connected in parallel across said first circuit, means for periodically charging and discharging said second condenser in synchronism with the charging and discharging of said first condenser to produce a saw-tooth voltage wave across said second condenser, the rate of rise of the voltage wave produced across said second condenser being less than that produced across said first condenser and the same as the rate of voltage rise at the high potential ends of said first and second resistances whereby the potential drop across said second resistance is constant and the rise in voltage across said second condenser is linear.

3. An apparatus for generating a voltage wave

5

of saw-tooth form comprising a first circuit including a condenser and a resistance connected in series and a second circuit including a condenser and a resistance connected in series, means for connecting said circuits in parallel across a source of direct current whereby said condensers are charged, means for periodically discharging said condensers simultaneously whereby said condensers are periodically charged and discharged to produce saw-tooth voltages across said condensers, the charging rate of the condenser in said first circuit being lower than that of the condenser in said second circuit whereby the saw-tooth voltage produced across said second circuit condenser rises faster than that across said first circuit condenser, and means responsive to the voltage rise across said second circuit condenser for producing a rate of voltage rise at the higher potential terminal of said first circuit equal to the rate of rise across said first circuit condenser whereby the rate of flow of current through said first circuit resistance is constant and the rise in potential of the saw-tooth wave produced across said first circuit condenser is linear.

4. An apparatus for generating a voltage wave of saw-tooth form comprising two electron discharge devices each having an anode and a cathode and a control electrode, a first resistance connected to the anode of the first of said devices, a second resistance connected to the anode of the second of said devices, means for connecting said devices and their respective resistances in parallel across a source of direct current, a first condenser connected between the anode and cathode of said first device, a second condenser connected between the anode and cathode of said second device, means for impressing an alternating potential on said control electrodes whereby said devices simultaneously are rendered alternately conducting and nonconducting and said

6

condensers are alternately charged and discharged to produce at the anodes of said devices voltage waves of saw-tooth form, said condensers and said resistances being of such relative size that the voltage rise at the anode of said second device is at a higher rate than that at the anode of said first device, and means responsive to the voltage rise at the anode of said second device for increasing the voltage at the higher potential terminals of said resistances at the same rate as the voltage rise at the anode of said first device whereby constant current flows through said first resistance and renders constant the rate of rise of voltage at the anode of said first device.

5. An apparatus for generating a voltage wave of saw-tooth form comprising first and second circuits each including a condenser and a resistance connected in series, means including a common resistance for connecting said circuits in parallel across a source of direct current to charge said condensers, means for periodically discharging said condensers to produce a saw-tooth voltage at the terminals of said condensers adjacent the resistances in their respective circuits, the rate of voltage rise across the condenser in said first circuit being lower than that across the condenser in said second circuit, and means including an electron discharge device having an anode and a cathode and a control electrode for producing a voltage rise across said circuits in parallel at a rate equal to the rate of rise across said first circuit condenser, said last mentioned means including a resistance in the cathode circuit of said device and a condenser coupling the cathode of said device and the junction of said circuits and said common resistance, said control electrode being coupled to the terminal of said second circuit condenser adjacent said second circuit resistance.

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