Feb. 6, 1951 G. R. FROST 2,540,478

MULTIVIBRATOR

Filed June 4, 1945

FIG. 1

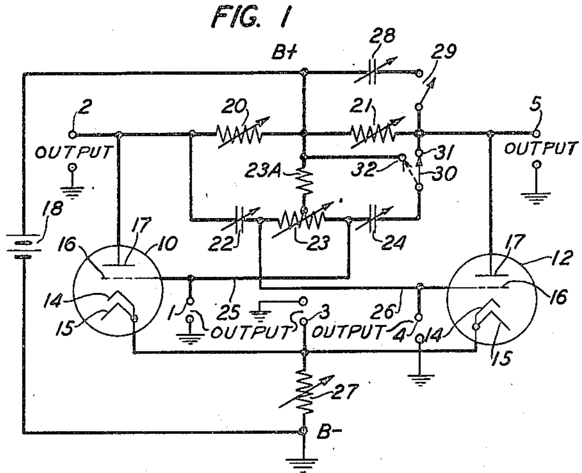

FIG. 2

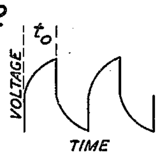

FIG. 3

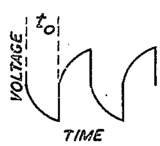

FIG. 4

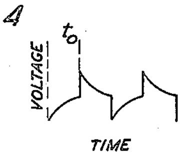

FIG. 5

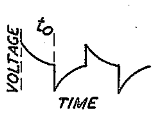

FIG. 6

FIG. 7

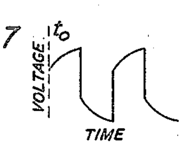

FIG. 8

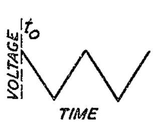

FIG. 9

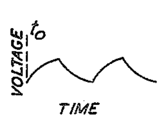

FIG. 10

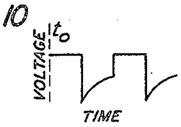

FIG. 11

FIG. 12

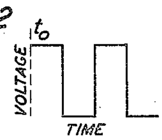

FIG. 13

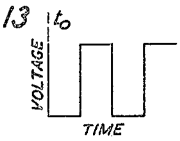

FIG. 14

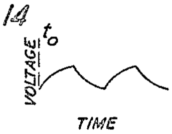

FIG. 15

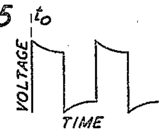

FIG. 16

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MULTIVIBRATOR

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Application June 4, 1945, Serial No. 597,463

11 Claims. (Cl. 250—36)

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This invention relates to self-oscillating generators, and particularly to multivibrator type generators.

One of the objects of this invention is to provide a simplified form of multivibrator type generator capable of generating voltage wave forms of various shapes, as square wave forms, saw-tooth wave forms and many other types of wave forms including all of the conventional types of wave forms found in various types of known multivibrators.

Another object of this invention is to provide a multivibrator type generator having a simple form of control for the frequency of vibration.

Another object of this invention is to provide a simple form of amplitude control for the output wave generated by a multivibrator type generator.

Another object of this invention is to provide switching means capable of delivering various forms of generated wave shapes to test equipment or to other associated circuits and apparatus.

For testing and other purposes, it is often desirable to have apparatus that is capable of generating various kinds of voltage wave forms among which may be certain wave forms difficult to produce. The multivibrator arrangement in accordance with the present invention is capable of producing many kinds of wave shapes and is of special interest because of the ease with which certain difficult wave forms may be directly generated. Thus, the basic circuit of this invention may be used to produce directly square type wave forms free from horns, and triangle type wave forms, and also many other types of wave forms such as upwardly extending pips, downwardly extending pips, different pips comprising upwardly extending pips alternating with downwardly extending pips, saw-tooth wave forms, half sine wave type wave forms and many others. It will be noted that a square wave may be generated directly, and without reshaping a sine wave.

In a particular arrangement, the multivibrator system in accordance with this invention may comprise a pair of vacuum or gas-filled electron tubes or space discharge devices each comprising a cathode, an anode or plate electrode and one or more grid electrodes. Suitable means including a power supply source may be provided for maintaining the anodes at a suitable positive potential in relation to the cathodes of the space discharge devices. Plate load resistors may be placed in one or both of the leads from the anodes to the positive terminal of the power supply

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source. A common cathode coupling resistor, variable from zero to a considerable value of resistance, may be provided in the lead from the cathodes of both space discharge devices to the negative terminal of the power supply source. A resistance-capacitance (R.-C.) network circuit may be provided either between the anodes of the two space discharge devices or between one of such anodes and the positive terminal of the power supply source, the network circuit referred to comprising a central resistor which is isolated by means of one or more series connected capacitors from each of the anodes, or from one of such anodes and the positive power supply terminal, according to the particular connection used for the network circuit. Connections are provided from the grid electrode of each space discharge device to different and opposite ends of the central or grid network resistor referred to, each connection being from the grid to the far end of the central resistor.

