Feb. 6, 1951 J. R. MOORE 2,540,539

MULTIVIBRATOR TYPE OSCILLATOR

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Fig. 1.

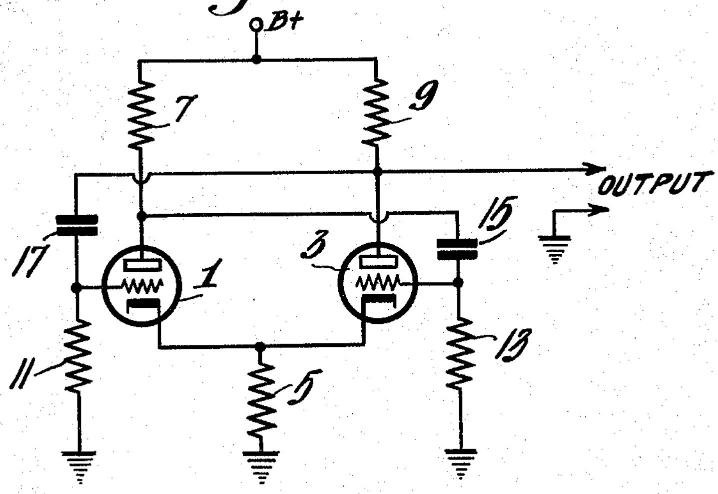
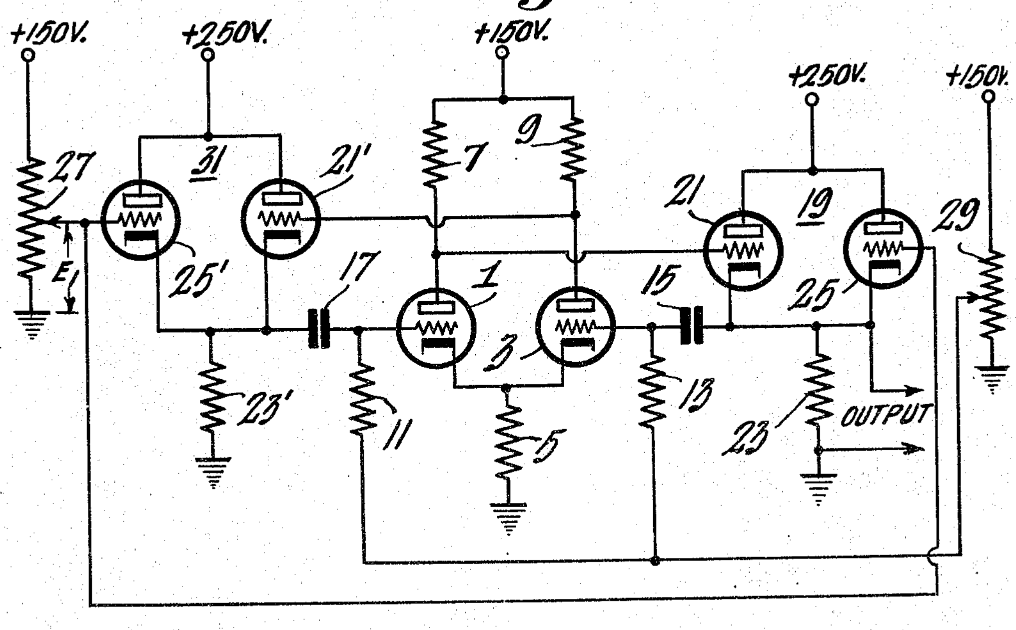


Fig. 2.



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MULTIVIBRATOR TYPE OSCILLATOR

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3 Claims. (Cl. 250—36)

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This invention relates to oscillators of the multivibrator type, and more particularly to the stabilization of such oscillators.

The principal object of the invention is to provide multivibrators in which the frequency and the amplitude of the output voltage are substantially independent of ordinary variations in characteristics of the component vacuum tubes.

Another object is to provide oscillators of the described type wherein the frequency of operation can be controlled by means of a bias voltage.

The invention will be described with reference to the accompanying drawing, wherein:

Figure 1 is a schematic circuit diagram of a multivibrator substantially in accordance with the prior art,

Figure 2 is a schematic diagram of a multivibrator circuit in accordance with the present invention.

Similar reference characters are applied to similar elements throughout the drawing.

The multivibrator of Fig. 1 is the cathode-coupled type, and includes two vacuum tubes 1 and 3 provided with a common cathode resistor 5, separate plate load resistors 7 and 9, respectively, and grid leaks 11 and 13. The plate of the tube 1 is coupled to the grid of the tube 3 through a capacitor 15. The plate of the tube 3 may be likewise coupled to the grid of the tube 1 through a capacitor 17, although this is not strictly essential to the operation of the circuit.

