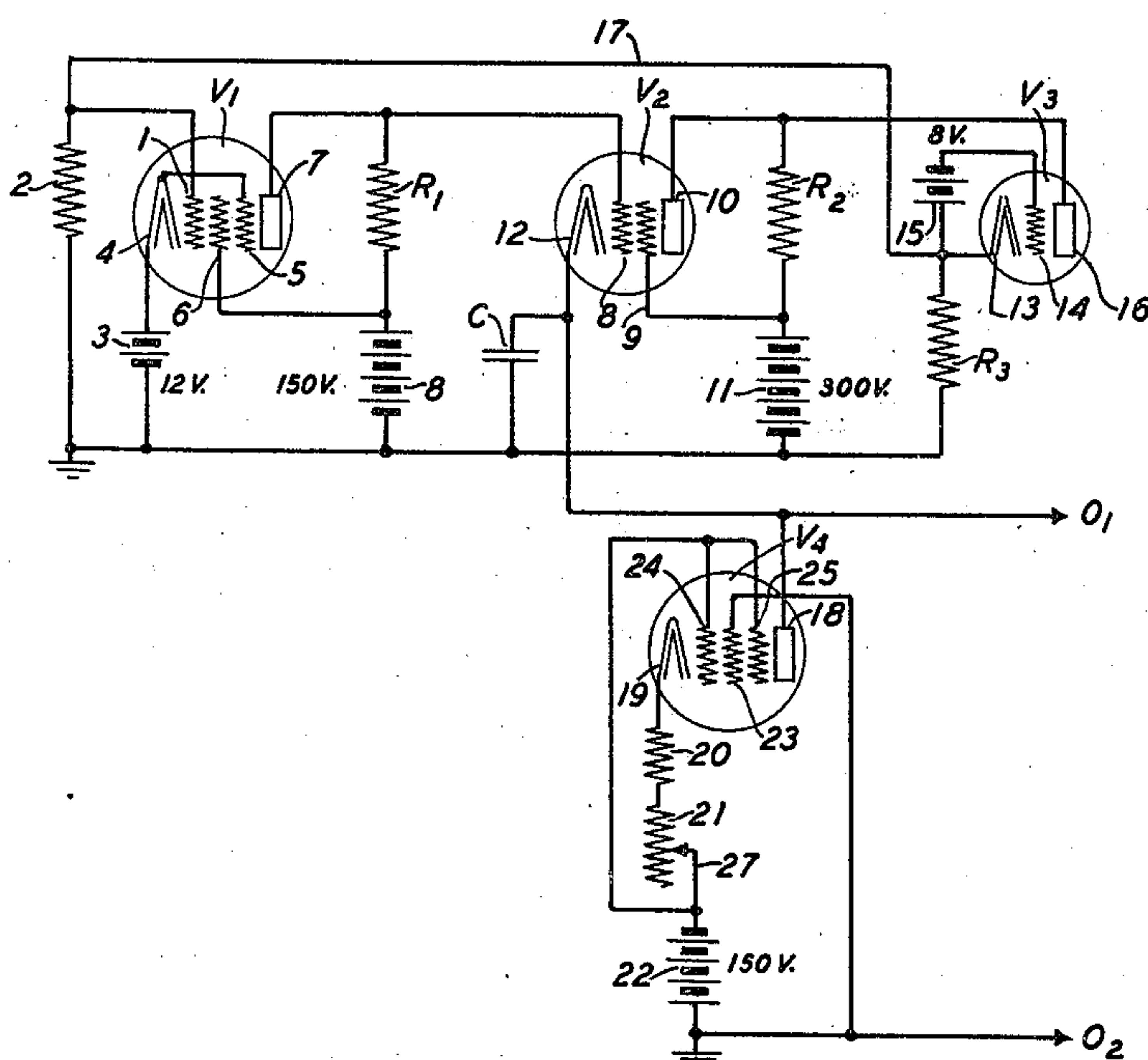


April 15, 1947.

