

Sept. 25, 1956

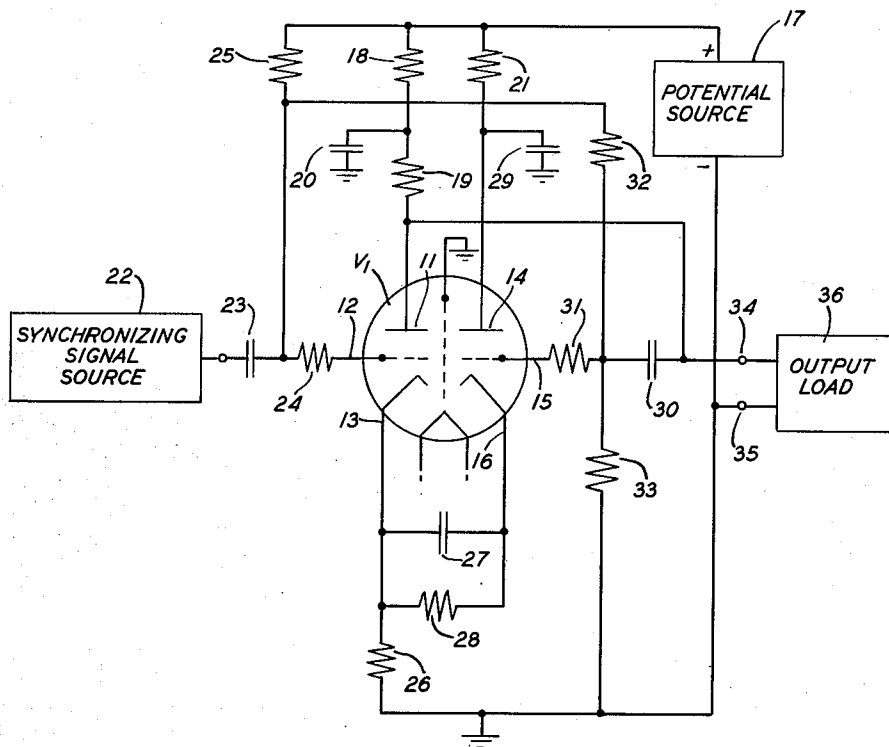
R. E. GRAHAM
MONOSTABLE MULTIVIBRATOR

2,764,677

Filed Dec. 23, 1952

2 Sheets-Sheet 1

FIG. 1



INVENTOR
R. E. GRAHAM

BY *Hugh S. Wertz*
ATTORNEY

Sept. 25, 1956

R. E. GRAHAM

2,764,677

MONOSTABLE MULTIVIBRATOR

Filed Dec. 23, 1952

2 Sheets-Sheet 2

FIG. 2A



FIG. 2B

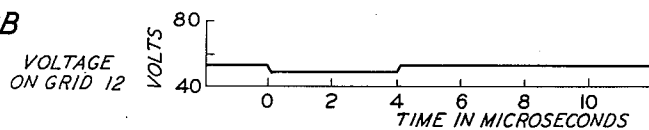


FIG. 2C

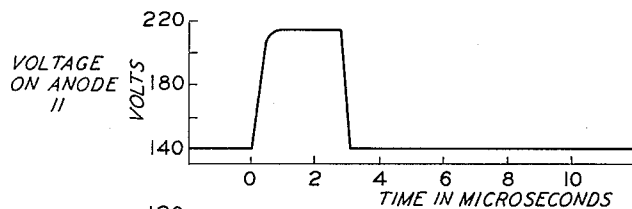


FIG. 2D

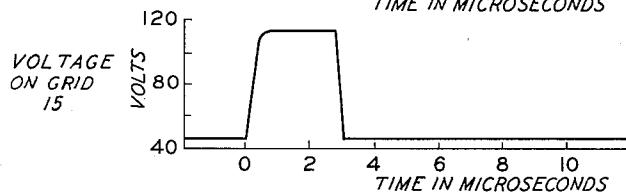


FIG. 2E

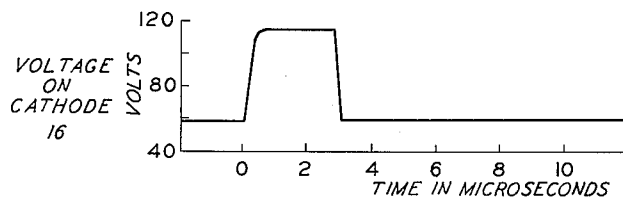
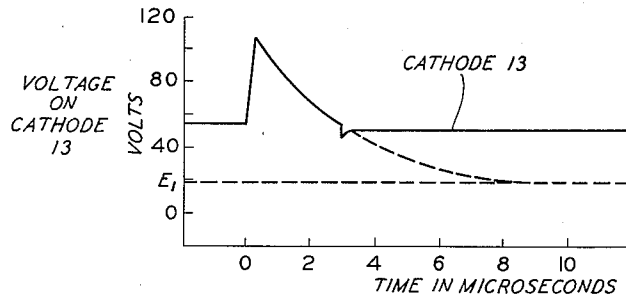


FIG. 2F



INVENTOR
R. E. GRAHAM
BY
Hugh S. Wertz
ATTORNEY

1

2,764,677

MONOSTABLE MULTIVIBRATOR

Robert E. Graham, Chatham Township, Morris County, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application December 23, 1952, Serial No. 327,611

4 Claims. (Cl. 250—27)

This invention relates to signal generator systems and more specifically to such systems of the multivibrator type which operate only in response to a triggering pulse.

In some types of electronic circuits, a signal generating system is frequently required that will, in response to an external timing or triggering pulse, provide a non-sinusoidal output pulse for a brief period. One such system, known as a monostable or "one-shot" multivibrator, includes a pair of coupled electron discharge tubes, one of which conducts only during the stable or "off" period of multivibrator and the other of which conducts only during its unstable or "on" period. The system provides an output pulse during the "on" period. The beginning of the "on" period is determined by the external triggering pulse and the duration of this period (and hence, the duration of the output pulse) is determined by the time constant of the coupling network connecting the two tubes.

It is an object of this invention to simplify and make more compact monostable multivibrators capable of providing output pulses whose duration may be of the order of microseconds or less and which can be varied over a wide range.

This invention contemplates the use of a pair of cross-coupled electron discharge devices or vacuum tubes. The coupling is (1) between the anode of one tube (called the first tube) and the grid of the other (second) tube and (2) between the cathodes of the two tubes. The cathode coupling network includes a capacitor connected between the cathodes which acts as a low impedance connection during the initial stage of the multivibrator "on" period to produce regeneration. During the remainder of this period, the cathode network serves as a timing circuit which controls the multivibrator "on" period. Unlike other monostable multivibrators of this type, the multivibrator circuit requires but two points of fixed potential throughout.

