

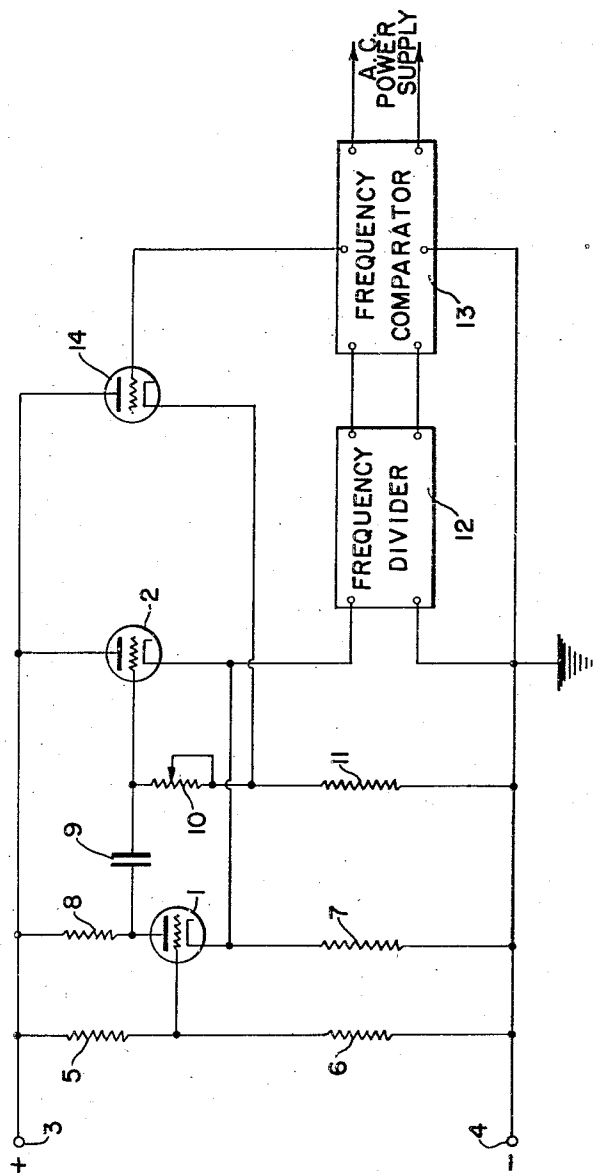
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AUTOMATIC FREQUENCY CONTROL APPARATUS

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AUTOMATIC FREQUENCY CONTROL
APPARATUS

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1 Claim. (Cl. 250—36)

This invention relates to automatic frequency control apparatus and particularly to such apparatus used in conjunction with the relatively high frequency oscillator of a television timer.

According to conventional television practice it is customary to employ timer apparatus for definitely correlating the frequency of the synchronizing signals with a source of standardizing frequency such as a commercial alternating current power supply. The timer apparatus includes a high audio frequency oscillator and a timer chain or frequency divider by means of which the oscillations of twice horizontal scanning frequency (where interlaced scanning is employed) are converted into control impulses at the frequency of the standardizing source.

In order to control the frequency of the oscillation generator so that the frequency of the oscillations is related at all times to a standardizing frequency there also are derived from the frequency divider relatively low frequency impulses which are compared with impulses of substantially the same frequency derived from the standardizing source. Any deviation of the frequency of these impulses is detected and a control voltage is generated representative of the deviation. The control voltage is utilized to adjust the frequency of the oscillator to restore it to the desired relationship with the standardizing frequency.

A conventional form of oscillator generally is one which generates a sinusoidal wave. Such a wave is employed to control the operation of the frequency divider whereby sub-multiple frequencies of the oscillator frequency are derived for synchronizing the frequency of the scanning generators.

As is well understood in the art, however, a sinusoidal wave is not particularly well adapted for the control of the usual type of frequency divider for the reason that it does not possess a wave form which is sufficiently steep to operate the frequency divider in the most accurate manner. An oscillator of the multivibrator type is better suited for this purpose since the voltage impulse generated thereby is one which has a very steep leading edge. In one of the simpler forms of multivibrator, the frequency control circuit is of relatively low impedance. Usually the impedance of the circuit in which the frequency control voltage is developed is relatively high.