A suitable switch may be provided for connecting the network in circuit, either between the anodes of the two space discharge devices, or between one of such anodes and the positive power supply terminal, according to the particular connection desired to be used for obtaining various generated voltage wave shapes. Also a switch may be provided for bridging capacitance across one plate load resistor for the purpose of obtaining certain desired voltage wave shapes. The central network resistor may be made adjustable in resistance value for control of the frequency of vibration of the generated voltage waves, and the common cathode resistor may be made adjustable in resistance value for control of the amplitude of the voltage waves generated.

One of the network capacitors may have its capacitance made of considerably greater or larger value than that of the other, in order to provide a square wave form at the anode terminal associated with the larger capacitor referred to. Also, a grid leak resistor may or may not be used to connect the power supply positive terminal with the actual or the effective mid-point of the central network resistor or with either one of the individual grids. The output voltages may be of various wave forms and may be taken off at any point whatever in the circuit such as at the cathode, grid, or plate electrodes of either of the electron tubes.

For a clearer understanding of the nature of this invention and the additional advantages, features and objects thereof, reference is made to the following description taken in connection with the accompanying drawings, in which like reference characters represent like or similar parts and in which:

Fig. 1 is a circuit diagram illustrating a multivibrator system in accordance with this invention;

Figs. 2 to 16 are graphs illustrating examples of various forms of voltage versus time wave shapes which may be generated by the multivibrator system illustrated in Fig. 1, Fig. 8 for example illustrating a triangle wave shape form, and Figs. 12 and 13 illustrating square type wave shapes.

Referring to the drawing, Fig. 1 is a circuit diagram illustrating a self-oscillating multivibrator type generator in accordance with this invention. As shown in Fig. 1, the multivibrator may comprise a pair of suitable vacuum or gas-filled space discharge devices or multielement tubes 10 and 12, each having a cathode 14, a cathode heater 15, a grid electrode 16 and an anode or plate electrode 17. While the electronic tubes 10 and 12 are illustrated in Fig. 1 as having a single grid electrode 16 and an indirectly heated cathode 14, it will be understood that the tubes 10 and 12 may be provided in the form using directly or indirectly heated cathodes, one or more grid elements, and separate envelopes or a single envelope, and that the space discharge tubes 10 and 12 may be any suitable space discharge devices which can be alternately driven to saturation and cut off by the circuit voltages applied thereto.

Plate voltages for the space discharge devices 10 and 12 may be supplied by a battery 18 or other suitable power supply source capable of maintaining the anodes 17 of the electronic devices 10 and 12 at a suitable positive bias potential in relation to and with respect to the cathodes 14 of the space discharge tubes 10 and 12. Plate load resistors 20 and 21 may be connected in one or in both of the connection leads from the plate electrodes 17 of the electron tubes 10 and 12 to the positive terminal B+ of the plate supply source 18. The plate resistors 20 and 21 as shown in Fig. 1 are connected between the anodes 17 of the electron tubes 10 and 12 and may be made of selected resistance values for wave shaping of the output waves taken off from either of the anode output load terminals 2 and 5. The insertion or the omission or the changing of the resistance value of the resistors 20 and 21 are of any resistance in series with the power supply circuit 18 interconnecting the anodes 17 with the cathodes 14 of the space discharge tubes 10 and 12 has the effect of changing the shape of the output voltage wave. It will be noted that the plate resistors 20 and 21 may provide a plate loading function as well as a wave shaping function, and are also part of the timing circuit which determines the frequency of vibration of the multivibrator system illustrated in Fig. 1.

The timing circuit as shown in Fig. 1 also includes a resistance and capacitance or R.-C. circuit comprising the elements 22, 23 and 24 which may be connected in series circuit relation between the anodes 17 of the space discharge tubes 10 and 12 as illustrated by the contact position 31 of the switch 30 in Fig. 1, or between one of such anodes 17 and the positive terminal B+ of the anode supply source 18 as illustrated by the connection to the other contact position 32 of the switch 30 in Fig. 1. With either of these connections, as determined by the contact position of the switch 30, the R.-C. circuit comprises a central grid resistor 23 which is isolated from each of the anodes 17, or from one of such anodes 17 and the positive terminal B+ of the plate supply source 18, by means of the capacitors 22 and 24 disposed at the opposite ends of the central resistor 23. The central resistor 23 may be conveniently utilized as a simple means for control over the frequency of vibration and for that purpose its resistance value may be varied over a wide range as from 0 to 100,000 ohms for example.

