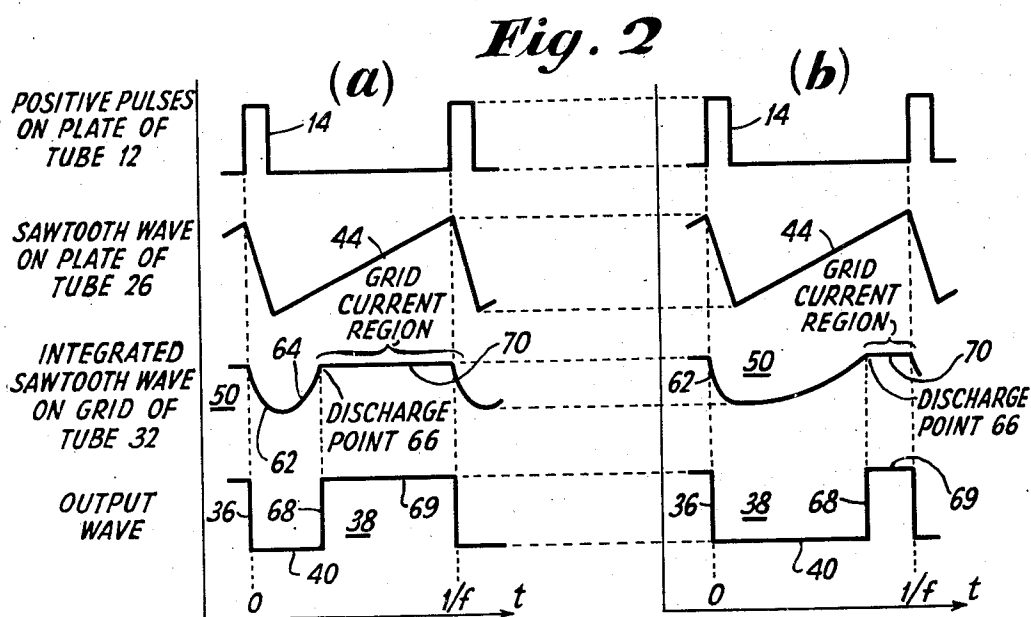
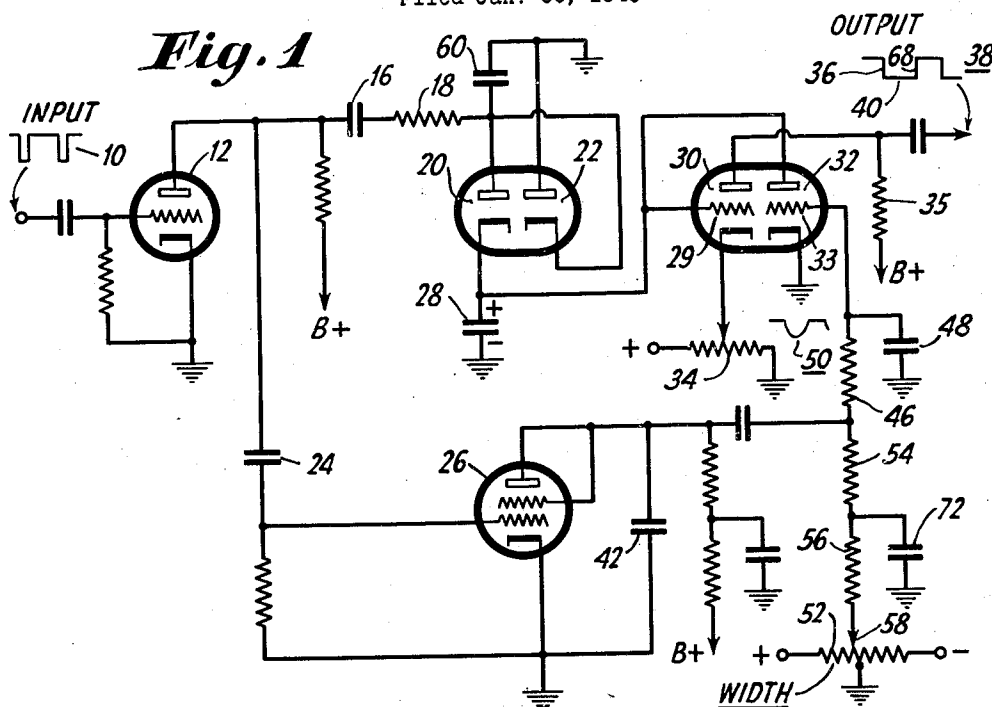


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ELECTRONIC WAVE GENERATING METHOD AND MEANS

Filed Jan. 30, 1946



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2,469,227

ELECTRONIC WAVE GENERATING METHOD
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Application January 30, 1946, Serial No. 644,201

15 Claims. (Cl. 250—27)

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The present invention relates to electronic apparatus of the type wherein square wave outputs are developed and which are particularly useful to effect switching operations between various circuits. Such apparatus and circuits have wide applications in the field of television, as will become evident from the description to follow.

