

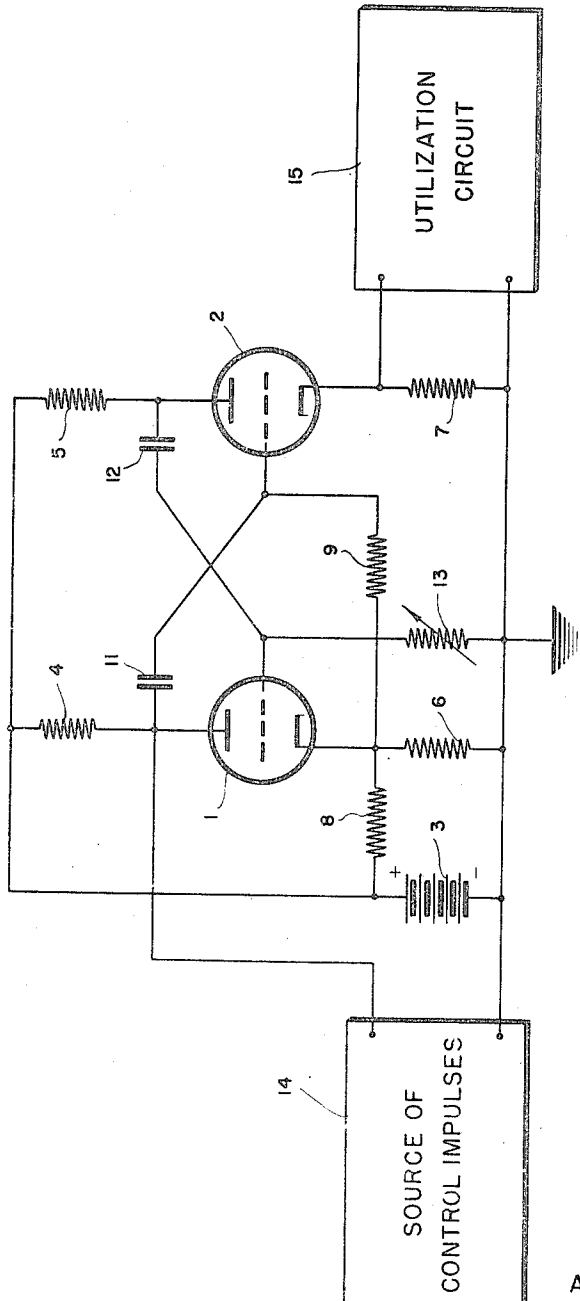
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MULTIVIBRATOR

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MULTIVIBRATOR

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1 Claim. (Cl. 250—27)

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This invention relates to impulse generators and particularly to apparatus of this character employing multivibrators.

Where it is desired to generate so-called square wave impulses it is common practice to employ some form of multivibrator. Such a device frequently is preferred for the reason that because of its nature the conduction of space current in the electronic devices employed therein is initiated and terminated substantially instantaneously, whereby there are developed across an impedance device traversed by the space current voltage waves which are rich in harmonics. These voltage waves, however, ordinarily are not true rectangular wave forms. In most of the conventional forms of multivibrators the current conduction initially increases so abruptly that the major portion of the leading edge of the impulse is substantially vertical relative to a horizontal time base. The same abrupt type of operation occurs at the termination of the conduction of space current so that the major portion of the trailing edge of the impulse also is substantially vertical with respect to a horizontal time base. However, it is well known that the space current in one of the electronic devices forming the multivibrator, just before reaching a steady state value, increases or decreases, depending upon the portion of a cycle of operation considered, at a more reduced rate. The result of this characteristic of conventional multivibrators is a rounding-off of the voltage impulse at both the leading and trailing edges thereof.

Many improvements on the basic multivibrator arrangement of a pair of electronic devices have been made to minimize this rounding-off of the leading and trailing edges of the generated impulses. The most marked improvement of this character has been made by suitable circuit design with respect to the leading edges of the generated impulses, possibly for the reason that in most applications for devices of this type it is the leading edge of an impulse which is required to control some other apparatus. At any rate, in most conventional multivibrators there is a need for steepening the trailing edges of a series of generated impulses. Such a requirement is particularly necessary where other apparatus is to be controlled with accuracy by the trailing edges of a series of generated square wave impulses.