A grid leak resistor 23A may be connected between the positive power supply terminal B+ and the actual or effective midpoint of the central network resistor 23. While the circuit illustrated in Fig. 1 is capable of vibrating with a stability equal to that of any resistance-capacitance type vibrator, to prevent possible external source interference blocking the free grids 16 of the space discharge devices 10 and 12, the grid leak resistor 23A having a resistance of the order of 2 to 10 megaohms value may be connected from the mid-point or from either terminal of the network resistor 23 to either plate 17 of the space discharge tubes 10 and 12 or to the power terminal B+. The grid circuit comprising the grids 16 and the resistor 23 isolated by the capacitors 22 and 24 must be well insulated from the B— supply circuit for oscillations to maintain, whether the resistor 23A is employed or not. The grid leak resistor 23A does not enter into either the frequency control or the wave shaping control when used, but serves merely as a leak to prevent blocking of the grids 16 under conditions of potential shock from external influences.

The capacitors 22 and 24 may be made of equal capacitance values with respect to each other and may be made of adjustable capacitance values to relate one to the other, to provide for different frequencies of vibration of the multivibrator, and for other purposes. Where either or both of the capacitors 22 and 24 are to be made adjustable, the variable capacitance thereof may be obtained either from one of a plurality of fixed condensers connected into the circuit separately by a suitable switch or from a single adjustable condenser unit in a known manner.

Connectors 25 and 26 may be utilized to establish separate electrical connections from the grid electrode 16 of each of the space discharge devices 10 and 12 to that end of the central resistor 23 which is adjacent the capacitor 22 or 24 associated with and connected to the anode 17 of the other of the space discharge devices 10 and 12. Thus, as shown in Fig. 1, the grid electrode 16 of the space discharge tube 10 may be connected by the connector 25 to the right-hand end of the grid resistor 23 at a point intermediate the central resistor 23 and the capacitor 24 that is connected with the anode 17 of the other space discharge tube 12; and the grid electrode 16 of the space discharge tube 12 may be connected by the connector 26 to the left-hand end of the central resistor 23 at a point intermediate the resistor 23 and the other capacitor 22 that is connected with the anode 17 of the other space discharge tube 10. It will be understood that the switch 30 may be associated with either of the capacitors 24 and 22 in cases where it is desired to provide an R.-C. circuit connection directly to the positive terminal B+ of the plate supply source 18, and to one of the anodes 17 of the electronic tubes 10 and 12, the switch 30 being utilized for connecting the circuits 22, 23 and 24 between the two anodes 17 of the space discharge devices 10 and 12, or between one of such anodes 17 and the positive lead B+ of the power supply source 18.

A common cathode resistor 27 connected at one of its ends with the cathodes 14 of both of the space discharge tubes 10 and 12 and connected at its opposite end with the negative terminal B— of the power supply source 18 provides a common cathode coupling resistance of variable value in the negative voltage lead from the power supply source 18. The resistor 27 may be of variable resistance values from a zero value to a considerable resistance values such as for example to 25,000 ohms or more. The common coupling resistor 27 provides a simple control of the signal amplitude and may contribute a modified form of wave at the junction terminal 3 of the resistor 27 with the common connection to the cathodes 14 of the space discharge tubes 10 and 12.

A shunt capacitor 28 may be bridged across one of the plate load resistors 21 by means of a switch 29 in order to provide control of the voltage wave shape produced at the adjacent output anode terminal 5. Also, it will be noted that the left and righthand plate load resistors 20 and 21 may be made adjustable for wave shaping purposes, and the variable central resistor 23 used for control of the frequency of vibration. The cathode resistor 27 may be made adjustable for control of the amplitude and for wave shaping of the cathode wave at the output terminal 3. The condenser 28 may be made adjustable for wave shaping purposes and may be shunted across either of the plate resistors 20 and 21. The output may be taken off from any of the output terminals 1 to 5, such as from the anode terminals 2 or 5, which may be coupled to a suitable amplifier by means of known capacitance and resistance coupling devices.

