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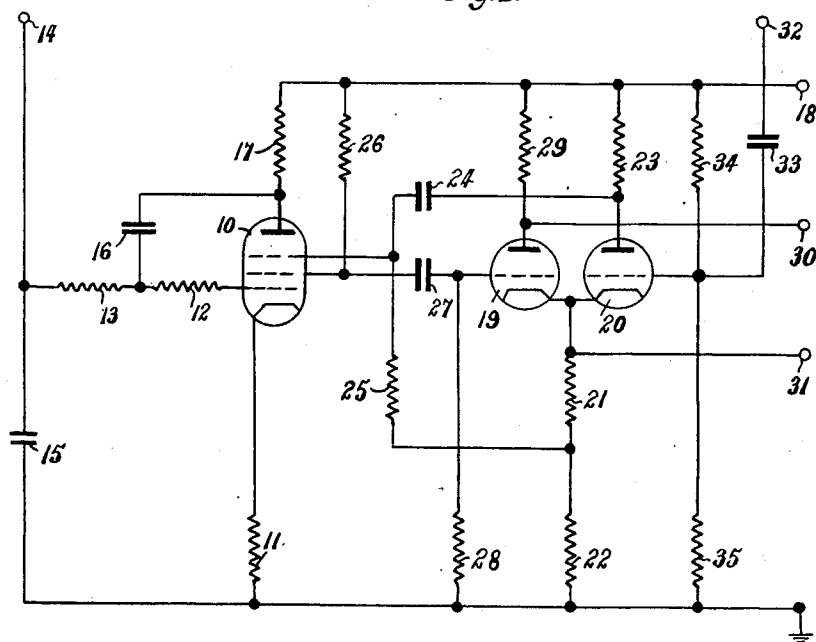
D. A. LEVELL
VOLTAGE GENERATING CIRCUIT

2,662,178

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Fig. 1.



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Fig. 2.

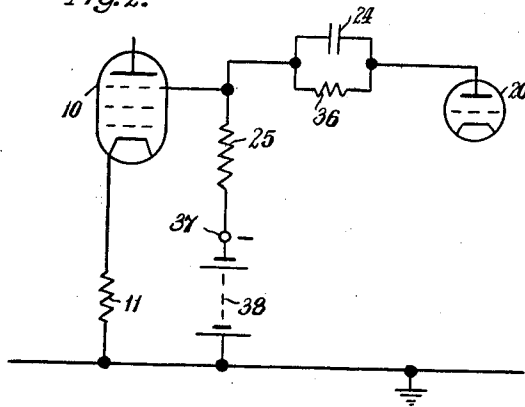
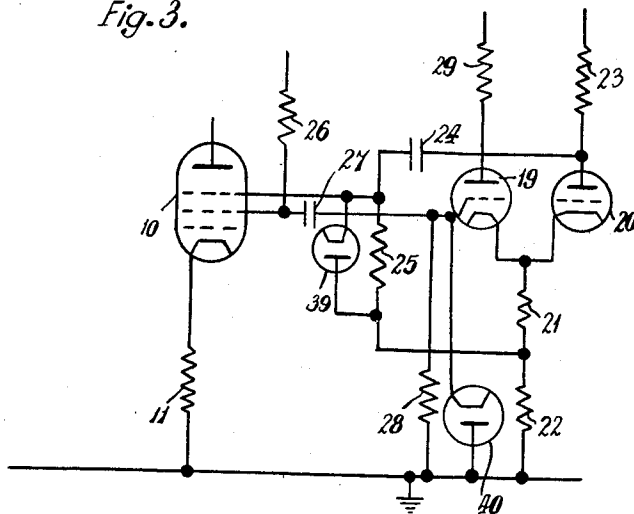


Fig. 3.



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VOLTAGE GENERATING CIRCUIT

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8 Claims. (Cl. 250—27)

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The present invention relates to circuits for generating voltage variations of saw-tooth and rectangular waveform.

In order to generate voltage variations of saw-tooth waveform various circuits have been proposed of the type comprising an electron discharge valve having an anode, a cathode and at least three control electrodes, a first control electrode being nearest the cathode, a second being between the first control electrode and the anode and the third being nearest the anode, a resistor connected between the first control electrode and the positive terminal of a source of direct voltage whose negative terminal is connected to the cathode of the valve, an anode load impedance element for the valve, a capacitor connected between the anode and the first control electrode of the valve, and a control circuit associated with the second and third control electrodes, the arrangement being such that on the application of a triggering pulse to the control circuit the potential of the anode falls progressively from a first datum to a second datum and returns to the first datum, or that the circuit is free-running and provides at the anode of the valve an oscillatory voltage of saw-tooth waveform.