Both tubes 1 and 3 conduct initially when the plate supply voltage is turned on. The potentials at both plates decreases, owing to drop in the load resistors 7 and 9, and at the same time the cathodes become increasingly positive with respect to ground because the plate currents of both tubes flow through the common cathode resistor 5. The decrease in potential at each plate is communicated through the respective coupling condenser 15 or 17 to the grid of the other tube. This, together with the positive cathode potential, tends to drive both tubes toward plate current cutoff.

Any slight difference between the tubes 1 and 3 or their associated circuit elements causes one of the tubes, for example the tube 1, to cut off first. The plate current of the other tube 3 will then increase suddenly, causing a further sudden decrease in the potential at its plate. The resulting negative pulse appearing at the grid of the tube 1 by way of the condenser 17 drives the tube 1 still further beyond cutoff.

The tube 3 is now fully conducting and the

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tube 1 is well below cutoff. This condition persists while the condenser 17 discharges, through the resistor 11, to a potential approximating that between the plate of the tube 3 and ground. This allows the grid of the tube 1, which was driven negative by the pulse from the plate of the tube 3, to approach ground potential at a rate which depends upon the capacitance of the condenser 17 and the resistance of the resistor 11.

Finally the grid of the tube 1 becomes sufficiently less negative to allow conduction to start in the tube 1. This increases the drop in the cathode resistor 5 and also applies a negative pulse to the grid of the tube 3. These effects together operate to reduce the plate current in the tube 3, causing an increase in the potential at the plate of the tube 3. The increasingly positive voltage at the plate of the tube 3 drives the grid of the tube 1 in a positive direction, accelerating the increase of plate current in the tube 1 and quickly driving the tube 3 beyond cutoff.

Conditions are now reversed, with the tube 1 conducting and the tube 3 cut off. The condenser 15 discharges through the resistor 13, and the cycle is repeated. The tubes 1 and 3 conduct alternately, each for a period determined by the R-C product or time constant of its respective grid leak and condenser. The time required for the actual transfer of conduction from one tube to the other is extremely small. Output may be taken from the plate of the tube 3 as shown, or from the plate of the tube 1, or from both tubes.

Oscillators of the above described type are used to produce sharply defined non-sinusoidal waves for various applications. Often the frequency is set approximately by the R-C networks and controlled exactly by injecting a timing wave, for example at the control grid of one of the tubes. The present invention contemplates oscillators of the multivibrator type which are sufficiently stable so that they will operate at a definite selected frequency without being controlled by an externally produced timing wave.

The frequency of operation of an oscillator like that of Fig. 1, assuming no timing wave to be applied, depends not only upon the time constants of the coupling networks but also upon the voltage of the supply source and the individual tube characteristics. The supply voltage determines how far positive the plate of either tube will go when the plate current is cut off; the tube itself, as well as the supply voltage, determines how low the potential at the plate will go when the tube is conducting. Moreover, the potential at the plate of the tube varies during the time that tube is conducting. All of these factors affect the length of the conducting periods for each tube, and thus the frequency. The amplitude of the output wave and its shape are also functions of the supply voltage and of the tube characteristics.

According to the present invention, the negative grid swing, i. e. the most negative potential which can appear at the grid of either of the multivibrator tubes, is set at a definite level which does not depend on the minimum plate potential at either tube and is preferably a predetermined fraction of the plate supply voltage.

Referring to Fig. 2, the tubes 1 and 3 are, as in Fig. 1, provided with a common cathode resistor 5. The plate of the tube 1 is not coupled directly to the grid of the tube 3, however, but goes to a cathode follower circuit 19. The cathode follower 19 includes a tube 21 with its entire load resistor 23 in its cathode circuit. The plate of the tube 21 is connected directly to the plate supply source. The cathode of the tube 21 is coupled through the condenser 15 to the grid of the tube 3.

A further tube 25 also has its cathode connected to the resistor 23 and its anode connected to that of the tube 21, so that the space discharge paths of the tubes 21 and 25 are in parallel. The control grid of the tube 25 is biassed positive with respect to ground by means of a voltage divider 27 connected across the plate supply source of the tubes 1 and 3. The grid leaks 11 and 13 of the tubes 1 and 3 are not returned directly to ground as in Fig. 1, but are also biassed positive by a voltage divider 29, also connected across the plate supply source.