Additionally, and also unlike previously known monostable multivibrators of this general type, the grid of the second tube is biased by an internal impedance arrangement in the circuit whereby the grid is maintained at a constant potential with respect to its corresponding cathode during the "off" period irrespective of any fluctuations in the potential levels of the coupled cathodes. The biasing means provides an important advantage by insuring that the multivibrator will not be triggered into an "on" period by inopportune fluctuations of the voltage level in the cathode circuit, and further insures that the grid-to-cathode bias will always be maintained within such limits as to permit the small triggering pulse reaching the grid of the second tube to trigger it into its conductive state.

Other advantages will be apparent and the invention will be more clearly understood from the following description taken in connection with the accompanying drawings forming a part thereof, in which:

Fig. 1 is a circuit diagram of a multivibrator in accordance with the invention; and

Figs. 2A to 2F, inclusive, show voltage wave forms

2

appearing on various elements of the multivibrator circuit.

With specific reference to the drawing, there is shown in Fig. 1, as an exemplary embodiment of the invention, a multivibrator system which includes a twin triode vacuum tube VI comprising a first triode section including an anode or plate element 11, a grid element 12 and a cathode element 13, a second triode section comprising an anode or plate element 14, a grid element 15 and a cathode element 16, a heater element common to both cathode elements, and a shield. The anode 11 is connected to the positive terminal of a potential source 17 through series-connected load resistor 19 and resistor 18. A condenser 20 connected between the junction of resistors 18 and 19 and ground potential provides for decoupling the plate from the potential source. Anode 14 is connected to the positive terminal of source 17 through resistor 21. The anode 14 is connected to ground through a condenser 29.