It also is characteristic of many multivibrators known in the art that they are relatively unstable; that is, the output voltages are subject to variation as a result of slight variations occurring elsewhere in the circuit which usually are

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difficult, if not impossible sometimes, to control with accuracy. For example, voltage variations occurring in the source of space current for the tubes are reflected in the impulses generated by apparatus of this character. These are some uses of impulse generators where it is highly desirable to minimize these fluctuations of the impulses, or in other words to stabilize the operation of the impulse generator.

It, therefore, is an object of the present invention to provide a novel multivibrator whereby the generated impulses are of steeper wave form than those obtainable from prior art devices of this character.

Another object of the invention is to provide a novel multivibrator wherein the operation is stabilized so as to minimize variations in the output as a result of fluctuations elsewhere in the circuit.

In accordance with this invention, there is provided a multivibrator comprising a pair of vacuum tubes, each of which has a cathode, an anode and a control grid. The respective anodes of the tubes are cross-coupled to the respective control grids by means of condensers. There also is provided a leak circuit for each of the coupling condensers. Such an arrangement is generally that of a conventional multivibrator. This invention, however, provides additionally for the biasing of one of the tubes to a point above that of space current cut-off. The expressions "above the point of space current cut-off" and "below the point of space current cut-off" as used in the specification and claims denotes the normal space current conduction and non-conduction respectively in the tubes when the control grid-to-cathode potential is derived solely from the biasing source. In accordance with this invention the tube which is biased above the point of space current cut-off periodically is rendered non-conducting under the control of voltage derived from the other tube. When a positive control voltage derived from the other tube is impressed upon the grid of the biased tube, to initiate the conduction of space current therein, the biasing of this tube will expedite the initiation of the flow of space current therein sufficiently to materially steepen the trailing edge of an impulse developed by this biased tube. Also, there is provided a means for biasing the other of these tubes to a point below that of space current cut-off, whereby this tube normally is rendered non-conducting. The multivibrator is set into operation for one cycle by means of a

source of control impulses coupled to the multivibrator in any well known manner.

More specifically, in accordance with the illustrative embodiment of the invention disclosed herein, the grid of the tube which is biased above the point of space current cut-off is coupled by means of a resistor to the positive terminal of a source of space current for the tubes. Also, the cathode of the tube which is biased below the point of space current cut-off is coupled by means of a resistor to the positive terminal of the space current source. Further, in accordance with the instant invention, the control grid of the tube which is biased above the point of space current cut-off is connected by means of a resistor to the cathode of the other tube. By means of this connection there is in effect established a negative feed-back to the tube which is biased above the space current cut-off point. The effect of this negative feed-back is to stabilize the operation of the device, whereby the impulses developed are of relatively constant voltage, irrespective of voltage or other variations occurring in other portions of the multivibrator circuit.

For a better understanding of the invention, together with other and further objects thereof, reference is had to the following description, taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claim.

The single figure of the accompanying drawing is a schematic circuit arrangement of a multivibrator embodying the present invention.

Having reference now to the drawing, there are shown two vacuum tubes 1 and 2, comprising the electronic devices of the multivibrator. Each of the tubes is provided with at least a cathode, an anode and a control grid. Space current for the tubes is provided from a suitable source such as a battery 3, the negative terminal of which is connected to ground and the positive terminal of which is connected through load resistors 4 and 5 to the anodes of tubes 1 and 2, respectively. The cathodes of tubes 1 and 2 are connected through respective resistors 6 and 7 to the grounded negative terminal of the battery 3.

The tube 1 is biased to a point below that of space current cut-off by means of the connection of the cathode thereof through a resistor 8 to the positive terminal of the battery 3. Also, the tube 2 is biased to a point above that of space current cut-off by means of the connection of the control grid thereof through a resistor 9 to a source of positive potential. The resistor 9 may be connected for this purpose to the cathode of the tube 1 or, if desired, the resistor 9 of suitably higher value may be connected directly to the positive terminal of the battery 3 or any other source of potential which is of positive polarity relative to the cathode of tube 2.

The anode of tube 1 is coupled by a condenser 11 to the control grid of the tube 2. In like manner the anode of tube 2 is coupled by a condenser 12 to the control grid of tube 1. A leak circuit for the coupling condenser 11 includes the resistor 9. A leak circuit for the coupling condenser 12 comprises a variable resistor 13 connected between the control grid of tube 1 and ground.

The operation of the multivibrator is controlled by a series of control impulses derived from a source 14 which is coupled to the anode of tube 1. The impulses generated by this apparatus are

developed in the resistor 7 which may be coupled in any suitable manner to any desired utilization circuit 15.