An object of the present invention therefore, is to provide a means for impressing a frequency control voltage derived from a relatively high impedance circuit upon a relatively low imped-

ance frequency-determining circuit of a multivibrator type of oscillator.

In accordance with the present invention, there is provided an arrangement of electronic devices for generating periodic impulses having steep wave fronts and in which the impulsive voltage is derived from a relatively low impedance device connected in the cathode circuits of the electronic devices. The periodicity of the impulses is relatively high. These impulses are applied to a chain of electronic devices commonly known as a timer chain or frequency divider whereby substantially any sub-multiple frequency of the generated frequency may be derived. One of these sub-multiple frequencies corresponds to the frequency of the commercial source of alternating current power which is converted to supply direct current energy to the television transmitting apparatus. A series of impulses is derived from the alternating current power supply at the frequency of the supply. These impulses are compared by a frequency comparator with similar impulses of substantially the same frequency derived from the frequency divider. A difference in frequency produces a control voltage. The polarity of this voltage is determined by the sense of the deviation of the oscillator derived impulses with respect to the power supply impulses, and the magnitude of the control voltage is determined by the amount of the frequency deviation.

This control voltage is developed in a circuit of relatively high impedance and is impressed upon the input circuit of an electronic device having a relatively low impedance device connected in the cathode circuit thereof. The voltage developed in the cathode circuit impedance device corresponds to the voltage applied to the control grid of the tube. The cathode impedance potential is impressed upon the low impedance frequency control circuit of the high frequency impulse generator, whereby to alter the frequency thereof in sense and magnitude corresponding to the product of the frequency comparison.

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.

In the accompanying drawing, the single figure is a circuit diagram of a high audio frequency generator embodying the instant invention.

Having reference to the drawing, there is shown a high frequency impulse generator of the multi-

vibrator type which includes two electronic devices 1 and 2. These devices are both illustrated as triodes but in practice they may be combined in a single envelope tube of the twin triode type. Direct current power supply for the apparatus is obtained from terminals 3 and 4. The direct current may be supplied by rectifying, in a conventional manner, alternating current derived from a commercial power supply. The control grid of the tube 1 is connected to the junction point of two series resistors 5 and 6, connected to the positive and negative direct current terminals 3 and 4, respectively. The cathodes of both tubes 1 and 2 are connected to the negative direct current terminal 4 through a relatively small resistor 7. The anode of the tube 1 is connected through a resistor 8 to the positive direct current terminal 3.

The anode of tube 1 is coupled to the control grid of tube 2 by a condenser 9. The junction point between the condenser and the control grid of the tube 2 is connected through an adjustable leak resistor or potentiometer 10 and a relatively small resistor 11 to the negative direct current terminal. The anode of the tube 2 is connected directly to the positive direct current terminal.

The voltages developed in the resistor 7 are applied to a frequency divider 12 which functions under the control of these voltages to produce voltages having frequencies which are sub-multiples of the frequency of the voltage developed in the resistor 7. The sub-multiple frequency corresponding to the frequency of the alternating current power supply is applied to a frequency comparator 13. There also is applied to the comparator, impulses derived from the alternating current power supply. The voltage which is the result of the comparison made by the frequency comparator 13 is impressed upon the input circuit of a frequency control tube 14. The input circuit of this tube includes the control grid and cathode electrodes thereof and the resistor 11. The anode of the tube 14 is connected directly to the positive direct current terminal so that the output load circuit includes, externally of the tube, only the resistor 11. This tube thus functions as a cathode follower.

