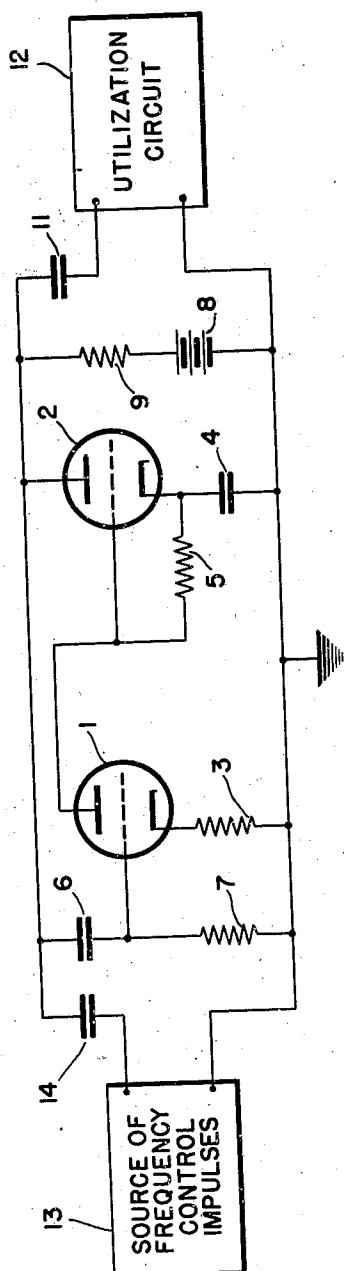


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MULTIVIBRATOR
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MULTIVIBRATOR

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This invention relates to oscillation generators and particularly to multivibrators.

In accordance with conventional practice, multivibrators frequently are used to generate alternating current waves which are rich in harmonics of the fundamental frequency of oscillation. For this reason this type of oscillator is preferred to sinusoidal wave oscillation generators for numerous uses. It ordinarily is easier to control the frequency of a multivibrator from an external exciting source than it is to control similarly the oscillation frequency of a sine wave oscillator. Multivibrators also lend themselves readily for frequency multiplication and division applications.

As is well known in the art however, a multivibrator employs at least two electronic elements. The drain on an energy source for the supply of space current thereto, therefore, is of considerable magnitude. Furthermore, the output circuit energy ordinarily is derived from only one of the electronic devices. As a result, the increased current supplied to the multivibrator is utilized at a relatively low efficiency.

It is an object of the present invention, therefore, to provide an improved multivibrator wherein the number of circuit components required is less than that previously needed and wherein the space current drain on an energy source is appreciably less than in devices of this character known to the prior art.

In accordance with the invention there is provided a pair of vacuum tubes, each of which has a space discharge path. A condenser is connected to these tubes in such a manner that it is charged by the flow of current through one of the space discharge paths and is discharged through the other space discharge path. In addition, there is provided means for rendering the space discharge paths conducting and non-conducting in alternation. By reason of this arrangement, the major portion of the space current for the tube employed to discharge the condenser is supplied from the condenser.

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 claims.

The single figure of the drawing is a schematic circuit diagram of a multivibrator embodying the instant invention.

Having reference now to the drawing, there is shown a pair of vacuum tubes 1 and 2, each of

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which is provided with an anode, a cathode and a control grid. If desired, the two tubes may be included in the same envelope, in which case the double triode tube may be a 6SN7 type or its equivalent. A resistor 3 may be connected between the cathode of the tube 1 and ground, although this resistor is not absolutely essential for the operation of the device. Its primary function is to limit additionally the magnitude of the space current supplied to this tube. An energy storage condenser 4 is connected between the cathode of the tube 2 and ground. A leak resistor 5 for the storage condenser is connected between the cathode electrode of the condenser and the anode of the tube 1. This anode also is conductively connected to the grid of the tube 2. The anode of tube 2 is coupled to the grid of tube 1 by a coupling condenser 6. A leak resistor 7 for this condenser is connected between the grid electrode thereof and ground. Space current for the multivibrator is derived from a source of unidirectional energy, such as a battery 8. The negative terminal of this battery is connected to ground and the positive terminal thereof is connected through a current limiting resistor 9 to the anode of tube 2.

The output energy of the device is derived from the anode of tube 2. The output circuit of the tube 2 is coupled by means of a condenser 11 to any desired utilization circuit 12.

A source of frequency control impulses 13 is coupled by a condenser 14 to the anode of tube 2. This facility is provided to control the frequency of the energy developed by the multivibrator in the desired manner.