It is frequently desirable, in connection with switching circuits employing electron discharge devices, that a voltage variation be available the waveform of which is of substantially rectangular configuration. It is furthermore desirable, where such a voltage variation is initiated by a synchronizing impulse, that the leading edge of each cycle of the voltage variation be constant with respect to such synchronizing impulse, and that the width of the variation be controllable within a certain percentage of the period of the synchronizing impulse. Such a voltage wave is useful, for example, in television systems where a line traveling across the viewing screen "wipes out" one image and replaces it with another.

It is an object of the present invention, therefore, to provide a method and means for producing voltage variations having a waveform of substantially rectangular configuration.

It is a further object of the present invention to provide a method and means for producing a substantially rectangular, cyclically recurring, voltage variation the width of which is controllable within a certain percentage of the period of the synchronizing impulses.

It is a still further object of the present invention to provide a circuit of the above nature which is stable in operation.

Further objects and advantages of the invention will be apparent from the following description of a preferred form of the invention and from the drawings, in which:

Fig. 1 is a circuit diagram of a preferred embodiment of the present invention; and

Figs. 2a and 2b are each sets of curves illustrating the operation of the circuit of Fig. 1.

In describing the operation of the circuit of Fig. 1, let it be assumed that a series of negative input or driving pulses 10 is applied to the grid of an electron discharge tube 12. These negative input pulses 10 may, if desired, be obtained either from the horizontal or vertical sync generator in a television system. Tube 12 is connected to act as a class A amplifier, so that the negative pulses 10 are inverted to appear as a series of positive pulses in the plate circuit of the amplifier tube 12. These positive pulses are represented in Fig. 2 by the reference character 14.

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A portion of the output of tube 12 is coupled by means of the series combination of capacitor 16 and resistor 18 to the plate of one electron discharge device 20, and also to the cathode of a further electron discharge device 22.

The two electron discharge devices 20 and 22 are preferably enclosed in a single envelope, as shown in the drawing, although separate tubes may obviously be employed if desired. The remaining portion of the output of amplifier tube 12 is coupled by means of a capacitor 24 to the control grid of a further tube 26. However, in the following description, the portion of the output of tube 12 which is applied to the electron discharge devices 20 and 22 will first be considered.

During the time that the positive pulses 14 are being received on the plate of the electron discharge device 20, the latter is rendered conductive, and current flowing in the cathode circuit of the tube charges condenser 28 with the polarity shown in the drawing. When the negative portion of the amplifier tube output is received on the cathode of tube 22, the latter is rendered conductive to place the plate of tube 20 effectively at ground potential and thus discharge the coupling capacitor 16. As a result of this mode of operation, and by the selection of a proper value for capacitor 28, the latter may be maintained at positive potential until discharged by means which will now be described.

The charge on capacitor 28 is applied to the control electrode 29 of one tube 30, and also to the plate of a further tube 32 having a control electrode 33. As in the case with tubes 20 and 22, the tubes 30 and 32 may also be enclosed in a common envelope.

Tube 30 is so biased by means connecting its cathode to a positive point on the voltage divider 34 that when the control electrode 29 is at ground potential, no current flows in the tube. However, when capacitor 28 acquires a positive charge in the manner above described, this charge is applied to the control electrode 29, and tube 30 is rendered conductive. The constants of the tube and circuit are so selected that this current flow in tube 30 will be of saturating proportions.

When tube 30 is rendered conductive, the increasing current flow through the output load resistor 35 produces a corresponding voltage variation 36. This constitutes the initial portion of the output waveform 38. Since, as above stated, the current flow through triode 30 reaches saturating proportions, the output voltage developed across load resistor 35 levels off to produce the

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waveform portion 40. This waveform portion 40 thus in effect constitutes the "trough" portion of the output waveform 38.