Known circuits of this type when adapted to operate in response to triggering pulses have the disadvantage that the triggering voltage has to be of high amplitude, say 20 volts or more. It is not always convenient to provide a triggering voltage of such high amplitude.

One object of the present invention is to provide an improved electron discharge valve circuit of the type specified which can be adapted to operate in response to a triggering pulse of relatively low amplitude, say 2 volts, and is adapted to provide voltage variations of rectangular, as well as saw-tooth, waveform.

According to the present invention, in an electron discharge valve circuit of the type specified, the control circuit comprises second and third electron discharge valves, each having an anode, a cathode and at least one control electrode, a common cathode impedance element coupling the second and third valves to one another, means coupling the anode of the second valve to the third control electrode of the first said valve, and means coupling the second control electrode of the first said valve to the control electrode of the third valve.

The invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a theoretical circuit diagram of one embodiment of the invention, and

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Figures 2 and 3 are circuit diagrams showing modifications of the arrangement shown in Figure 1.

In Figure 1 a pentode valve 10 has its cathode connected to earth through a cathode resistor 11. The control grid of the pentode valve is connected through two series-connected resistors 12 and 13 to the positive terminal 14 of a source (not shown) of direct voltage whose negative terminal is earthed. A capacitor 15 is connected between the terminal 14 and earth and acts as a by-pass capacitor, and a further capacitor 16 is connected between the anode of the pentode 10 and the junction of the two series-connected resistors 12 and 13. The anode of the pentode is connected through a load resistor 17 to the positive terminal 18 of a source of high tension whose negative terminal is earthed.

The screen and suppressor grids of the pentode valve 10 are associated with a control circuit including two triode valves 19 and 20. These two triodes are coupled by common cathode resistors 21 and 22 connected in series. The anode of the valve 20 is coupled to the suppressor grid of the valve 10 by means of a resistor 23, a coupling capacitor 24 and a further resistor 25, the resistor 23 being connected as an anode load for the valve 20, the capacitor 24 being connected between the anode of the valve 20 and the suppressor grid of the valve 10, and the resistor 25 being connected between the suppressor grid of the valve 10 and the junction of the two resistors 21 and 22.

The screen grid of the valve 19 is connected to the positive terminal 18 through a resistor 26, and is coupled by means of a coupling capacitor 27 and a grid leak 28 to the control grid of the triode 19. The anode of the valve 19 is connected to the positive terminal 18 through a load resistor 29, and directly to an output terminal 30. A second output terminal 31 is connected to the junction of the two cathodes of the valves 19 and 20.

An input terminal 32 for applying triggering pulses to the control circuit is coupled to the control grid of the triode 20 through a differentiating circuit including a capacitor 33 and resistors 34 and 35.

The circuit shown in Figure 1 is adapted to operate in response to triggering pulses and is not free-running. When in its quiescent state, that is to say before a triggering pulse is applied to the terminal 32, the potential of the suppressor grid of the valve 10 is arranged to be sufficiently negative with respect to its cathode to prevent the flow of current to the anode. Substantially all current from the cathode then flows to the

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screen grid. The valve 20 passes anode current owing to the fact that its control grid is positively biased, and the voltage developed across the resistors 21 and 22 is arranged to be sufficient to render the valve 19 non-conducting or substantially so.

If a positive-going triggering pulse of rectangular shape is applied to the terminal 32 the differentiating circuit serves to provide at the control grid of the triode 20 a sharp positive-going pulse coincident with the leading edge of the triggering pulse and a sharp negative-going pulse coincident with the trailing edge of the triggering pulse, or vice versa if the triggering pulse is negative-going.

The sharp negative-going pulse derived from the triggering pulse causes the anode potential of the valve 20 to rise rapidly. This rapid increase in voltage is transmitted through the coupling capacitor 24 to the suppressor grid of the valve 10. This valve becomes conducting and less current passes to the screen grid. The potential of the screen grid rises and this rise is transmitted to the control grid of the triode 19 and renders this valve conducting or more conducting. The increase in voltage across the common cathode resistors 21 and 22 causes a further fall in the anode current in the triode valve 20 and hence a further rise in the anode potential of this valve. This further rise is passed to the suppressor grid of the pentode 10 causing a further increase in anode current, a further decrease in screen current, and an increase in the screen potential. The increase in the screen potential leads to a further increase in the anode current of the valve 19 and a decrease in the anode current in the valve 20. This action is cumulative and proceeds beyond the condition of anode current cut-off in the valve 20.

