

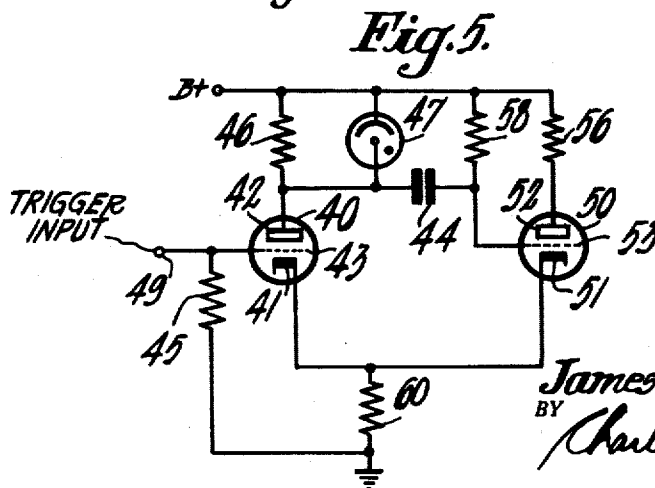
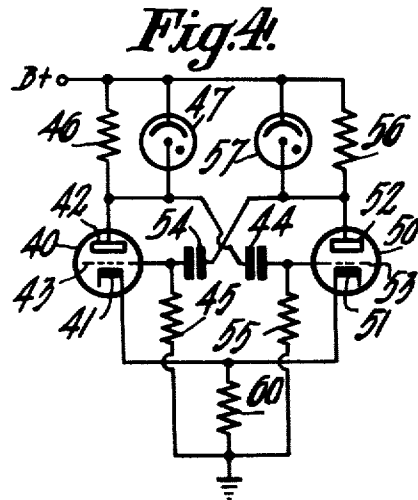
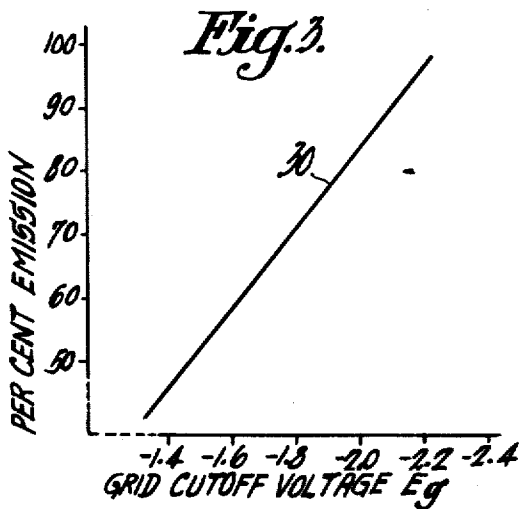
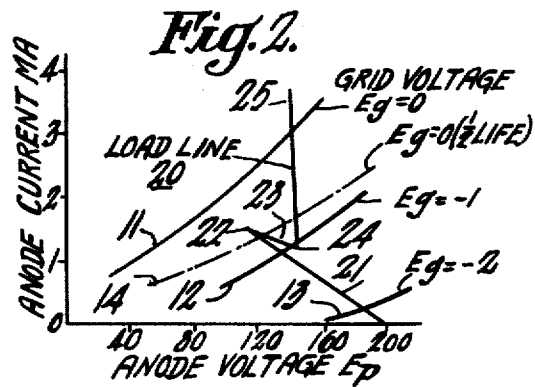
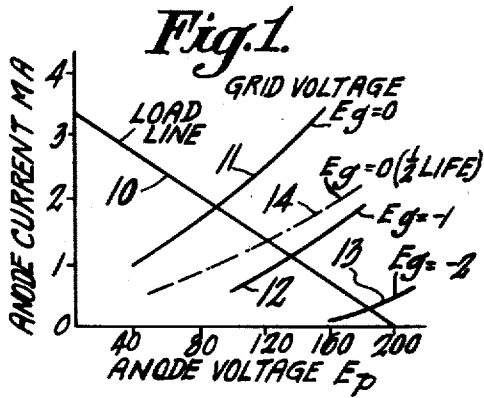
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J. G. ARNOLD

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STABILIZED MULTIVIBRATORS

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INVENTOR.
James G. Arnold
BY Charles H. Brown
ATTORNEY

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STABILIZED MULTIVIBRATORS

James G. Arnold, Westville, N. J., assignor to Radio Corporation of America, a corporation of Delaware

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The terminal fifteen years of the term of the patent to be granted has been disclaimed

5 Claims. (Cl. 250—36)

The invention relates to multivibrators, and particularly to a method of and means for stabilizing astable or monostable multivibrators.