The current flow in tube 30 will continue as long as capacitor 28 is charged positively. Since the charge on capacitor 28 is maintained positive, in the manner above set forth, during the time that the positive pulses 14 are being received on the plate of tube 20, the present invention provides means for discharging capacitor 28 a predetermined time interval following the initiation of each cycle of the output waveform. This means will now be described.

It will be noted that the high potential side of capacitor 28 is not only connected to the control electrode 29 of tube 30, but is also connected to the plate of the normally non-conductive tube 32. The cathode of tube 32 is grounded. Hence, when this tube conducts, a low-impedance path shunts the capacitor 28 to ground, and the capacitor 28 will be discharged.

The means for rendering tube 32 conductive necessitates reference again to the output of amplifier tube 12. It will be recalled that the output energy of tube 12 is divided, a portion being applied to the plate and cathode respectively of tubes 20 and 22, and the remaining portion being applied through capacitor 24 to the control electrode of a tube 26.

This tube 26, in combination with its associated components including the capacitor 42, constitutes a sawtooth wave generator which is synchronized by the pulses 14 to produce an output voltage variation which may be such as indicated in Fig. 2 by the reference character 44. The sawtooth wave 44 is then passed through an integrating network consisting of resistor 46 and capacitor 48. The integrating network 46, 48 changes the sawtooth wave 44 into a partially parabolic wave having a form which may be such as indicated by the reference character 50. These voltage variations represented by the wave 50 are then applied to the control electrode 33 of tube 32.

Bias for tube 32 is provided by means including a potentiometer 52 connected to the control electrode 33 through a pair of isolating resistors 54 and 56. The ends of the resistor element of potentiometer 52 are respectively connected to sources of positive and negative potential, as illustrated, so that by adjustment of the potentiometer tap 58 a bias may be placed on the control electrode 33 which varies between positive and negative limits.

In describing the operation of the above means, let it first be assumed that the control electrode 33 of tube 32 is positive with respect to ground. Under such conditions, electrons will flow from the cathode to the plate of tube 32, and, since the tube is connected in parallel with capacitor 28, the latter will discharge through the tube.

Since the control electrode 33 has been assumed to be positive with respect to the cathode of tube 32, electrons will be collected by the control electrode during conduction of the tube. These electrons will flow through the resistors 46, 54 and 56. Inasmuch as all of these resistors are chosen to be of a relatively high value, this electron flow will reduce the positive charge on the control electrode 33. During the interval that the positive charge on control electrode 33 is being reduced, the capacitor 28 is discharging through tube 32, and, as a result of these conditions, the control electrode 33 will reach plate current cut-off at approximately zero volts. At

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the instant when cut-off is reached, the charge on capacitor 28 (and hence the plate potential of tube 32) will also be approximately zero volts.

Accordingly, at time $t=0$ (Fig. 2a) the reception of the leading edge of a positive pulse 14 on the grid of tube 26 renders the tube 26 conductive, and discharges the capacitor 42 through the tube to produce the return, or snap-back, portion of the sawtooth wave 44. Reception of this same positive pulse 14 on the plate of tube 20 renders the tube 20 conductive to charge capacitor 28. It should be noted that resistor 18 and capacitor 60 together act as a delay network during this charging operation.

The positive charge on capacitor 28 is applied to the control electrode 29 of tube 30, and the latter is rendered conductive. As a result, current flows through the load resistor 35 and the voltage variation produced by this current flow constitutes the leading edge 36 of the output waveform 38.

As has been stated above, the integrating network 46, 48 changes the sawtooth wave 44 into a partially parabolic wave 50. From Fig. 2a it will be seen that conduction of tube 26 to discharge capacitor 42 causes the voltage on grid 33 to swing in a negative direction. This negative swing constitutes the initial section 62 of the parabolic portion of wave 50, and, as a result, tube 32 is driven below cut-off.

Since tube 30 will conduct as long as its control electrode 29 is maintained at positive potential by the positive charge on capacitor 28, and since capacitor 28 can discharge only through tube 32, it will be seen that the voltage across output resistor 35 will remain at a level 40 determined by the saturation current through tube 30 as long as tube 32 remains at or below cut-off.