It will be seen therefore that as a result of a small triggering pulse applied to the terminal 32 a relatively large pulse appears on the suppressor grid of the valve 10.

The potential of the anode of the valve 10, following the initial drop, makes a substantially linear progressive fall until the valve 10 "bottoms," that is to say until the anode, control grid and suppressor grid potentials are such that anode current ceases to increase with increasing control grid voltage. The current to the screen increases causing the screen grid to become less positive. This brings about a reduction in the anode current of the valve 19 causing the valve 20 to become conducting and to pass a negative-going voltage to the suppressor grid of the pentode 10. This negative-going potential on the suppressor grid of the pentode reduces the anode current and increases the screen current still further. This action is cumulative and proceeds until anode current in the pentode is cut off, and the valve 20 is non-conducting or substantially so once more. The potential of the anode of the valve 10 then rises to that of the terminal 13 at a rate dependent upon the time constant of the capacitor 16 and resistor 17.

Throughout the time when the potential of the anode of the valve 10 is falling it is essential that the suppressor grid potential is more positive than that necessary to prevent the flow of current to the anode of the valve 10. The potential of the junction of the resistors 21 and 22 is arranged to be high enough during that time to ensure that the anode current is not cut off.

In this arrangement a positive-going, rectangular pulse appears at the output terminal 31, the

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leading edge of this pulse being coincident with the derived sharp negative-going pulse applied to the control grid of the valve 20, and the trailing edge being coincident with the negative-going pulse appearing at the suppressor grid of the pentode 10 at the end of the progressive fall in the anode potential of the pentode. A pulse of identical waveform but in antiphase with that appearing at the output terminal 31 appears at the output terminal 30. If desired a further output terminal may be connected to the anode of the pentode 10 to provide an output voltage of saw-tooth waveform.

In a known circuit of the type specified in which the valve is a pentode valve, the suppressor grid is connected through a leak resistor to a point of positive potential of sufficient magnitude to prevent anode current from being cut off during the time when the potential of the anode is making its progressive fall. In this known circuit the pentode has to be provided with a cathode resistor of relatively large value to ensure that the circuit remains quiescent until triggered. The use of a cathode resistor of large value reduces the linearity of the fall of anode potential. In the present embodiment the cathode resistor 11 can be made of relatively small resistance.

Cut-off of the valve 10 during the fall in anode potential may also be avoided by replacing the A. C. coupling 24 and 25 by a D. C. coupling for example as shown in Figure 2. In Figure 2 the capacitor 24 is shunted by a resistor 36, and the lower end of the resistor 25 is disconnected from the junction of the two resistors 21 and 22 and is connected to the negative terminal 37 of a battery 38 whose positive terminal is earthed.

Alternatively the modification shown in Figure 3 may be used. In Figure 3 a diode 39 is connected across the resistor 25 as shown and a further diode 40 is connected between the control grid of the valve 19 and earth as shown. The time constant of discharge of the capacitor 24 is made long compared with the duration of the fall in the anode potential of the valve 10 and the diodes 39 and 40 act as D. C. restoring diodes to prevent frequency division arising from the use of the long time constant of discharge of the capacitor 24. Further, the cathode resistor 11 may be omitted, and hence the linearity of the progressive fall in the anode voltage of the valve 10 improved, if the resistor 25 is disconnected from the junction of the resistors 21 and 22 connected to the negative terminal of a source of bias of suitable magnitude. In some circumstances, the circuit may be required to respond to triggering pulses only when in excess of a predetermined amplitude. D. C. coupling or A. C. coupling and a D. C. restoring diode are then essential in the place of the A. C. coupling 24 and 25 shown in Figure 1.

The circuit shown in Figure 1 may be made free-running by disconnecting the resistor 25 from the junction of the resistors 21 and 22 and connecting it to the positive terminal of a source of bias of suitable magnitude, and arranging the time constant of the capacitor 24 and resistor 25 to have a suitable value.

Suitable components for use in the circuit shown are as follows:

- 10=Type CV 329 valve
- 11=2.2 K Ω .
- 12=470 ohms
- 13=180 K Ω .