In astable or monostable multivibrators, or in trigger circuits, where the frequency is determined by the charging or discharging of a capacitor, changes in the frequency of oscillation are caused by several factors. The resistor and capacitor values and the supply voltage may vary. These, however, can be controlled by methods that are known in the art. Another factor of importance is the variation of the characteristics of a vacuum tube during its life, and the differences in characteristics between different vacuum tubes when first used in the multivibrator.

An object of the invention is to provide a multivibrator that has a stabilized frequency of oscillation over a wide variation in the characteristics of the vacuum tubes being used.

The invention provides a multivibrator having a pair of intercoupled vacuum tubes connected in parallel with each vacuum tube anode load resistor, and a common cathode resistor having one end connected to the cathodes of the vacuum tubes, and the other end connected to a point of reference potential. Proper choice of the value of the cathode resistor, when used with the gaseous discharge tubes, insures a frequency of oscillation that remains stabilized despite a decrease in the emission of the vacuum tubes by one half.

The invention is explained in detail in the following description, taken with reference to the accompanying drawing, in which:

Fig. 1 shows the anode characteristics and load line of a conventional triode vacuum tube;

Fig. 2 shows the plate characteristics of the triode represented in Fig. 1 with a load line obtained in accordance with the invention;

Fig. 3 shows the relationship between the grid cutoff voltage and the percent of total emission of the triode represented in Fig. 1;

Fig. 4 shows a circuit for an astable multivibrator in accordance with the invention; and

Fig. 5 shows a circuit for a monostable multivibrator in accordance with the invention.

In a conventional astable or monostable multivibrator, the period may be expressed as

$$T = \frac{1}{f} = 2RC \log_e \left(\frac{E_b - E_p}{E_g} \right)$$

where R and C are the values of the grid resistors and the anode-to-grid coupling capacitors respectively, E_b is the D.-C. anode supply voltage, E_p is the anode voltage of the tubes in the multivibrator when the grid voltage is zero, and E_g is the grid voltage at which the tubes in the multivibrator conduct. From an examination of the above formula, it will be seen that the stability of the period or frequency of the multivibrator is dependent upon several factors. The values of the resistors R, the capacitors C, and the anode voltage E_b may be maintained at the constant desired levels by known methods,

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However, the characteristics of the vacuum tubes used may be different and may vary as the tubes age and it is these characteristics that determine the anode voltage E_p and the grid voltage E_g .

In Fig. 1, the anode characteristics of a conventional triode, the 12AX7 which contains two triodes in one evacuated envelope, are shown. A load line 10, obtained by assuming a D.-C. anode supply voltage E_b of 200 volts and a load resistor of 60,000 ohms, is drawn between the two extreme operating conditions. The three solid curves 11, 12, 13 represent the characteristic of a new triode for various values of control grid voltage E_g . As the characteristics of the triode change, because of aging for example, the triode has a characteristic which may be represented by the dashed curve 14. It will be noted that when the control grid voltage is zero, the characteristic of the tube for a 50% reduction in emission, represented by the dashed curve 14, is considerably different from the characteristic of a new tube, represented by the solid curve 11. This difference is a result of decreased emission of the tube as it ages, and results in a change of the period or frequency of the multivibrator.

For the load line 10 and the characteristic curve 11 when the grid voltage is zero, the anode voltage E_p may vary between 200 volts and approximately 90 volts. However, for the load line 10 and the characteristic curve 14 when the grid voltage is zero but the tube has only 50% full emission, the anode voltage E_p varies only between 200 volts and approximately 125 volts. This difference between the two ranges through which the anode voltage varies may result in a frequency deviation as high as 9%.