However, the negative swing of the voltage on control electrode 33 as represented by the leading section 62 of the parabolic portion of waveform 50 reaches its maximum at a certain point. The voltage on control electrode 33 then begins to rise in a positive direction. This voltage rise is represented in Fig. 2a by the terminating section 64 of the parabolic portion of waveform 50.

At a certain point 66 (Fig. 2a) the rising voltage on control electrode 33 reaches the cut-off level of tube 32. Tube 32 now conducts to discharge capacitor 28, and, as has been stated above, when the charge on the latter reaches approximately zero volts, the plate current of tube 30 ceases. Upon termination of current flow through tube 30, the voltage across the load resistor 35 rises almost immediately to source potential, as shown by the vertical portion 68 of the output waveform 38. The output voltage then remains at source potential, as shown by the substantially horizontal waveform portion 69, until time $t=1/f$, where f is the recurrence frequency of the input pulses 10. This waveform portion 69 thus in effect constitutes the "crest" portion of the output waveform 38.

When tube 32 becomes conductive in the manner described above, it acts to discharge capacitor 48 due to the electron flow between the grid and cathode of the tube. The grid 33 is thus returned to approximately zero potential at the beginning of the next cycle of operation. This is due to the fact that the grid-cathode resistance of tube 32 is small in comparison with the values of the resistors 46, 54 and 56.

The point 66 at which the rising voltage represented by the waveform portion 64 reaches the cut-off level 70 of tube 32 (see Fig. 2a) may be

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varied by adjustment of the potentiometer tap 58 so as to change the bias on tube 32. This changes the width of the output wave 33. In practice, this width has been varied between the limits of approximately 12% to 88% of the period of the input pulses 10.

Fig. 2b illustrates the effect of an adjustment of the potentiometer tap 58 so as to place a more negative D.-C. bias on the control electrode 33 of tube 32, and shows how the instant of discharge of capacitor 28 may be delayed through a variation in the instantaneous slope of the waveform portion 34 resulting from a change in grid bias.

It will be obvious that, if desired, a suitable manual or electronic switching element may be inserted in the grid circuit of tube 32 so as to effect periodic changes in the D.-C. bias applied to control electrode 33. In such an event, the time constant of resistor 56 and capacitor 72 should preferably be long.

It will also be clear that the output wave 33 may be passed through one or more wave shaping and/or clipping circuits. In this connection, however, it should be noted that the tube 30 is in itself a clipper, since as above described the waveform portion 40 of the output wave 33 results from a saturation current flowing through tube 30 and load resistor 35.

Having thus described my invention, I claim:

1. In a wave-generating system in which a series of synchronizing pulses control the production of an output voltage variation of substantially rectangular waveform, the leading edge of each cycle of the voltage variation being constant with respect to the leading edge of a synchronizing pulse, and the width of each cycle of the voltage variation being a selected percentage of the period of the synchronizing pulses, the combination of means responsive to the reception of said synchronizing pulses for initiating a current flow, a saw-tooth wave generator, means responsive to the reception of each synchronizing pulse of said series for initiating the discharge portion of each cycle of operation of said sawtooth wave generator, means for integrating the output of said sawtooth wave generator, and means for applying the output of said integrating means to terminate cyclically said current flow.

2. A wave-generating system in accordance with claim 1, in which said means responsive to the reception of said synchronizing pulses for initiating a current flow includes a rectifier, a source of energizing potential, and a capacitor connected in series relation, whereby said capacitor is charged during conduction of said rectifier, a grid-controlled electron discharge device, and means for applying the charge on said capacitor to the grid of said electron discharge device.

3. A wave-generating system in accordance with claim 1, in which said means for integrating the output of said sawtooth wave generator comprises a resistance-capacitance network so arranged as to change the output of said sawtooth wave generator into a voltage variation having a waveform of partially parabolic configuration.

4. A wave-generating system in accordance with claim 1, in which said means for applying the output of said integrating means to terminate cyclically said current flow includes a normally non-conductive electron discharge device shunting a portion of said means responsive to the reception of said synchronizing pulses for initiating a current flow, and means for applying the output of said integrating means to said normally

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non-conductive electron discharge device so as to render the latter conductive.

5. A wave-generating system in accordance with claim 1, further comprising means for altering the waveform of the output of said integrating means so as to vary the instant of termination of said current flow.