Current is supplied to grid 12 from the positive terminal source 17 by the grid resistor 25 which is connected to the grid through the anti-sing resistor 24. Through the use of a potential dividing arrangement comprising the series connected resistors 32 and 33, one end terminal of which is connected to the junction of resistors 24 and 25, the common terminal of which is connected to grid 15 through anti-sing resistor 31 and the other end terminal of which is connected to the negative terminal of source 17, the potential between grids 12 and 15 is held substantially constant during the "off" period. It is obvious that a potentiometer may be used instead of resistors 32 and 33. Cathode 13 is connected to ground and to the negative terminal of source 17 through load resistor 26, and cathode 16 is coupled to cathode 13 and resistor 26 through a parallel-connected capacitor 27 and resistor 28. Anode 11 is coupled to grid 15 through a series-connected capacitor 30 and anti-sing resistor 31. The external timing or triggering wave from the synchronous signal source 22 is applied to grid 12 through the series-connected coupling capacitor 23 and the resistor 24. One output terminal 34 is connected to the anode 11 and the other terminal 35 is connected to the negative terminal of source 17. This output terminal pair in turn supplies an output pulse to a useful output load here represented by 36.

With reference to the mode of operation of the circuit arrangement just described, prior to the appearance of the triggering pulse in the circuit the multivibrator is "off," with the first section of tube VI conducting at approximately zero grid-to-cathode potential and the second section of the tube substantially cut-off with the cathode positive with respect to the grid. The first section of tube VI is maintained at zero grid-to-cathode potential by an appropriate choice of values for the potential source 17 and for the resistors 24, 25 and 26. Values for the resistors 18 and 19 are chosen in light of the value already given to resistor 26 so that the anode dissipation of the first section will not be exceeded. Further, the size of resistor 19 will be determined by the magnitude of the output pulse desired. The second triode section of VI is held substantially at cut-off by biasing means comprising resistors 32 and 33, and the cathode resistor 28.

When a negative timing or triggering pulse shown in Fig. 2A is applied from source 22 to the grid 12, the grid voltage drops as shown in Fig. 2B and starts cutting off the first section, thereby causing an amplified positive pulse shown in Fig. 2C to appear on the anode 11. A regenerative cycle is then initiated by two actions that take place in the circuit. The first takes place instantaneously with the initial negative swing of grid 12 in the first triode section which causes the voltage on cathode 13 to fall by cathode follower action. This sudden drop in voltage is communicated to the cathode

3

16 of the second section which causes the voltage on this cathode to also drop. At the same instant, the second (and most important) action takes place at grid 15 of the second section. The positive pulse on the anode 11 is impressed on grid 15 through coupling condenser 30 and resistor 31, thereby causing the voltage on grid 15 to rise as shown in Fig. 2D. The combined effect of these simultaneous actions on the grid and cathode of the second section is to suddenly change the grid-to-cathode bias from a cut-off level to a conducting level. Current begins to flow through the second section of the tube and, because the plate voltage of the tube is held constant by the plate decoupling condenser 29 during the timing wave interval, a cathode follower action takes place and the voltage on cathode 16 rises as shown in Fig. 2E to approximately the voltage on grid 15.

The rise in cathode voltage in the second section is communicated to cathode 13, as shown in Fig. 2F, through condenser 27, thereby tending to further reduce the current in the first triode section, increasing the magnitude of the positive pulse on anode 11, and further raising the voltage on grid 15. The gain around this regenerative loop substantially exceeds unity so that the action proceeds with great rapidity until the first triode section is cut off by having its cathode driven highly positive with respect to its grid. At the same time the second triode section becomes conducting with its grid-to-cathode potential at substantially zero.