As a specific illustrative example, the values of the component elements of a particular multivibrator constructed in accordance with the circuit arrangement of Fig. 1 may be approximately as follows: Resistor 20=10,000 ohms, resistor 21=10,000 ohms, capacitor 22=.05 microfarad, resistor 23=0 to 100,000 ohms, capacitor 24=.05 microfarad, resistor 27=0 to 25,000 ohms, capacitor 28=1.0 microfarad, power supply source 18=approximately 300 volts, tube 10 a conventional vacuum tube such as a ½ 6SN7, a ½ 6SL7, a 6J5, a 6L6, or other suitable space discharge device, and tube 12 the same as tube 10.

It will be noted that the basic circuit illustrated in Fig. 1 comprises two space discharge tubes 10 and 12 having a common cathode connection connected with the negative power supply lead B—, one or more plate load resistors 20 and 21 connected with the positive power supply lead B+, and R.-C. network circuit comprising capacitors 22 and 24 disposed at each of the opposite ends of a central or grid resistor 23 and connected across both plate resistors 20 and 21, and a connection from the grid of each tube 10 and 12 to the far or remote end of the network central resistor 23. An examination of this circuit will disclose that a drop in potential takes place alternately at the plate terminals 2 and 5 of the plate resistors 20 and 21, the period being controlled primarily by the total values of the resistance and capacitance in the grid circuit network. The potentials of the plate electrodes 17 of the tubes 10 and 12 are therefore out of phase with respect to each other and a potential difference will therefore alternate in polarity between the anodes 17 of the two space discharge tubes 10 and 12 which alternately charges the condensers 22 and 24 to one polarity and then to the opposite polarity. During the alternate charging periods a potential difference will exist across the network resistor 23 because of the electron movement through the resistor 23 in the act of charging the capacitors 22 and 24. The potential difference is at a maximum value at the beginning of each charging period and decreases as the charging period progresses. The time constant of this network therefore controls the period of alternation of this vibrator. With the grid electrodes 16 cross-connected with the resistor 23 as shown in Fig. 1, the space discharge tubes 10 and 12 are alternately driven toward saturation and cut off by the positive and negative potentials at the opposite ends of the network resistor 23. As the condensers 22 and 24 progress in charge, the voltage drop across the network resistor 23 decreases exponentially and the grid electrodes 16 of the space discharge tubes 10 and 12 return toward zero voltage. This changing voltage on the grid electrodes 16 results in an opposite change of potential on the respective plate electrodes 17 which decreases the potential difference between the plate terminals 2 and 5 thereby diminishing the charging voltage on the condensers 22 and 24. Eventually a cross-over point is reached when the voltage on the condensers 22 and 24 equals the potential difference between the plate terminals 2 and 5, and when such cross-over point is passed, the condensers 22 and 24 will attempt to discharge. The process is repeated, with the opposite space discharge tubes 10 and 12 alternatively reaching saturation and cut off. The circuit thus vibrates at a frequency determined by the resistance and capacitance values making up the timing network 20 to 24, and the cut-off value of the particular tubes 10 and 12 that are used. The frequency of vibration is easily adjusted over a wide range by varying the value of the grid timing resistor 23.

More particularly, the operation of the circuit illustrated in Fig. 1 may be described as follows. It is assumed that the switch 30 is disposed on the contact position 31 thereby connecting the circuits 22, 23 and 24 between the anodes 17 of the two space discharge devices 10 and 12 and across the plate resistors 20 and 21. Should any slight electronic disturbance or change take place in either of the space discharge devices 10 or 12, either to raise or lower the space current through the space discharge devices 10 or 12, the voltage drop across the plate load resistors 20 and 21, or 20 or 21, will change with a resulting change in the potential of the plate or anode 17. This change in plate potential will be applied to the circuit comprising the elements 22, 23 and 24 and cause a current flow through the resistor 23, when and as the capacitors 22 and 24 change their values of charge. The effect is such that should the current flow through the space discharge device 10 be increased, the potential at its plate or anode 17 will decrease, thereby causing electron flow through the resistor 23 from the capacitor 22 towards the capacitor 24 and driving the grid electrode 16 of the space discharge tube 10 in a positive direction. At the same time, the grid electrode 16 of the other space discharge device 12 will be driven in a negative direction by the same electron flow. Through the grid action mentioned, the plate current in the space discharge device 10 will increase while the plate current in the space discharge device 12 will decrease, thus increasing the potential difference across the circuit comprising the capacitors 22 and 24 and the resistor 23. Accordingly, the electron flow through the resistor 23 is increased and the effect, being cumulative, is to rapidly drive the space discharge tube 10 to saturation and the other space discharge tube 12 to cut off. When and as the capacitor 22 and the resistor 23 cease to change their charge due to the impressed potential difference across the network 22, 23 and 24 reaching a steady state value, the electron flow through the resistor 23 diminishes and the grid electrode 16 of the space discharge tube 10 now moves in a negative direction while the grid electrode 16 of the space discharge tube 12 moves in a positive direction. Reversed action is thus instituted, and again the effect is cumulative, now driving the tube 10 toward cut off and the other tube 12 toward saturation. Thereafter, the potentials on the grid electrodes 16 of the space discharge devices 10 and 12 will be moved oppositely and the action outlined above will be repeated over and over again, the multivibrator thus becoming free running. Control over the frequency may be obtained by adjustment of the resistance value of the resistor 23, and control over the amplitude of the generated signal voltage may be obtained by adjustment of the resistance value of the common coupling resistor 27.