Referring now to the operation of the apparatus embodying the instant invention, attention will be directed first to the functioning of the high frequency generator without referring to the frequency control apparatus. Assume that the condenser 9 is charged to a potential approaching the direct current potential of the terminals 3 and 4. By reason of the condenser charge, the control grid of the tube 2 is highly negative with respect to its associated cathode. Space current in this tube, therefore, is cut off. At this time assume also that the tube 1 is rendered conducting. Then the anode of this tube is at a less positive potential than that of the direct current terminal 3 by reason of the current flow in the resistor 8.

By reason of the reduced positive potential of the anode of tube 1 the charge on the condenser 9 is gradually dissipated through the potentiometer 10. As the charge is dissipated the potential of the control grid with respect to the associated cathode of tube 2 is made less negative. When the condenser discharge has progressed to the point where the grid-to-cathode potential of the tube 2 is at the point of anode-to-cathode current cutoff, the tube 2 is on the threshold between its nonconducting and its conducting state. A further incremental discharge of the condenser raises the grid potential of tube 2 sufficiently to

initiate the conduction of space current in this tube.

The space current of the tube 2 is added to the space current of the tube 1 in the cathode resistor 7, thereby driving the cathode of tube 1 to a greater positive potential with respect to the control grid of this tube. Since the potential of the control grid of tube 1 with respect to ground is unchanged, the effect is an increase in the negative grid-to-cathode potential of this tube, thereby initiating a decrease in the conductance thereof.

As a consequence of the decreased conductance of the tube 1, the potential drop across the resistor 8 decreases correspondingly to cause the potential of the anode of the tube to increase positively. The increased positive anode potential is applied to the grid of tube 2 by means of the condenser 9, whereby to increase still further the conduction of space current in this tube. Thus, the voltage drop across the resistor 7 also is increased as a result of the flow of the increased space current of tube 2 through the resistor.

By reason of the fact that the amplification factor of tube 1 is considerably greater than unity, a relatively small change in the grid-to-cathode potential effects a relatively large change in the potential of the anode. Consequently, the increase in the positive potential of the anode of tube 1 is much greater than the increase in the positive potential of the cathodes of tubes 1 and 2, with the result that the grid voltage of tube 2 with respect to ground increases at a much greater rate than the cathode voltage of this tube with respect to ground. As a result, the interaction between tubes 1 and 2 is strongly regenerative. In operation, the space current in tube 1 is interrupted abruptly and space current in tube 2 is initiated abruptly.

With tube 1 non-conducting, the potential of the grid of tube 2 tends to become positive with respect to its associated cathode. The grid and cathode elements then function as a diode and charging current for the condenser 9 flows through resistor 8 to the cathode of tube 2. As the condenser approaches its fully charged state, there is an exponential decrease in the charging current which effects a decrease in the positive grid-to-cathode voltage of tube 2. Thus, there is produced a corresponding decrease in the conductivity of the tube which decreases the current flow through the resistor 7. The voltage drop across this resistor decreases as a result of the decreased current flow, thereby increasing the grid-to-cathode voltage of the tube 1 gradually, until the point is reached where this tube is rendered conducting.

Immediately upon the initiation of the conduction of space current in the tube 1, there is produced a voltage drop across the resistor 8 whereby the anode voltage of the tube is rendered less positive. This altered potential is applied to the grid of tube 2 by means of condenser 9 and produces a still further decrease in the current flow through resistor 7, resulting from the space current of the tube 2. Again, by reason of the specified amplification factor of the tube 1 the interaction between the tubes is strongly regenerative. Consequently, space current in the tube 2 is interrupted abruptly and space current in the tube 1 is initiated abruptly.

Because of the fact that the output circuit of tube 1 includes the resistor 8 while the output circuit of tube 2 is not provided with any appreciable corresponding impedance, the current flow

through the resistor 7 is much greater when tube 2 is conducting than it is when tube 1 is conducting. Consequently, the voltage developed across the resistor 7 is subject to a corresponding variation. Thus, this voltage is a series of impulses having very steep leading and trailing edges. The crest of each of these impulses decreases exponentially from the leading to the trailing edges as a result of the described decrease of the charging current for condenser 9 occurring during conductive periods of tube 2.