To eliminate such a deviation, it is desirable to maintain the voltage to which the anode falls as constant as possible. By connecting a constant voltage device, such as a gaseous discharge tube, in parallel with the anode load resistor, a more stable anode voltage variation is obtained. Such devices present an essentially constant voltage drop over a wide range of currents. Fig. 2 shows the same anode characteristics as shown in Fig. 1, and a load line 20 obtained by assuming an anode supply voltage E_b of 200 volts, a load resistor of 60,000 ohms, and an NE-16 voltage regulator tube connected in parallel with the load resistor. Since the regulator tube assumed does not begin to conduct current until a drop of approximately 80 volts is developed across it, a portion 21 of the load line 20 is similar to the load line 10 in Fig. 1. However, when the anode voltage E_p falls to approximately 120 volts, as indicated at the point 22 on the load line 20, the voltage regulator tube begins to conduct current and decreases the voltage drop across the load resistor. This is indicated by the negative resistance portion 23 of the load line 20. The voltage drop across the resistor decreases until a point 24 is reached, after which there is very little voltage change across the load resistor despite an increase in anode current. This is indicated by the portion 25 of the load line 20. In this portion 25, the anode voltage E_p remains substantially at 150 volts for values of current between 1.5 and 4 milliamperes. Thus, as long as the curves 11, 14 for a grid voltage of zero do not fall below the constant voltage point 24 of the load line 20, the anode voltage E_p will remain substantially constant. And although the negative resistance portion 23 of the load line 20 actually intersects the curve 14 representing the characteristics of the tube for a 50% reduction in emission when the grid voltage is zero, this is permissible since the grid will actually swing above zero when the tube begins to conduct, and then return to zero as the grid draws current. When the anode voltage E_p is so stabilized, the frequency deviation for a tube at 50% full emission is still low enough to be negligible.

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Referring to the formula previously given, it will be recalled that the stability of an astable or monostable multivibrator also depends upon the grid voltage E_g at which the tube conducts. Fig. 3 shows the relationship between the grid cutoff voltage E_g (or voltage E_g at which the tube conducts) and the percent of total emission of a conventional triode, the 12AX7 represented in Fig. 1. The curve 30 of the relationship is essentially linear, and it will be noted that for a 50% reduction in emission, the grid cutoff voltage E_g is approximately 0.9 volt less negative. This change in cutoff voltage E_g can be compensated for by a cathode resistor having a value equal to the change in the grid cutoff voltage E_g over a 50% reduction in emission divided by the change in the anode current over a corresponding reduction in emission. The change in the grid cutoff voltage E_g (as obtained from Fig. 3) is approximately 0.9 volt, and the change in the anode current (as obtained from the load line 20 between the two characteristic curves 11, 14 for zero grid voltage) is approximately 1.5 milliamperes. These values require a cathode resistor of approximately 600 ohms. With such a cathode resistor, the voltage difference between the control grid and the cathode will remain essentially constant for a 50% reduction in emission so that the grid voltage must still vary the same amount.

Fig. 4 shows a circuit for a free-running or astable multivibrator having stabilizing gaseous discharge tubes and a cathode resistor connected according to the previous explanation. Two triode vacuum tube electrode structures 40, 50 (which may be in separate evacuated envelopes or in the same envelope) have their cathodes 41, 51 connected together. The cathode resistor 60 has one end connected to the cathodes 41, 51 and the other end connected to a point of reference potential. A capacitor 44 is connected between the anode 42 of one tube 40 and the control grid 53 of the other tube 50. Another capacitor 54 is connected between the anode 52 of the other tube 50 and the control grid 43 of the one tube 40. The two control grids 43, 53 are connected to the point of reference potential by respective resistors 45, 55. The positive terminal of a source of D.-C. potential, designated as B+, is connected to the two anodes 42, 52 by respective load resistors 46, 56. Gaseous discharge tubes 47, 57 are connected in parallel with the load resistors 46, 56 respectively. Typical values for such a circuit are as follows:

Tubes 40, 50	12AX7
Tubes 47, 57	NE-16
Capacitors 44, 54	mmfd. 120
Grid resistors 45, 55	ohms 100,000
Load resistors 46, 56	do. 60,000
Cathode resistor 60	do. 600
B+	volts 200

A circuit constructed according to Fig. 4 and having the values specified above will have a frequency of oscillation that is stabilized to within 2% against any tube variations within reasonable limits.

Fig. 5 shows a circuit for a one-shot or monostable multivibrator according to the invention. The circuit of Fig. 5 is somewhat similar to that of Fig. 4, with like parts having the same reference numerals. However, no connection is made between the control grid 43 of the one tube 40 and the anode 52 of the other tube 50. Nor is the control grid 53 of the other tube 50 connected to the point of reference potential through a resistor. Instead, a resistor 58 is connected between the control grid 53 and the positive terminal B+. A gaseous discharge tube 47 is connected in parallel with only the anode load resistor 46 of the one tube 40, which, for a monostable multivibrator, is the normally non-conducting tube. Connecting the gaseous discharge tube 47 in the monostable multivibrator circuit gives the same frequency stability as the two gaseous discharge tubes 47, 57 in the astable multivibrator shown in Fig. 4, since there is only

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one unstable condition in a monostable multivibrator. The monostable multivibrator of Fig. 5 may be triggered by applying positive pulses to an input terminal 49 which is connected to the control grid 43 of the normally non-conducting tube 40.