The operation of the circuit differs somewhat from the above description when the switch 30 is placed on the contact position 32, thus connecting the network 22, 23 and 24 between the positive power supply lead B+ and the anode 17 of one of the space discharge tubes which, as particularly illustrated in Fig. 1, is the plate electrode 17 of the space discharge tube 10. In this arrangement, the circuit action differs in that changes in the potential across the R.-C. network 22, 23 and 24 are now impressed by one plate load resistor 20, and the coupling between the space discharge devices 10 and 12 is afforded in one direction through the common coupling resistor 27. Typical values for the component elements of this circuit connection are the same as given hereinbefore. It will be understood that the invention is not restricted to any particular values as given in the illustrative example, or to the particular switching arrangement illustrated, or to the particular embodiment illustrated. It will be noted that the electron tubes 10 and 12 utilized may be of any suitable type, may be heated directly or indirectly, and may be of the single or multigrid type, and that outputs may be taken from any point in the circuit, according to the wave form desired.

The output of the multivibrator system illustrated in Fig. 1 may be taken from various points of the circuit, such as for example from any of the output terminals 1 to 5 which are separately connected with the two plate electrodes 17, the two grid electrodes 16 and the common cathodes 14 of the two space discharge devices 10 and 12. The output terminals may be any of the terminals 1 to 5, the other connection that cooperates with the terminals 1 to 5 being the ground connection, as illustrated in Fig. 1.

Figs. 2 to 16 are graphs illustrating some of the various forms of voltage versus time wave shapes which may be generated by the multivibrator circuit shown in Fig. 1, depending upon the output terminals 1 to 5 selected, and depending upon the position of the switches 29 and 30. The ordinates of the curves in Figs. 2 to 16 represent voltage values, and the abscissae represent time values.

Figs. 2 to 6 are a group of graphs illustrating five various forms of voltage wave shapes which may be generated by the multivibrator shown in Fig. 1, when the switch 30 is on the contact position 31 connecting the R.-C. circuit 22, 23 and 24 between the plate electrodes 17 of the electron tubes 10 and 12, and when the switch 29 is in open circuit position so that the capacitor 28 is not bridged across the plate load resistor 21. With such connections for the circuit shown in Fig. 1, the voltage wave forms illustrated in Figs. 2 to 6 may be taken at the various terminal points 1 to 5 of the circuit. The curve illustrated in Fig. 2 represents the voltage wave taken off from the ground connection and the anode terminal 2 which is connected with the plate electrode 17 of the tube 10, and the curve illustrated in Fig. 3 represents the form of voltage wave taken off from the ground connection and the anode terminal 5 which is connected with the plate electrode 17 of the other space discharge tube 12. The curve illustrated in Fig. 4 represents the form of voltage wave taken off from the ground connection and the grid terminal 1 which is connected with the grid electrode 16 of the tube 10, and the curve illustrated in Fig. 5 represents the form of voltage wave taken off from the ground connection and the grid terminal 4 connected with the grid electrode 16 of the other space discharge tube 12. The curve illustrated in Fig. 6 represents the form of voltage wave taken off from the ground connection and the common cathode terminal 3 connected with the common cathodes 14 of both of the space discharge tubes 10 and 12.

Figs. 7 to 11 are a group of five graphs showing the modifications in the generated voltage wave forms which occur when the shunt capacitor 28 is placed across the plate load resistor 21 by the switch 29 in its closed position, the switch 30 being, as before, on its contact position 31 which connects the R.-C. circuit 22, 23 and 24 between the plate electrodes 17 of both of the space discharge tubes 10 and 12. Figs. 7 to 11 illustrate the various types of voltage wave forms taken off from the ground connection and the output terminals 2, 5, 1, 4 and 3, respectively, and hence compare with the wave forms illustrated in Figs. 2 to 6, respectively, which are taken off from the corresponding output terminals. The difference in wave forms results from the addition of the capacitor 28 to the circuit. Thus, as illustrated in Fig. 8, an equilateral triangle type voltage wave form—instead of the form illustrated in Fig. 3—is generated at the plate terminal 5 connected with the resistor 21 and the plate electrode 17 of the tube 12 when a shunt capacitor 28 of suitable value is bridged across the plate load resistor 21; and as illustrated in Fig. 9, a capacitative triangle form of wave is obtained from the grid terminal 1, instead of the wave form shown in Fig. 4.