Referring now to the operation of the multivibrator embodying this invention, it will be assumed initially that steady state conditions exist. By reason of the positive biasing of the control grid of tube 2 by means of the coupling thereof to the positive terminal of the battery 3, this tube is in condition for the conduction of space current. Accordingly, there is a voltage which is positive with respect to ground developed in the cathode resistor 7 for impression upon the utilization circuit. Also, the positive potential of the anode of this tube relative to ground is depressed below the voltage of the battery 3 by reason of the voltage drop in the resistor 5 produced by the traversal thereof by the space current. If it be assumed that this condition of the apparatus exists for a sufficient time to allow the charge on the coupling condenser 12 produced by the depressed anode voltage of the tube 2 to leak off through the resistor 13, then the potential impressed upon the control grid of tube 1 is substantially zero. However, by reason of the positive biasing of the cathode of tube 1 by means of the connection thereof to the positive terminal of the battery 3, this tube is biased to a point below that of space current cut-off. Therefore, the tube 1 is in a non-conducting state. As a consequence, the potential of the anode of tube 1 is substantially equal to the voltage of the battery 3.

If now an impulse of negative polarity derived from the source 14 is impressed upon the anode of tube 1 and, by means of the coupling condenser 11, also upon the control grid of tube 2, and if this impulse is of a suitable magnitude to at least partially overcome the positive bias of the control grid of tube 2, the termination of the conduction of space current in this tube is initiated. As a consequence, the potential of the anode of tube 2 starts to increase and, by means of the coupling condenser 12, this increase in a positive sense of the anode voltage of tube 2 is impressed upon the control grid of tube 1. In this manner the bias of the tube 1 is overcome and the conduction of space current is initiated in the tube. In a manner well known in the multivibrator art the anode potential of the tube 1 is depressed as a result of the voltage drop in the resistor 4 produced by the traversal thereof by the space current and this depressed voltage also is impressed by the coupling condenser 11 upon the control grid of tube 2 to still further reduce the flow of space current therein. As a result, the conduction of space current in the tube 2 is terminated and the conduction of space current in tube 1 is initiated substantially instantaneously. Thus the voltage developed in the resistor 7 decreases to zero to generate the leading edge of a negative impulse for impression upon the utilization circuit 15.

This condition of the apparatus exists until the charge on the coupling condenser 12 has leaked off through the resistor 13 sufficiently for the bias of tube 1 to become effective again to initiate the termination of the conduction of space current in this tube. The potential of the anode of tube 1 then increases in a positive sense and, by means of the coupling condenser 11, is impressed upon the control grid of tube 2 to again initiate the conduction of space current in this tube. The space current of tube 2 develops a voltage in the resistor 7 to generate the trailing

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edge of the negative impulse impressed upon the utilization circuit 15. The reversal of the current conducting conditions of the respective tubes again occurs in a relatively short time. The described cycle of operation is repeated upon the impression of another one of the control impulses derived from the source 1 upon the apparatus in the manner described.

The impulses generated by this apparatus operating in the manner described are of negative polarity as developed in the resistor 7. The leading edges of the impulses are developed when the conduction of space current in the tube 2 is terminated. The trailing edges of the impulses are developed by the initiation of the conduction of space current in this tube. The width or time durations of these impulses then are determined by the time during which the tube 2 is maintained in a non-conducting state. This condition in turn is determined by the time required for the positive charge of the coupling condenser 12 to leak off through the resistor 13 sufficiently to permit the biasing of tube 1 to terminate the conduction of space current in this tube. Therefore, the widths or time durations of the impulses developed in the resistor 7 may be varied by effecting a suitable adjustment of the variable resistor 13. The time constant of the circuit including this resistor and the coupling condenser 12 thereby may be changed to effect a corresponding variation in the time required for the condenser charge to leak off sufficiently to render the tube 1 non-conducting.

As is well known to those acquainted with the performance of conventional multivibrators, the initiation of space current in one of the electronic devices such as the tube 2 occurs substantially instantaneously until the magnitude of the space current approaches its steady state condition. The wave form of the voltage produced by the initiation of the conduction of space current in one of the tubes, consequently, is somewhat rounded off. In other words, the current does not rise abruptly from one steady state value to another and level off at this other value immediately to produce a sharp wave form.