O. D. ENGSTROM
MULTIVIBRATOR CIRCUIT

2,418,826

Filed Jan. 22, 1943



INVENTOR
O. D. ENGSTROM
BY
G. H. Heydt.
ATTORNEY

UNITED STATES PATENT OFFICE

2,418,826

MULTIVIBRATOR CIRCUIT

Olle D. Engstrom, East Williston, N. Y., assignor
to Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

Application January 22, 1943, Serial No. 473,189

4 Claims. (Cl. 250—36)

1

This invention relates to an improvement in multivibrator circuits. It is of value at any oscillation frequency which the multivibrator may be used to produce but is particularly important when this frequency is lower than ten cycles per second.

The multivibrator circuit known to the prior art comprises a pair of thermionic vacuum tubes commonly referred to, one as an amplifier tube, the other as a trigger tube. Ordinarily the anode of the amplifier tube is conductively or capacitatively coupled to the control grid of the trigger tube, the control grid of the former being at the same time capacitatively coupled to the anode of the latter. The cathode circuit of the trigger tube comprises a condenser shunted by a constant current discharge tube of variable conductance or by a variable resistance. When such a multivibrator is in operation the cathode condenser is alternately charged and discharged whereby saw-tooth voltage oscillations are generated across its terminals. The frequency is determined by the selected conductance of the discharge tube or of the resistance shunting the condenser. This saw-tooth voltage is available to a subsequent circuit connected in parallel with the condenser, for example, the horizontal deflection plates of a cathode ray oscilloscope. Circuits of the type in question are disclosed, for example, in United States Patents 1,934,322, granted November 7, 1933, to W. O. Osborn, and 2,114,938, granted April 19, 1938, to O. S. Puckle, and are described in general terms in an article entitled "Hard value scanning circuits," by G. Parr, Television and Short-Wave World, August 1938, page 475.

The capacitive feedback from the anode of the trigger tube to the control grid of the amplifier tube effects the transfer between these elements of voltage impulses but involves the time constant of an R.-C. circuit comprising the feedback condenser and the customary grid leak of the amplifier tube. The charging time of the feedback condenser circuit is not a negligible fraction of the period of the generated oscillation and the condenser is usually made adjustable to the optimum value for the frequency desired. Otherwise, as pointed out by Parr in the article cited above, the output saw-tooth voltage varies in amplitude as the frequency is changed.

For many purposes it may be desired that the amplitude of the generated saw-tooth voltage be independent of frequency and this requires the elimination of the condenser coupling the anode of the trigger tube to the control grid of the am-

2

plifier tube. In the present invention this is accomplished by replacing the usual capacitive feedback by direct current feedback.

It is therefore an object of the invention to provide an improved multivibrator circuit.

Another object of the invention is to provide a multivibrator circuit whereby oscillating voltages may be generated having an amplitude independent of the oscillation frequency.

Finally, it is an object of the invention to provide a multivibrator circuit comprising an amplifier tube and a trigger tube wherein an auxiliary vacuum tube is used to couple the anode of the trigger tube to the control grid of the amplifier tube.

A feature of the invention is the provision of a resistor in the anode circuit of the above-mentioned auxiliary tube across which appear, with amplification, variations in anode voltage of the trigger tube which are directly transferred to the control grid of the amplifier tube.

The invention will be understood from the following description read with reference to the accompanying drawing the single figure of which is a multivibrator circuit constituting a preferred embodiment of the invention.

Referring to the figure, V1 is the amplifier tube, suitably a 6AC7. In tube V1, control grid 1 is connected to ground through grid leak 2; cathode 4 and suppressor grid 5 are connected together and biased positively to ground by 12-volt battery 3; screen grid 6 and anode 7 are supplied with positive potential from 150-volt battery 8, grid 6 directly and anode 7 through resistor R1. Trigger tube V2 is suitably a 6L6. Its control grid 8 is conductively coupled, as shown, to the junction of anode 7 of V1 and resistor R1. Screen grid 9 and anode 10 of V2 are supplied from 300-volt battery 11, grid 9 directly and anode 10 through resistor R2. Cathode 12 of V2 is capacitatively coupled to ground through condenser C across the terminals of which appear the voltage oscillations generated in the operation of the circuit.