It will be noted that a useful wave in the form of a triangle is illustrated in Fig. 8. This wave may be generated at the anode terminal 5 in cooperation with the ground connection by the circuit of Fig. 1 when the switch 30 is on the contact position 31, when the condenser 28 of about 1 microfarad capacitance value is bridged across the resistor 21 by closure of the switch 29, and when the common cathode resistor of about 15,000 ohms resistance value is in series circuit relation between the cathodes 14 of the tubes 10 and 12 and the negative power supply terminal of the source 18. The frequency of vibration of the triangle form of wave referred to is determined by the resistance values of the resistors 20, 21 and 23 and the capacitance values of the condensers 22 and 24 and its amplitude may be controlled by the value of the cathode resistor 27. The triangular shape of the wave is determined by the bridging condenser 28. Using the same circuit which produces the triangle form of wave at the plate terminal 5 of the tube 12, a square pulse of the form illustrated in Figs. 12 and 13 may be simultaneously taken off from the ground connection and the plate terminal 2 of the tube 10 by merely making the condenser 22 of greater capacitance value than that of the condenser 24, the relative values of capacitance being roughly of the order of 10 to 1.

Figs. 12 to 16 are a group of graphs showing further modifications in the generated voltage wave forms which occur when the bridging capacitor 28 is removed and the switch 30 is now placed in its contact position 32 which connects the R.-C. circuit 22, 23 and 24 between the plate electrode 17 of the space discharge tube 10 and the B+ terminal of the power supply source 18 Figs. 12 to 16 illustrate the voltage wave forms taken off from the ground connection cooperating with the terminals 2, 5, 1, 4 and 3, respectively, and hence compare as to the output terminal sources with the curves illustrated in Figs. 2 to 6, respectively, the difference in wave forms from the same terminals resulting from a change in the position of the switch 30 from the contact 31 to the contact 31. Thus, as illustrated in Figs. 12 and 13, a useful square type wave form is obtained from either of the plate terminals 2 or 5 cooperating with the ground connection, when the R.-C. circuit 22, 23 and 24 is connected between one of the plate electrodes 17 and the B+ terminal of the power supply source 18, as illustrated in Fig. 1 by the switch 30 at the contact position 32.

While particular forms of voltage wave shapes are illustrated in Figs. 2 to 16, it will be understood that many other forms of voltage wave shapes may be generated by the multivibrator system of Fig. 1, and although this invention has been described and illustrated in relation to specific arrangements, it is to be understood that it is capable of application in other organizations and is therefore not to be limited to the particular embodiments disclosed.

What is claimed is:

1. A multivibrator for generating a voltage wave comprising two space discharge devices each having a cathode, an anode and a grid electrode, means including a power supply source having positive and negative terminals for maintaining said anodes of said devices at a positive potential with respect to said cathodes, a resistor disposed in at least one of the leads from said anodes to said positive terminal, a common cathode resistor disposed in the lead from said cathodes to said negative terminal, a network connecting said anode of one of said devices with said anode of the other of said devices, said network comprising a central resistor and capacitors connected in series circuit relation with said central resistor and disposed at each of the opposite ends of said central resistor, said central resistor being isolated from each of said anodes of said devices by said capacitors, and connectors separately connecting said grid electrode of each of said devices to the end of said central resistor adjacent said capacitor that is connected to said anode of the other of said devices, said central resistor being adjusted to a resistance value corresponding to the value of the desired frequency of vibration for said generated voltage wave, and said common cathode resistor being adjusted to a resistance value corresponding to the value of the desired amplitude for said generated voltage wave.

2. A multivibrator for generating a voltage wave comprising two space discharge devices each having a cathode, an anode and a grid electrode, means including a power supply source having positive and negative terminals for maintaining said anodes of said devices at a positive potential with respect to said cathodes, a resistor disposed in each of the leads from said anodes to said positive terminal, a common cathode resistor disposed in the lead from said cathodes to said negative terminal, a network connecting said anode of one of said devices with said anode of the other of said devices, said network comprising a central resistor and capacitors connected in series circuit relation with said central resistor and disposed at each of the opposite ends of said central resistor, said central resistor being isolated from each of said anodes of said devices by said capacitors, and connectors separately connecting said grid electrode of each of said devices to the end of said central resistor adjacent said capacitor that is connected to said anode of the other of said devices, said central resistor being adjusted to a resistance value corresponding to the value of the desired frequency of vibration for said generated voltage wave, and said common cathode resistor being adjusted to a resistance value corresponding to the value of the desired amplitude for said generated voltage wave.