With the triggering action completed, the circuit is in temporary equilibrium, the first triode section being cut off, the second section being conducting and a positive output pulse being supplied at the terminals 34 and 35. It becomes apparent that this temporary equilibrium condition exists only so long as the current through condenser 27 and resistor 26 maintains the cathode 13 positive with respect to the grid 12 in an amount exceeding the cut-off potential of the tube. Immediately after the triggering action is completed, the condenser 27 begins to charge and the potential of cathode 13 consequently begins to fall towards a voltage E_1 established by the voltage divider comprising resistors 26 and 28 as shown in Fig. 2F. Inasmuch as the internal impedance of cathode 16 is very small compared to the values of resistors 26 and 28, the rate of fall is determined by the parallel value of these two resistors and the cathode coupling capacitor 27.

When the voltage on cathode 13 of the first section has fallen to a value that permits the first triode section to conduct again, the triggering action is repeated in reverse. A negative pulse appears on the anode 11 of the first section which is communicated to the grid 15 of the second section thereby lowering its potential with respect to cathode 16 and tending to drive this section beyond cutoff. Cathode follower action lowers the voltage on cathode 16, which through coupling capacitor 27 further lowers the voltage on cathode 13 of the first section. This, of course, places the first section in a more stable operating condition and further tends to cut off the second triode section so that the circuit is returned to its stable state with great rapidity and the positive pulse at terminals 34 and 35 is cut off.

It is desirable that before the multivibrator is again triggered into its unstable state, the capacitor be discharged to its stable state potential. The time required to do this is determined by the value of condenser 27 and the value of resistor 28, which resistor provides a parallel discharge path across condenser 27.

The choice of values for resistors 26 and 28 in this circuit is seen to be restricted by several conditions. In the first instance, resistor 26, together with resistors 19 and 18, must limit the plate dissipation of the first triode section. Secondly, the value of resistors 26 and 28 in parallel, together with the value of condenser 27, must determine the "on" period of the multivibrator. Thirdly, the values of resistors 26 and 28 which form a voltage

4

divider must establish a voltage towards which the capacitor 27 charges that is well below the cathode voltage required to cause the first triode section to conduct. Finally, the time constant established by resistor 28 and condenser 27 must be short enough to permit the multivibrator to arrive again at its stable state so that it may be triggered when next called upon by the synchronous signal source to provide an "on" period.

The resistor 28 not only serves in the functions described above, but it also serves as one element in the biasing means for the second triode section, which biasing action we shall now consider.

One element of the biasing means is that portion of the potential divider connecting the grid circuit of the first section and the grid circuit of the second section, which potential divider comprises resistors 32 and 33. The values of the resistors are chosen so that the current in the resistors 32 and 33 is small as compared with the grid current in resistor 24 during the "off" condition, and resistor 33 is large compared with resistor 32. Another element in the biasing means is resistor 28 connecting the two cathodes by which any change in the potential of either cathode causes a similar change in the potential of the other cathode. Any change in the cathode voltage of the first section affects the grid current flow through resistor 25 which causes the grid voltage of the first section to change in magnitude and direction according to the change on the cathode voltage. This change in grid voltage in the first section is reproduced on the grid of the second section by the potential dividing arrangement thereby causing the grid-to-cathode bias of this section to be substantially constant.

To better understand this biasing action, consider the condition wherein the voltage levels of the cathodes have increased above their given values during the "off" period. There follows then a decrease in the grid-to-cathode potential in the first section which is at this time conducting, and a decrease in the grid current in this first section. Inasmuch as the resistor 25 is large compared to anti-sing resistor 24 and the internal grid-to-cathode impedance of the first section, the decrease in grid current causes the voltage drop across resistor 25 to decrease and the voltage level of the grid 12 to increase both by an amount substantially equal to the increase in the voltage level of the cathode 13. Thus, the grid-to-cathode potential of the first section remains substantially constant. With resistor 32 small as compared to resistor 33, the voltage level of the grid 15 of the second section is caused to be increased by an amount similar to that of the grid 12 of the first section and by an amount similar to that of cathode 16 so that the grid-to-cathode potential of the second section remains substantially constant. It is clear that in the case where the voltage levels of the cathodes have decreased, appropriate changes in the voltage levels of the grids will occur to maintain the grid-to-cathode potentials constant. The advantage of this arrangement is that the second triode section, which is non-conducting during this "off" period, is prevented from being tripped into a conducting state by fluctuations in the voltage levels of the cathodes and similarly there is assurance that the grid-to-cathode bias of the second section will stay relatively constant during this period and permit the pulse appearing on grid 15 of the second section to trip this section into its conductive state.