6. An electrical circuit comprising: means for cyclically initiating a current flow; an energy-storage device; means for charging said energy-storage device; means responsive as a function of the cyclic operation of said initiating means for discharging said energy-storage device; means for integrating the cyclically varying charge on said energy-storage device; and means for applying the output of said integrating means to terminate said current flow.

7. An electrical circuit in accordance with claim 6, in which said integrating means comprises a resistance-capacitance network, further comprising a source of direct current, and means for charging the capacitance of said resistance-capacitance network from said source of direct current so as to alter the wave-form of the output of said integrating means.

8. In a wave-generating system, a source of synchronizing pulses, a rectifier and a first condenser connected in series relation, means responsive to the reception of synchronizing pulses from said source to cause a current flow through said rectifier and said first condenser whereby the latter will be charged, a grid-controlled electron discharge device, means for connecting the positive plate of said first condenser to the grid of said electron discharge device so as to initiate a current flow through said device, a second condenser, a source of direct current, a resistor, means for applying a steady direct current from said source to said second condenser through said resistor so as to develop a steadily increasing charge on the latter, means responsive to the reception of synchronizing pulses from said source to discharge said second condenser, whereby the voltage developed across said second condenser will be substantially of sawtooth configuration, an integrating network, means for applying the voltage developed across said second condenser to said integrating network so as to produce a voltage output therefrom a portion of which is substantially parabolic in shape, a second normally non-conductive grid-controlled electron discharge device connected in parallel relation with said first condenser, and means for applying the partially parabolic voltage output of said integrating network to the grid of said second electron discharge device so as to control the conduction of the latter and hence the discharge of said first condenser.

9. A wave-generating system in accordance with claim 8, further comprising a source of bias potential, and means for connecting the grid of said second electron discharge device to said source of bias potential so as to further control the conduction of said second electron discharge device.

10. A wave-generating system in accordance with claim 8, further comprising a source of bias potential, means for connecting the grid of said second electron discharge device to said source of bias potential, and means for varying the value of said potential and hence the amount of the bias on said second electron discharge device.

11. A wave-generating system in accordance with claim 8, in which said integrating network comprises a resistance-capacitance combination,

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further comprising a source of potential, means for connecting said source of potential to the grid of said second electron discharge device and also to the capacitance of said integrating network, whereby the charge thus developed on the capacitance of said integrating network acts to alter the configuration of the output waveform of said integrating network as applied to the grid of said second electron discharge device.

12. A square wave generator having uniformly repeating periodicity coinciding with an input control pulse series and having the crest and trough portions controllable to occupy selected fractional portions of the time period between successive control pulses of the control series, comprising means responsive to each input control pulse to initiate and maintain a current flow under the control of the control pulse series, means also responsive to each input control pulse to initiate a series of saw-tooth wave currents of periodicity coinciding with that of the control pulse series, means to integrate the developed saw-tooth wave currents, and means operating under the control of the integrated saw-tooth wave currents to interrupt the said current flow, with the interruption period occupying a selected unexpired time period between successive control pulses.

13. In a square wave generator having uniformly repeating periodicity coinciding with an input control pulse series and having the crest and trough portion controllable to occupy selected fractional portions of the time period between successive control pulses of the control series, the method which comprises initiating a current flow under the control of the control pulse series, initiating, under the control of the control pulse series, a series of saw-tooth wave currents of periodicity coinciding with that of the control

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pulse series, integrating the said saw-tooth wave currents, and interrupting said current flow under the control of the said integrated saw-tooth wave currents, said interruption period occupying a selected unexpired time period between successive control pulses.

14. In a wave-generating system in which a series of synchronizing pulses control the production of an output voltage variation of substantially rectangular waveform, the leading edge of each cycle of the voltage variation being constant with respect to the leading edge of a synchronizing pulse, and the width of each cycle of the voltage variation being a selected percentage of the period of the synchronizing pulses, the method which comprises initiating a current flow in response to the reception of said synchronizing pulses, generating a current wave of substantially saw-tooth configuration under the control of said synchronizing pulses, the period of said saw-tooth current wave coinciding with the period of said synchronizing pulses, integrating said saw-tooth current wave, and applying said integrated saw-tooth current wave to terminate cyclically said current flow.

15. The method of claim 14, further comprising altering the waveform of the said integrated saw-tooth current wave so as to vary the instant of cyclic termination of said current flow.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,265,290	Knick	Dec. 9, 1941
2,419,340	Eaton	Apr. 22, 1947