3. A multivibrator for generating a voltage wave comprising two space discharge devices each having a cathode, an anode and a grid electrode, means including a power supply source having positive and negative terminals for maintaining said anodes of said devices at a positive potential with respect to said cathodes, a resistor disposed in each of the leads from said anodes to said positive terminal, a common cathode connection disposed in the lead from said cathodes to said negative terminal, a network connecting said anode of one of said devices with said anode of the other of said devices, said network comprising a central resistor and capacitors connected in series circuit relation with said central resistor and disposed at each of the opposite ends of said central resistor, said central resistor being isolated from each of said anodes of said devices by said capacitors, and connectors separately connecting said grid electrode of each of said devices to the end of said central resistor adjacent said capacitor that is connected to said anode of the other of said devices, and means for bridging a capacitor across one of said anode lead resistors.

4. A multivibrator for generating a voltage wave comprising two space discharge devices each having a cathode, an anode and a grid electrode, means including a power supply source having positive and negative terminals for maintaining said anodes of said devices at a positive potential with respect to said cathodes, a resistor disposed in each of the leads from said anodes to said positive terminal, a common cathode resistor disposed in the lead from said cathodes to said negative terminal, a network connecting said

anode of one of said devices with said anode of the other of said devices, said network comprising a central resistor and capacitors connected in series circuit relation with said central resistor and disposed at each of the opposite ends of said central resistor, said central resistor being isolated from each of said anodes of said devices by said capacitors, and connectors separately connecting said grid electrode of each of said devices to the end of said central resistor adjacent said capacitor that is connected to said anode of the other of said devices, said central resistor being adjusted to a resistance value corresponding to the value of the desired frequency of vibration for said generated voltage wave, said common cathode resistor being adjusted to a resistance value corresponding to the value of the desired amplitude for said generated voltage wave, and means for bridging a capacitor across one of said anode lead resistors.

5. A multivibrator for generating a voltage wave comprising two space discharge devices each having a cathode, an anode and a grid electrode, means including a power supply source having positive and negative terminals connected with leads for maintaining said anodes of said devices at a positive potential with respect to said cathodes, a resistor disposed in each of the leads from said anodes to said positive terminal, a common cathode resistor disposed in the lead from said cathodes to said negative terminal, a network connected across at least one of said resistors disposed in said leads from said anodes to said positive terminal, said network comprising a central resistor and capacitors connected in series circuit relation with said central resistor and disposed at each of the opposite ends of said central resistor, said central resistor being isolated from said anodes and from said positive terminal by said capacitors, a connector connecting said grid electrode of one of said devices to the end of said central resistor adjacent said capacitor that is connected to said anode of the other of said space discharge devices, a connector connecting said grid electrode of said last-mentioned space discharge device to the opposite end of said central resistor, and means for bridging a capacitor across one of said anode lead resistors.

6. A multivibrator comprising two space discharge devices each having a cathode, an anode and a grid electrode, means including a power supply source having positive and negative terminals connected with leads for maintaining said anodes of said devices at a positive potential with respect to said cathodes, a resistor disposed in at least one of the circuit leads from said anodes to said positive terminal, a common cathode coupling resistor of selected resistance value disposed in the circuit lead from said cathodes to said negative terminal, a network comprising a central resistor and a capacitor connected in series circuit relation with each of the opposite ends of said central resistor, one of said network capacitors at one end of said central resistor having a capacitance value substantially greater than the capacitance value of the other of said network capacitors at the opposite end of said central resistor, means for connecting said network from said anode of one of said devices to said anode of the other of said devices, connectors independently connecting said grid electrode of each of said devices to different and opposite ends of said central resistor, and a grid leak resistor connecting said positive terminal of said source with substantially the effective mid-point of said network central resistor.

7. A multivibrator comprising two space discharge devices each having a cathode, an anode and a grid electrode, means including a power supply source having positive and negative terminals connected with leads for maintaining said anodes of said devices at a positive potential with respect to said cathodes, a resistor disposed in at least one of the circuit leads from said anodes to said positive terminal, a common cathode coupling resistor of selected resistance value disposed in the circuit lead from said cathodes to said negative terminal, a network comprising a central resistor and a capacitor connected in series circuit relation with each of the opposite ends of said central resistor, one of said network capacitors at one end of said central resistor having a capacitance value substantially greater than the capacitance value of the other of said network capacitors at the opposite end of said central resistor, means for connecting said network from said anode of one of said devices to said anode of the other of said devices, connectors independently connecting said grid electrode of each of said devices to different and opposite ends of said central resistor, a grid leak resistor connecting said positive terminal of said source with substantially the effective mid-point of said network central resistor, and a circuit including a capacitor bridging said anode lead resistor.