The monostable multivibrator shown in Fig. 5 may be used as a frequency dividing circuit by giving the capacitor 44 connected between the anode 42 of the normally non-conducting tube 40 and the control grid 53 of the normally conducting tube 50 a value large enough to hold the normally conducting tube 50 cut off for several trigger pulses. The output for such a circuit may be derived from the anode 52 of the normally conducting tube 50. Should a constant amplitude output be desired, a gaseous discharge tube may be connected in parallel with the anode load resistor 56 of the normally conducting tube 50. However, such a tube does not increase the frequency stability as does the tube 47 connected in parallel with the anode load resistor 46 of the normally non-conducting tube 40.

What is claimed is:

1. In a multivibrator having at least one inherent frequency determining circuit therein for controlling the frequency of oscillation thereof, the combination of first and second vacuum tubes having at least an anode, a cathode, and a control grid, means interconnecting said tubes so that when one of said tubes is conducting, the other of said tubes is cut off, a load resistor connected to each anode of said vacuum tubes for applying a D.-C. potential to said anodes, a gaseous discharge tube connected directly in parallel with at least one of said load resistors over connections devoid of concentrated impedance, and a cathode resistor having one end connected to each of said cathodes and the other end connected to a point of reference potential.

2. In a multivibrator having at least one inherent frequency determining circuit therein for controlling the frequency of oscillation thereof, the combination of first and second vacuum tubes having at least an anode, a cathode, and a control grid, means interconnecting said tubes so that when one of said tubes is conducting, the other of said tubes is cut off, means for applying a D.-C. potential to said multivibrator, a first load resistor connected between said means for applying said D.-C. potential and said anode of said first vacuum tube, a gaseous discharge tube connected directly in parallel with said first load resistor over connections devoid of concentrated impedance, a second load resistor connected between said means for applying said D.-C. potential and said anode of said second vacuum tube, a gaseous discharge tube connected directly in parallel with said second load resistor over connections devoid of concentrated impedance, means connecting said cathodes together, and a common cathode resistor connected between said cathodes and a point of reference potential.

3. In an astable multivibrator, the combination of first and second vacuum tubes each having at least an anode, a cathode, and a control grid, a first capacitor connected between the anode of said first vacuum tube and the control grid of said second vacuum tube, a second capacitor connected between the anode of said second vacuum tube and the control grid of said first vacuum tube, a grid resistor connected between each of said control grids and a point of reference potential, means for applying a D.-C. potential to said multivibrator, a first load resistor connected between said means for applying said D.-C. potential and said anode of said first vacuum tube, a first gaseous discharge tube connected directly in parallel with said first load resistor over connections devoid of concentrated resistance, a second load resistor connected between said means for applying said D.-C. potential and said anode of said second vacuum tube, a second gaseous discharge tube connected directly in parallel with said second load resistor over connections devoid of concentrated resistance, means connecting said cathodes to-

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gether, and a common cathode resistor connected between said cathodes and said point of reference potential.

4. In a multivibrator having at least one inherent frequency determining circuit therein for controlling the frequency of oscillation, the combination of a normally conducting vacuum tube and a normally non-conducting vacuum tube, each of said vacuum tubes having at least an anode, a cathode, and a control grid, means interconnecting said tubes so that when one of said tubes is conducting, the other of said tubes is cut off, a load resistor connected to each anode of said vacuum tubes for applying a D.-C. potential to said anodes, a gaseous discharge tube connected in parallel with said load resistor connected to the anode of said normally non-conducting vacuum tube, said gaseous discharge tube being connected directly in parallel with said load resistor over connections devoid of concentrated impedance, and a cathode resistor having one end connected to each of said cathodes and the other end connected to a point of reference potential.

5. In a monostable multivibrator, the combination of first and second vacuum tubes each having at least an anode, a cathode, and a control grid, a first capacitor connected between the anode of said first vacuum tube

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and the control grid of said second vacuum tube, a grid resistor connected between said control grid of said first vacuum tube and a point of reference potential, means for applying a D.-C. potential to said multivibrator, a first load resistor connected between said means for applying said D.-C. potential and said anode of said first vacuum tube, a second load resistor connected between said means for applying said D.-C. potential and said anode of said second vacuum tube, a grid resistor connected between said means for applying said D.-C. potential and said control grid of said second vacuum tube, a gaseous discharge tube connected directly in parallel with said first load resistor over connections devoid of concentrated resistance, means connecting said cathodes together, and a common cathode resistor connected between said cathodes and said point of reference potential.

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