Referring now to the operation of the multivibrator, assume that it is operating in a free running manner, not subject to external frequency control. Assume the cycle of operation to start at the instant that the tube 2 is rendered conducting. Characteristically of multivibrators, the tube 1 at this instant is rendered non-conducting in a manner to be described presently. At this same instant space current, therefore, flows from the battery 8 through the space discharge path of the tube 2 and the storage condenser 4. In this manner the storage condenser becomes charged so that its cathode connected electrode is raised to a substantial positive potential with respect to ground.

Just prior to the instant assumed as the starting point of the cycle of operation, the coupling condenser 6 is charged to an appreciable positive potential by reason of its connection to the anode of the tube 2, which during the non-conducting

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state of this tube is at its maximum positive potential. As the conduction of space current in the tube 2 increases, the anode voltage of this tube becomes less positive. The result is that the coupling condenser 6 becomes negatively charged and thereby depresses the grid voltage of the tube 1 below the space current cutoff value thereof. Consequently, the conduction of space current in this tube is interrupted as abruptly as space current conduction in the tube 2 is initiated.

While the tube 2 is conducting to charge the storage condenser 4, the negative charge on the coupling condenser 6 is dissipated through the resistor 7. In this manner the voltage of the control grid of tube 1 gradually approaches the cutoff value which, when reached, initiates the conduction of space current again in this tube. At the very beginning of the space current flow in tube 1, the current is derived from the battery 8 which flows through the space discharge path of tube 2 and the leak resistor 5 to the anode of tube 1. The potential of this electrode, therefore, is rendered less positive than in the preceding instant. As a consequence, the grid voltage of the tube 2 also is rendered less positive, whereby to decrease the magnitude of the space current flowing through this tube. The anode voltage of the tube 2 increases in positive value as a consequence of the decrease of space current flow in the tube. This increased positive voltage is impressed upon the grid of tube 1 by the coupling condenser 6 to increase still further the conduction of space current in this tube. This process continues very rapidly in a manner well known in the art relating to multivibrators. Ultimately, space current conduction in tube 1 is at a maximum and space current conduction in tube 2 is completely interrupted. Tube 1, however, continues to conduct for an additional period. Space current is supplied during this interval from the energy stored in the condenser 4. The rate at which this energy is dissipated is determined chiefly by the time constant of the condenser and the leak resistor 5.

The space current derived from the storage condenser 4 decays at the well known exponential rate determined by the time constant of the discharge circuit. So long as the current flow through the leak resistor 5 is appreciable there is developed across the terminals of this resistor a voltage of sufficient magnitude to maintain the grid voltage of tube 2 sufficiently negative with respect to its associated cathode to prevent the conduction of space current in this tube. Ultimately, however, the space current for tube 1, derived from the storage condenser 4, diminishes to such a relatively small magnitude that the voltage developed across the leak resistor 5 is no longer sufficient to maintain the tube 2 in a non-conducting state. As soon as conduction of space current is initiated in this tube, the potential of the anode thereof, and consequently that of the grid of tube 1, is depressed below the cutoff value for space current flow in tube 1, whereby space current conduction in tube 1 is interrupted completely, and the described cycle of operation is repeated.

The natural period of oscillation of the multivibrator in accordance with this invention preferably is determined principally by the values of the energy storage condenser 4 and the leak resistor 7. By reason of the novel circuit structure in accordance with this invention, however, it is possible, if desired, to determine the free

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oscillation frequency of the multivibrator in a somewhat different manner.

Suppose, for example, for a given value of the coupling condenser 6 the leak resistor provided therefore has a relatively large value. The time constant of this circuit, therefore, also is relatively large. Suppose, also, in such a case that the value of the energy storage condenser 4 is relatively small so that the time constant of both the charging and discharging circuits therefor is small in comparison with the time constant of the circuit including the condenser 6 and the resistor 7. The charging of the condenser 4 during the conducting period of tube 2 will require less time than is required for the negative charge of condenser 6 to decay through the leak resistor 7 sufficiently to raise the voltage of the control grid of tube 1 to the space current cutoff value. Since, at this time the condenser 4 is completely charged, there no longer is a current flow through the space discharge path of the tube 1. Consequently, the anode voltage of this tube is increased to its maximum positive value and this voltage is impressed by the coupling condenser 6 upon the control grid of the tube 1 to render it conducting. Conduction continues in this tube as in the case previously described until the voltage developed across the resistor 5 reaches the grid voltage cutoff value for the tube 2. At this time conduction again is initiated in tube 2 and the cycle of operation is repeated as described. It is seen, therefore, that the initiation of conduction of space current in each of the vacuum tubes is directly under the control of the energy storage condenser 4.