8. A multivibrator for generating a triangle form of voltage wave comprising two electronic devices each having a cathode, an anode and a grid electrode, a power supply source having a positive terminal connected through resistors to said anodes of said devices and having a negative terminal connected through a common resistor to said cathodes, a network comprising a central resistor and a capacitor connected in series circuit relation with each of the opposite ends of said central resistor, means connecting said network between said anodes of said devices, and connectors separately connecting the grid electrode of each of said devices to different ends of said central resistor, and a capacitor bridging one of said anode resistors.

9. A multivibrator for generating a square type voltage wave form at one anode and a triangle type voltage wave form at the other anode comprising a pair of electronic devices each having a cathode, an anode and a grid electrode, a frequency timing and wave shaping circuit comprising parallel paths interconnecting said anodes of said devices, one of said parallel paths comprising series-connected plate load resistors and a condenser connected in shunt with one of said resistors, another of said parallel paths comprising series-connected capacitors and a central resistor disposed between said capacitors, one of said capacitors having substantially greater capacitance than the other, and a connector connecting said grid of each of said electronic devices with the end of said central resistor that is adjacent said capacitor connected to the anode of the other of said electronic devices.

10. A multivibrator for generating a voltage wave comprising a pair of electronic devices each having a cathode, an anode and a grid electrode, means including a pair of series-connected anode resistors interconnecting said anode electrodes of said pair of electronic devices, means including a

power supply source connected in series circuit relation with an adjustable common cathode resistor disposed in said series circuit leading from said cathode electrodes to the negative terminal of said source and connecting said cathode electrodes of said pair of electronic devices with said anode electrodes thereof through a connection point intermediate said series-connected anode resistors, said power supply source constituting means for maintaining said anode electrodes of said pair of electronic devices at a positive potential with respect to said cathode electrodes thereof, means comprising a network connected in shunt circuit relation with at least one of said series-connected anode resistors, said network comprising a central resistor and a capacitor connected in series circuit relation with each of the opposite ends of said central resistor, means comprising a grid-leak resistor connecting substantially the effective mid-point of said central resistor of said network with said connection point intermediate said series-connected anode resistors, means connecting the grid electrode of one of said pair of electronic devices with one end of said central resistor that is connected with the anode electrode of the other of said pair of electronic devices, means connecting the grid electrode of the other of said pair of electronic devices with the other end of said central resistor that is opposite to said one end thereof, and means comprising a condenser connected in shunt circuit relation with one of said pair of anode resistors, said central resistor constituting means for controlling the frequency of said wave generated by said multivibrator and said common cathode resistor constituting means for controlling the amplitude of said wave, and means for taking off said wave in different shapes from separate output terminals connected with said cathode, grid and anode electrodes of said pair of electronic devices.

11. A multivibrator for generating a voltage wave comprising a pair of electronic devices each having a cathode, an anode and a grid electrode, means including a pair of series-connected anode resistors interconnecting said anode electrodes of said pair of electronic devices, means including a power supply source connected in series circuit relation with an adjustable common cathode resistor disposed in said series circuit leading from said cathode electrodes to the negative terminal of said source and connecting said cathode electrodes of said pair of electronic devices with said anode electrodes thereof through a connection point intermediate said series-connected anode resistors, said power supply source constituting means for maintaining said anode electrodes of said pair of electronic devices at a positive potential with respect to said cathode electrodes thereof, means comprising a network connected in shunt circuit relation with at least one of said series-connected anode resistors, said network comprising a central resistor and a capacitor connected in series circuit relation with each of the opposite ends of said central resistor, means comprising a grid-leak resistor connecting substantially the effective mid-point of said central resistor of said network with said connection point intermediate said series-connected anode resistors, means connecting the grid electrode of one of said pair of electronic devices with one end of said central resistor that is connected with the anode electrode of the other of said pair of electronic devices, means connecting the grid electrode of the other of said pair of electronic devices with the other end of said central resistor that is opposite to said one end thereof, said central resistor constituting means for controlling the frequency of said wave generated by said multivibrator and said common cathode resistor constituting means for controlling the amplitude of said wave, and means for taking off said wave in different shapes from separate output terminals connected with said cathode, grid and anode electrodes of said pair of electronic devices.

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