In the multivibrator circuits of the prior art anode 10 of V2 is coupled through a condenser to control grid 1 of V1 and condenser C is shunted either by a variable resistor or by a constant current discharge tube of variable conductance. In the circuit herein described anode 10 is coupled to grid 1 through the circuit of auxiliary tube V3, preferably a 6C5. In tube V3 cathode 13 is coupled to ground through resistor R3, control grid 14 is negatively biased by 8-volt battery 15, the positive terminal of which is connected to

cathode 13, and anode 16 is conductively coupled to the junction of anode 10 of V2 and resistor R2. Conductor 17 connects directly cathode 13 of tube V3 and control grid 1 of tube V1. Tube V3 thus provides coupling between anode 10 of V2 and control grid 1 of V1, replacing the condenser heretofore used to couple these elements.

Shunting condenser C is a discharge circuit including tube V4, suitably a 6AC7 like tube V1. Anode 18 of V4 is connected to cathode 12 of V2 at the junction of the latter with condenser C. Cathode 19 is connected to ground through a fixed resistor 20 in series with resistor 21 and 150-volt battery 22, the positive terminal of which is grounded and connected also to screen grid 23 of V4. Control grid 24 and suppressor grid 25 are together connected to the negative terminal of battery 22. Batteries 8, 11 and 22 are bypassed by suitable condensers, not shown. Cathode heater supplies are likewise to be understood. Where linearity of sweep is unimportant a variable resistor may replace the discharge circuit just described.

In the operation of the above circuit saw-tooth voltage oscillations are generated across condenser C of frequency determined by the conductance of tube V4, which may be regulated by the adjustment of tap 27 on resistor 21 together with the capacity of condenser C. This capacity is conveniently 32 microfarads for frequencies from one-tenth to one cycle per second and 3.2 microfarads for frequencies from one to ten cycles per second. The voltage oscillations so generated are available to an external circuit across output terminals 01 and 02, connected respectively to cathode 12 of V2 and to ground. The range of variation of voltage across condenser C is approximately 75 volts from a maximum of 150 volts to a minimum of 75 volts, approximately.

The novelty in the operation of the circuit will now be particularly described. For this purpose it is appropriate to tabulate the values found suitable for the various elements not already defined:

	Ohms
R1	8,000
R2	1,000
R3	860
2	500,000
20	600
21	10,000

¹ Maximum.

Consider the instant in the cycle, when trigger tube V2 is blocked, amplifier tube V1 is conducting and condenser C is charged to its maximum potential of approximately 150 volts. Under these conditions the voltage on anode 10 of V2 and anode 16 of V3 is a maximum. Tube V3 is conducting and by reason of the voltage drop across resistor R3 cathode 13 is approximately 10 volts positive to ground. This potential of cathode 13 is impressed through conductor 17 on control grid 1 of tube V1 in opposition to the effective 12-volt negative bias from battery 3. Control grid 1 is thus about 2 volts negative to ground corresponding to an anode current I_p in tube V1, of about 10 mils.

Control grid 8 of tube V2 at this time is about 80 volts negative to ground, this potential arising from the voltage of battery 8, less the voltage drop across R1 algebraically added to the negative bias derived from condenser C. The net voltage is $-I_p R_1 = -80$ volts. Now condenser C

discharges through the discharge circuit including tube V4 and the negative voltage on grid 8 is progressively reduced. As the voltage of condenser C approaches its minimum value of 75 volts, V2 begins to conduct and concurrently the voltage on anodes 10 and 16 decreases. The falling anode voltage of tube V3 corresponds to a decreasing space current in that tube which means a reduction in the voltage drop across R3 which through conductor 17 opposes the negative bias of battery 3. The circuit elements of tube V3 are chosen such that this tube is operating on the steep portion of its $I_p E_p$ characteristic. This being so, the falling anode voltage of tube V3 results in a rapidly increasing negative potential on grid 1. The instant is speedily reached when the space current of V2 reaches saturation, at which instant the voltage drop across R3 is about 2 volts and grid 1 is 10 volts negative to ground. V1 is now blocked and condenser C is being recharged by the space current in tube V2. When condenser C acquires its full voltage V2 blocks and the conductivity of V1 is regained, whereupon the described cycle is repeated.