In order to decouple the pulses appearing on each anode of each tube section from the direct-current source 17, resistance-capacitance networks comprising resistor 18 and condenser 20, and resistor 21 and condenser 29 are provided. The time constants of these networks are long compared to the "on" period of the multivibrator.

Multivibrators have been built in accordance with the invention having "on" periods of three microseconds and one microsecond, respectively, and it is apparent that the circuit elements may be chosen so as to provide a multivibrator having an "on" period that may be as brief as

5

0.1 microsecond. While there are a number of possible circuit constants for the various circuit elements, values used in an operable embodiment of the multivibrator system of Fig. 1 (for a multivibrator in which the applied trigger pulse is minus 2 volts and of 4 microseconds' duration, the output pulse is 70 volts and the "on" period is of three microseconds' duration) and which are reproduced below merely by way of example are:

V ₁ -----	2C51
17-----volts--	300
18-----ohms--	6200
19-----do-----	5600
20-----micromicrofarads--	9100
21-----ohms--	4700
23-----micromicrofarads--	9100
24-----ohms--	100
25-----megohms--	0.56
26-----ohms--	3300
27-----micromicrofarads--	1000
28-----ohms--	18000
29-----micromicrofarads--	9100
30-----do-----	9100
31-----ohms--	100
32-----megohms--	0.51
33-----do-----	7.5

It is understood the above described arrangement is merely illustrative of the application of the principles of the invention. Numerous other arrangements might be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A multivibrator adapted to be connected to an input wave source comprising a first electron discharge device and a second electron discharge device, each of said devices including an anode, a cathode and a grid, means for coupling the anode of one of said devices to the grid of the other of said devices, means including a resistor and a capacitor connected in parallel to one another for coupling the cathodes of said devices, a source of potential having a negative and a positive pole, means for connecting both of said anodes to said positive pole, means including a resistor for connecting the cathode of one of said devices to said negative pole, means including a further resistor for connecting the

6

grid of one of said devices to said positive pole, potential dividing means having two external terminals and an inner terminal, means for connecting one of said external terminals to the grid of one of said devices and to the said positive potential pole, means for connecting the other of said external terminals to said negative pole, and means for connecting said inner terminal to the grid of the other of said devices to maintain said grid at a constant potential with respect to its cathode.

2. A multivibrator according to claim 1 in further combination with means for applying an input wave to the grid of one only of said devices.

3. A multivibrator according to claim 1 wherein said two poles of said potential source are the only points of fixed potential in the multivibrator circuit.

4. A monostable multivibrator adapted to be connected to an input wave source comprising a first electron discharge device and a second electron discharge device, each of said devices including an anode, a cathode and a grid, means for coupling the anode of said first device to the grid of second said device, means including a resistor and a capacitor connected in parallel to one another for coupling the cathode of said second device to the cathode of said first device, a source of potential having a positive and a negative pole, said poles being the only points of fixed potential in the multivibrator, means for connecting both of said anodes to said positive pole, means including a resistor for connecting the cathode of said first device to said negative pole, means including a further resistor for connecting the grid of said first device to said positive pole, means for applying an input wave to the grid of said first device, potential dividing means having two external terminals and an inner terminal, means for connecting one of said external terminals to the grid of said first device, means for connecting the other of said external terminals to said negative pole, and means for connecting said inner terminal to the grid of said second device.

References Cited in the file of this patent

UNITED STATES PATENTS

2,403,984	Koenig et al.	July 16, 1946
2,459,852	Summerhayes	Jan. 25, 1949
2,524,134	Palmer	Oct. 3, 1950
2,526,000	Bliss	Oct. 17, 1950