If, on the other hand, the leak resistor 7 is made relatively small and the storage condenser 4 relatively large to make the time constants of the respective circuits, including the condensers 6 and 4 relatively small and large respectively, the operation of the multivibrator is substantially in accordance with that initially described. In such a case the initiation of the conduction of space current in the tube 1 is dependent upon the circuit, including the condenser 6 and the resistor 7, and the initiation of the conduction of space current in the tube 2 is dependent upon the time constant of the circuit including the condenser 4.

Where it is desired to maintain the multivibrator frequency in a predetermined relationship to another frequency source, impulses of suitable polarity and amplitude derived from an external frequency source such as 13 may be impressed upon the anode of the tube 2. Where the external source of impulses is of substantially the same frequency as the natural frequency of the multivibrator the operation of the latter is synchronized every cycle in a well known manner.

Characteristically of most multivibrators, the one according to the present invention is susceptible of external control in a manner to effect multiplication or division of an external exciting frequency. In the case where frequency division is desired, the control or exciting impulses derived from the source 13 have a periodicity which is an approximate multiple of the natural periodicity of the multivibrator. In such a case the amplitude of the control impulses is chosen so that only those occurring at substantially the multivibrator periodicity are effective to control the multivibrator operation. In this case, also, the multivibrator is subjected to control once in each cycle of its operation.

Where frequency multiplication is desired the

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control impulses are impressed upon the multivibrator only at the periodicity of the relatively low frequency to be multiplied. In this case the frequency control of the multivibrator is effected only during those cycles of its operation which are a multiple of the control frequency.

Apparatus in accordance with this invention has been operated satisfactorily to generate substantially rectangular impulses at a natural or free running frequency of 1200 cycles per second with the following values of circuit constants. The total current drain from the source of unidirectional energy is approximately 0.75 milliamperes.

Tubes 1 and 2	6SN7
Resistor 3	10,000 ohms
Condenser 4	0.05 microfarad
Resistor 5	5600 ohms
Condenser 6	2500 micro-microfarads
Resistor 7	560,000 ohms
Battery 8	325 volts
Resistor 9	10,000 ohms

It is apparent from the foregoing description of one apparatus embodying the invention that there is provided a multivibrator having fewer components than those known to the prior art. Such apparatus, therefore, may be more compactly mounted than heretofore. Additionally, it is seen that the current drain by such a multivibrator is considerably reduced. Furthermore, a substantial increase in the percentage of the total current drain is effected, whereby a more efficient use of the supplied energy is made.

While there has been described what, at present, is considered the preferred embodiment of the invention, it will be obvious to those skilled 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 claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A multivibrator comprising, first and second vacuum tubes, each having an anode, a cathode and a control grid, means including a source of direct current energy for supplying space current to said first tube, means including the space discharge path of said first tube and a storage condenser connected to the cathode of said first

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tube for supplying all of the space current to said second tube, a capacitative coupling between the anode of said first tube and the grid of said second tube, and a conductive coupling between the anode of said second tube and the grid of said first tube.

2. A multivibrator comprising, a first vacuum tube having an anode, a cathode and a control grid, a source of direct current energy having one terminal connected to said first tube anode, an energy storage condenser connected between said first tube cathode and the other terminal of said source of direct current energy, a second vacuum tube having an anode, a cathode and a control grid, a resistor connected between said storage condenser and the anode of said second tube, a coupling condenser connected between the grid of said second tube and the anode of said first tube, and a connection between the grid of said first tube and said resistor.

3. A multivibrator comprising, a first vacuum tube having an anode, a cathode and a control grid, a space current supply circuit for said first vacuum tube including a source of direct current energy having its positive terminal connected to said first tube anode, a second vacuum tube having an anode, a cathode and a control grid, a space current supply circuit for said second vacuum tube including an energy storage condenser connected between said first tube cathode and the negative terminal of said source of direct current energy and a resistor connected between the grid and cathode of said first tube, a coupling condenser connected between the grid of said second tube and the anode of said first tube, and a conductive coupling between the grid of said first tube and the anode of said second tube.

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