It will be clear that the rapidity of trigger action is now controlled by the steepness of the $I_p E_p$ characteristic of auxiliary tube V3 instead of by the much less steep discharge current of the usual coupling condenser and amplifier tube grid leak which circuits of the prior art depend upon. It is obvious that other types of auxiliary tubes than the 6C5 may be employed, and that by changes in the circuit elements easily made by one skilled in the art the auxiliary tube and the operation involved in the present invention may be applied to improve any form of multivibrator. The steepness of the $I_p E_p$ characteristic of the auxiliary tube effects amplification of the triggering variation in potential of the anode of the trigger tube. By reason of this steepness the variation in voltage drop across R3 may be made several times the variation in voltage of anodes 10 and 16. The triggering interval required to convert tube V1 from the conducting to the blocking condition is made as short as desired with the result that the extremes of voltage reached by condenser C are not affected by this interval whatever the frequency of recurrence of charge and discharge of the condenser. Therefore the saw-tooth voltage output of the multivibrator is constant and this is obviously true whether the condenser charging interval is the retrace period, as in the circuit described, or is the sweep period of the multivibrator.

What is claimed is:

1. A multivibrator circuit including an amplifier tube and a trigger tube, each of said tubes having at least a cathode, a control grid and an anode, power supplies for said tubes, conductive coupling between ground and the cathode of said amplifier tube, capacitative coupling between ground and the cathode of said trigger tube, conductive coupling between ground and the control grid of said amplifier tube, coupling between the anode of said amplifier tube and the control grid of said trigger tube and conductive coupling including a thermionic vacuum tube between the anode of said trigger tube and the control grid of said amplifier tube.
2. A multivibrator circuit including a pair of thermionic tubes interacting to generate voltage oscillations of any desired frequency, each of said interacting tubes having at least a cathode, a control grid and an anode, power supplies for said tubes, conductive coupling between ground

5

and the cathode of one of said tubes, capacitative coupling between ground and the cathode of the other of said tubes, conductive coupling between ground and the control grid of said one tube, coupling between the anode of said one tube and the control grid of said other tube, conductive coupling including a source of constant voltage between ground and the anode of said other tube, and means for rendering the amplitude of said voltage oscillations independent of frequency including an auxiliary thermionic tube in circuit between the control grid of said one tube and the anode of said other tube.

3. A multivibrator circuit for the generation of saw-tooth voltage oscillations of variable frequency and constant amplitude comprising a first, a second and a third vacuum tube, each of said tubes having at least a cathode, a control grid and an anode, power supply for said tubes, conductive coupling between ground and the cathode of said first tube, conductive coupling between the anode of said first tube and the control grid of said second tube, capacitative coupling between ground and the cathode of said second tube, a discharge circuit in shunt with said capacitative coupling including means for

6

controlling the frequency of said oscillations, conductive coupling between the anode of said second tube and the anode of said third tube, conductive coupling including a source of constant voltage between the control grid and the cathode of said third tube, conductive coupling between ground and the cathode of said third tube and conductive coupling between the cathode of said third tube and the control grid of said first tube.

4. A multivibrator circuit as described in claim 3 wherein said conductive coupling between ground and the cathode of said third tube is a resistor in parallel connection between ground and the control grid of said first tube.

OLLE D. ENGSTROM.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,114,938	Puckle	Apr. 19, 1938
2,155,210	Young	Apr. 18, 1939
2,265,290	Knick	Dec. 6, 1941