In accordance with the instant invention, however, the positive biasing of the control grid of tube 2 effects a material improvement in the wave form of the voltage developed in the resistor 7. One explanation for this which at present appears to be a plausible theory of operation of a device such as that disclosed embodying the invention is offered herewith. Assume that the tube 1 is conditioned for the conduction of space current and that tube 2 is conditioned for the non-conduction of space current. Under these conditions a positive potential is impressed upon the control grid of tube 1 which in time leaks off through the resistor 13 as described. As the point of space current cut-off in the tube 1 is approached, taking into consideration the positive cathode biasing of this tube in addition to the positive voltage impressed upon the control grid, there is effected a decrease in the magnitude of the space current conducted in this tube. The anode of tube 1 and also the control grid of tube 2 increase in positive potential to initiate the conduction of space current in tube 2. Thereupon, the potential of the anode of tube 2 is depressed in a negative sense to drive the control grid of tube 1 still further negative. As a result, the potential of the anode of tube 1 increases at a more rapid rate in a positive sense and the whole action of the device is accumula-

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tive as in all such devices so that the various potential changes occur at greatly increased rates. The increase in the positive potential of the control grid of tube 2, as a result of the termination of the conduction of space current in tube 1, has the effect as in conventional apparatus of this character to effect a substantially instantaneous increase in the space current of tube 2 approximately to its maximum steady state value. However, in the present instance the control grid of tube 2 not only is influenced by the potential derived from the anode of tube 1 in effecting the initiation of space current conduction therein, but it also is subjected to the influence of the positive biasing voltage derived through the resistor 9 from the battery 3. It is considered that the additional aid furnished by the positive biasing potential for the control grid of tube 2 is the means whereby the conduction of space current in the tube 2 is increased from zero to substantially its maximum value without gradually leveling off to the maximum value as in prior art multivibrators. As a consequence, the wave form of the impulsive voltage developed in the resistor 7 is materially improved by the steepening of its trailing edge. It is to be understood that even though the foregoing explanation is not the correct one to describe the operation of the multivibrator in accordance with this invention, it has been conclusively demonstrated that the increase in the conduction of space current in the tube 2 is much faster when the control grid of this tube is provided with a positive bias than it is without this bias.

Another decided improvement in the operation of a multivibrator in accordance with the present invention results from the conductive coupling by means of resistor 9 of the control grid of tube 2 and the cathode of tube 1. By means of this circuit, together with the capacitive coupling of the anode of tube 2 to the control grid of tube 1, there is provided in effect a negative feedback to tube 2. This negative feedback increases the stability of the device in much the same manner as the stability of an amplifier is improved by the use of negative feedback. Consequently, the gain or amplification factor of the tube 2 may vary over a considerable range for any of a number of reasons, such as a variation in the voltage of the battery 3, without effecting the reflection of such variations in the impulsive voltage developed in the cathode resistor 7.

It also has been found that, when apparatus arranged substantially as illustrated and described herein and consisting of circuit components having the values as set forth hereinafter, an impulsive voltage of the order of 50 volts may be obtained with considerable facility from the resistor 7 when employing a source of space current, such as the battery 3 of approximately 300 volts.

Vacuum tubes 1 and 2	6C4
Battery 3	volts-- 300
Resistors 4 and 5	ohms-- 15,000
Resistor 6	do-- 10,000
Resistor 7	do-- 2,200
Resistor 8	do-- 100,000
Resistor 9	do-- 39,000
Condenser 11	microfarads-- 0.01
Condenser 12	do-- 200
Variable resistor 13	ohms-- 156,000

While there has been described what, at present, is considered the preferred embodiment of the invention, it will be obvious to those skilled

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in the art that various changes and modifications may be made therein without departing from the invention, and therefore, it is aimed in the appended claim to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

A multivibrator comprising, first and second vacuum tubes, each having a cathode, an anode and a control grid, respective condensers coupled between the anodes of each of said tubes and the control grids of the other of said tubes, a source of space current for said tubes having its positive terminal coupled to the anodes of said tubes, respective resistors coupled between the cathodes of said tubes and the negative terminal of said source of space current, a leak resistor for one of said condensers coupled between the control grid of said first vacuum tube and the negative terminal of said source of space current, a leak resistor for the other of said condensers connected between the control grid of said second tube and the cathode of said first tube, a resistor coupled between the cathode of said first tube and the positive terminal of said source of space

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current, a source of control signals of negative polarity coupled to the anode of said first tube, and a utilization circuit coupled to the cathode-connected resistor of said second tube.

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