14=50 to 160 volts for pulse width of 4 to 12 microseconds

16=27 pF

17=320 K Ω .

18=h. t. line voltage of 280 volts

19 and 20=each one half of a CV 858 valve

21=1.8 K Ω .

22=330 ohms

23=33 K Ω .

24=300 pF

25=220 K Ω .

26=33 K Ω .

27=.01 microfarad

28=220 K Ω .

29=2.2 K Ω .

33=300 pF

34=560 K Ω .

35=18 K Ω .

36=1 M Ω .

I claim:

1. An electron discharge valve circuit, comprising a first electron discharge valve having an anode, a cathode and three control electrodes, the first of said control electrodes being nearest said cathode, a second being between the first control electrode and the anode, and a third being nearest the anode of said first valve, a source of direct current, a first resistor, means connecting said resistor between said first control electrode and the positive terminal of said source, a second resistor, means connecting said second resistor between an anode of said first valve and said positive terminal, a capacitor, means connecting said capacitor between the anode and the first control electrode of said first valve, means connecting the cathode of said first valve to the negative terminal of said source, second and third electron discharge valves each having an anode, a cathode and at least one control electrode, a common cathode coupling element for said second and third valves, means connecting said common cathode coupling element between the cathodes of said second and third valves and the negative terminal of said source, a load element for said second valve, means connecting said load element between the anode of the second valve and the positive terminal of said source, means connecting the anode of said third valve to the positive terminal of said source, means coupling the anode of said second valve to said third control electrode of said first valve, and means connecting the second control electrode of said first valve to the control electrode of said third valve.

2. An electron discharge valve circuit as claimed in claim 1, wherein the said means coupling the anode of said second valve to the third control electrode of said first valve comprises a second capacitor, means connecting said second capacitor between the anode of said second valve and the third control electrode of said first valve, a third resistor and means connecting said third resistor between the third electrode of said first valve and the cathode thereof.

3. An electron discharge valve circuit as claimed in claim 1, wherein the said means coupling the anode of said second valve to the third control electrode of said first valve comprise a capacitor and a resistor, means connecting the last said capacitor and resistor in parallel between an anode of said second valve and the third control electrode of said first valve, a further resistor, a source of bias voltage, a connection between the positive terminal of said source of bias voltage and the

cathode of said first valve, and means connecting said further resistor between the negative terminal of said bias source and the third control electrode of said first valve.

4. An electron discharge valve circuit as claimed in claim 1, and comprising a triggering pulse input terminal, a differentiating circuit, and means connecting said differentiating circuit between said triggering pulse terminal and the control electrode of said second valve.

5. An electron discharge valve circuit as claimed in claim 1, wherein said means coupling the anode of said second valve to the third control electrode of said first valve comprise a second capacitor, means connecting said second capacitor between the anode of said second valve and the third control electrode of said first valve, a third resistor, means connecting said third resistor between the third control electrode of said first valve and the cathode thereof, a rectifier device, and means connecting said rectifier device across said third resistor.

6. An electron discharge valve circuit as claimed in claim 5, comprising a second rectifier device, and means connecting said second rectifier device between the control electrode of said third valve and the cathode thereof.

7. An electron discharge valve circuit as claimed in claim 2, wherein the end of said third resistor remote from the third electrode of said first valve is connected to a point in said common cathode coupling element for said second and third valves.

8. An electron discharge valve circuit, comprising a first electron discharge valve having an anode electrode, a cathode electrode and three control electrodes, the first of said control electrodes being nearest said cathode, a second being between the first control electrode and the anode, and a third being nearest the anode of said first valve, a source of direct current, a first resistor, means connecting said resistor between said first control electrode and the positive terminal of said source, a second resistor, means connecting said second resistor between an anode of said first valve and said positive terminal, a capacitor, means effectively coupling said capacitor between the anode and the first control electrode of said first valve, means connecting the cathode of said first valve to the negative terminal of said source, second and third electron discharge valves each having an anode, a cathode and at least one control electrode, a common cathode coupling element for said second and third valves, means connecting said common cathode coupling element between the cathodes of said second and third valves and the negative terminal of said source, a load element for said second valve, means connecting said load element between the anode of the second valve and the positive terminal of said source, means connecting the anode of said third valve to the positive terminal of said source, a pulse transmitting connection extending between the anode of said second valve and one of the electrodes of said first valve, and means connecting the second control electrode of said first valve to the control electrode of said third valve.

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