Immediately upon the initiation of the conduction of space current in tube 1, there is evidenced a large decrease in the voltage applied to the cathode of tube 2. The result of this voltage decrease is to drive the grid-to-cathode voltage of this tube far beyond the point of space current cutoff. This condition is realizable by the functioning of the condenser 9 which prevents the grid voltage from changing suddenly.

However, the condenser charge is gradually dissipated through the potentiometer 10, thereby to allow the voltage of the grid of tube 2 to approach gradually its space current cutoff value. When this potential is reached, the conduction of space current in tube 2 again is initiated and the cycle is repeated as described.

The frequency of the impulsive voltage developed in the cathode resistor 7 is a function of the grid bias of the tube 2. This bias is positive with respect to ground and the magnitude thereof controls the operating time of the tubes. Thus, to increase the frequency of the impulsive voltage the bias is made more positive and to decrease the frequency of the impulsive voltage the grid bias is made less positive.

This impulsive high frequency voltage is applied to the frequency divider from which is obtained an impulsive voltage of relatively low frequency. If the frequency of the alternating current power supply is, say 60 cycles, then the frequency of the relatively low frequency impulsive voltage derived from the frequency divider 12 is also substantially 60 cycles.

When the frequency of the impulsive voltage derived from the frequency divider 12 is exactly equal to the frequency of the alternating current power supply, there is developed by the frequency comparator 13 a control voltage for the input circuit of the tube 14 of a magnitude such that there is produced a current flow through the tube and the cathode follower resistor 11 sufficient to produce a voltage drop in the resistor 11 of a normal magnitude. The voltage developed in the resistor 11 is impressed by means of the potentiometer 10 upon the control grid of the tube 2 so as to produce the normal positive bias of the grid with respect to ground.

When the frequency of the voltage derived from the frequency divider is less than the frequency of the alternating current power supply, there is produced by the frequency comparator, a voltage which, when applied to the input circuit of the control tube 14, increases the conduction of space current in the tube and through the cathode follower resistor 11. Thus, there is developed in this resistor a voltage which is greater than the normal voltage developed therein in an amount

corresponding to the deviation of the oscillator frequency from the power supply frequency. When this voltage is applied to the control grid of the tube 2, its effect is to decrease the positive bias in an amount corresponding to the frequency deviation. The decreased positive bias of the tube 2 increases the frequency of the generated impulses sufficiently to compensate for the detected frequency deviation.

If the frequency of the impulsive voltage derived from the frequency divider is greater than the frequency of the alternating current power supply, the frequency comparator produces a voltage to decrease the current in the tube 14 and in the resistor 11 whereby to decrease the voltage developed in this resistor. This decreased voltage, when impressed upon the control grid of the tube 2, increases the positive bias thereof sufficiently to decrease the frequency of the generated impulses to compensate for the deviation.

While it will be understood that the circuit specifications of the controlled frequency oscillator embodying the invention may vary according to the design for any particular application, the following circuit specifications for a generator employed for the use described, are included by way of example only, as follows:

Tubes 1 and 2	6SL7GT
Voltage between terminals 3 and 4	150 volts
Resistor 5	100,000 ohms
Resistor 6	10,000 do
Resistor 7	3,000 do
Resistor 8	50,000 do
Condenser 9	200 micro-microfarads
Potentiometer 10	50,000 ohms
Resistor 11	1,800 do
Tube 14	6J5GT

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 claim to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

In a television timer, a multivibrator having two electron discharge devices connected for self-sustaining alternate operation at a relatively high frequency determined by the input circuit biasing voltage of one of said devices, means for deriving from said multivibrator a voltage of substantially a predetermined frequency, a source of standardizing frequency substantially equal to said predetermined frequency, means for detecting a deviation in said frequencies, a circuit including an impedance device for developing a biasing voltage for said input circuit representative of said detected deviation, whereby to adjust the frequency of said multivibrator so as to be definitely related to said standardizing frequency, and a vacuum tube having a control grid coupled to said detecting means and a cathode connected to said impedance device.

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