A second cathode follower circuit 31 is included in the connection between the plate of the tube 3 and the grid of the tube 1. The circuit 31 is substantially identical with the circuit 19, and includes corresponding tubes 21' and 25' with a common cathode load resistor 23'. The grid of the tube 25' is biassed like that of the tube 25 by the voltage divider 27.

The operation of the system of Fig. 2 is similar to that of Fig. 1, with certain significant exceptions. The voltage divider 27 is adjusted to set the potential at the grids of the tubes 25 and 25' at a level E_1 of, say, 50 volts. The positive bias supplied by the voltage divider 29 may be varied to adjust the frequency of oscillation to some extent, since this voltage will determine how far either of the coupling condensers 15 and 17 must discharge before the respective tube 3 or 1 will be able to start conducting.

Assume that the tube 1 has just started to conduct. The potential at its plate assumes a relatively low value, less than the supply voltage by the drop in the resistor 7, and considerably less than E_1. The actual potential at the plate of the tube 1 thus depends not only on the plate supply voltage but also upon how much current the tube 1 can conduct.

As long as the potential at the plate of the tube 1 is greater than E_1, the cathode follower tube 21 conducts just enough to maintain the drop in its load resistor 23 equal to that potential. However, as soon as the tube 1 conducts and its plate potential drops below E_1, the tube 25 starts conducting and provides a drop substantially equal to E_1 across the resistor 23. This, being considerably greater than the potential at the grid of the tube 21, cuts the latter off, and any variations in the plate potential at the tube 1 have no effect on the voltage across the resistor 23.

Thus the voltage across the resistor 23 will have a substantially linear rectangular wave form, changing cyclically between 150 volts (the plate supply voltage) when the tube 1 is cut off and 50 volts (E_1) when the tube 1 is conductive. These limits are determined solely by the supply and bias voltages, and any normal variations in the characteristics of the tubes 1, 3, 21 and 25 will not change them. If the voltage divider 27 is connected to the same source of supply as the plates of the tubes 1 and 3, the bias voltage E_1 will bear a constant ratio to the plate supply voltage regardless of variations in the latter. Thus the maximum voltage across the cathode follower load will always be three (or some other definite number) times the minimum voltage. This tends to make the frequency of operation of the oscillator independent of normal supply voltage variations.

It is apparent without further discussion that the cathode follower circuit 31 acts exactly like the circuit 19, controlling accurately the negative swings of the voltage reaching the grid of the tube 1. Besides stabilizing the frequency of the oscillator, this keeps the amplitude substantially constant. The output may be taken as in Fig. 1 from either of the tubes 1 and 3, or may be taken off either of the cathode follower load resistors. The latter is preferable because variations in the load resistance at this point have substantially no effect on the system.

Summarizing briefly, the invention has been described as an improvement in oscillators of the multivibrator type. The frequency of oscillation is stabilized by limiting the negative swings at the grids of both tubes to a definite value, preferably some predetermined fraction of the plate supply voltage.

I claim as my invention:

1. An oscillator including two electron discharge tubes each including at least a cathode, a control grid, and a plate, a common cathode resistor connected to both of said cathodes and to ground; two cathode follower circuits, each including an electron discharge tube provided with a load resistor in its cathode circuit, the control grid of each of said cathode follower tubes being connected to the plate of a respective one of said first mentioned two tubes, and means coupling the cathode of each of said cathode follower tubes to the control grid of the other of said first mentioned tubes; two further tubes, each having its anode and its cathode connected to the anode and the cathode respectively of one of said cathode follower tubes, and means biassing the control grids of said further tubes to a potential in excess of the minimum voltage which appears at the plates of said first mentioned tubes during operation of the system.

2. The invention as set forth in claim 1, including means applying an adjustable positive bias to the control grids of said first mentioned tubes to control the frequency of oscillation thereof.

3. A stabilized oscillator of the multivibrator type, including two electron discharge tubes with the plate circuit of each coupled to the grid circuit of the other to produce and sustain oscillations comprising alternate pulses of current in said tubes, and limiter means connected between the plate of each of said tubes and the grid of the other to prevent decrease below a predetermined value of the voltage applied to either of said grids, said limited means comprising a cathode follower circuit including a vacuum tube and

a cathode output resistor and also including another vacuum tube having an anode to cathode space path that is connected in parallel conducting relation with the first mentioned vacuum tube of the cathode follower circuit, said limiter means further comprising means for biassing the control grid of said other tube to a potential in excess of the minimum voltage which appears at the plates of the first mentioned electron discharge tubes during operation of the system.

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