June 4, 1940. M. CAWEIN 2,203,519

PERIODIC WAVE GENERATOR

Filed Oct. 7, 1937

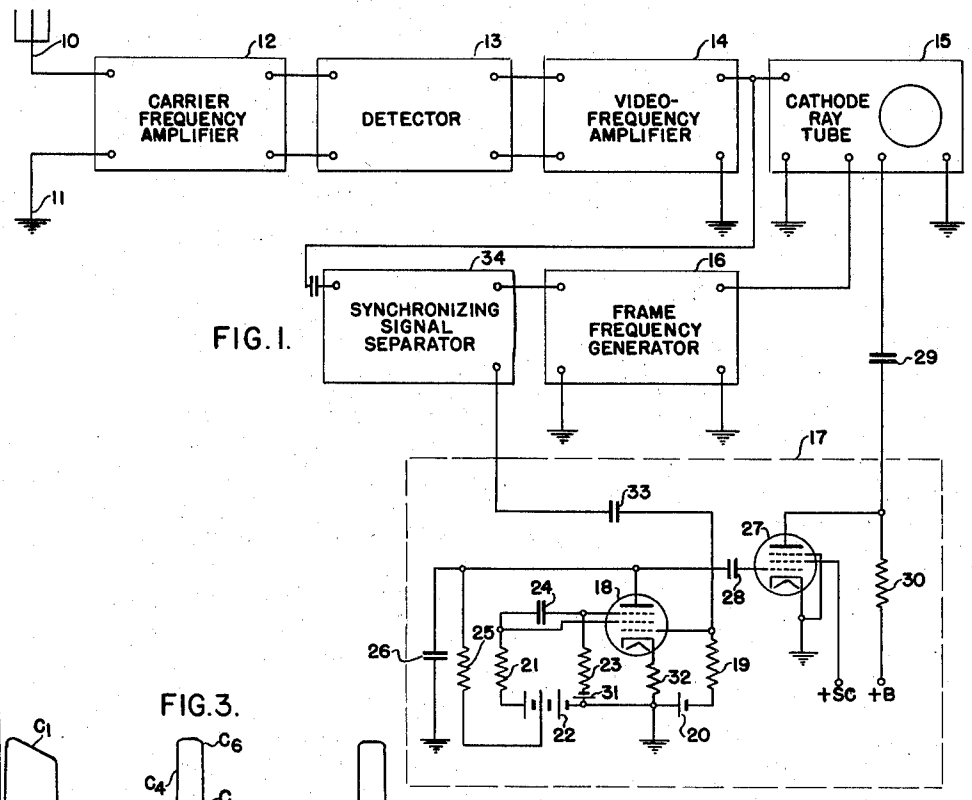


FIG. 1.

FIG. 3.

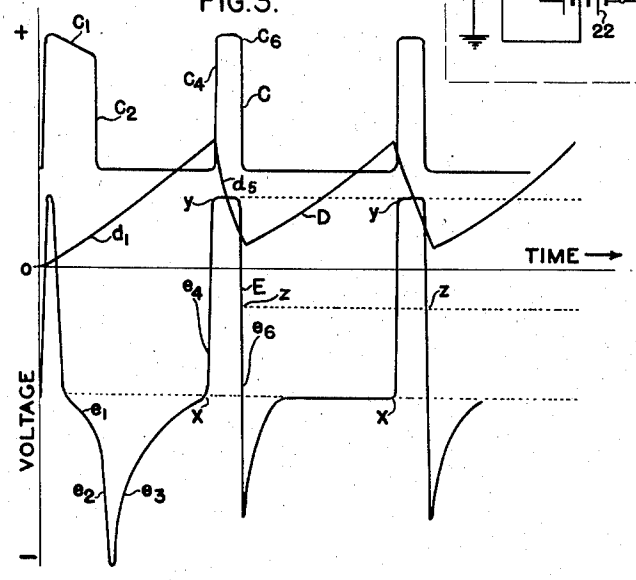


FIG. 2.

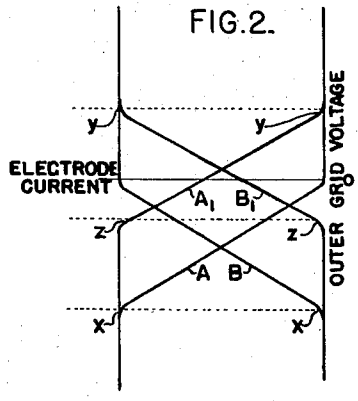
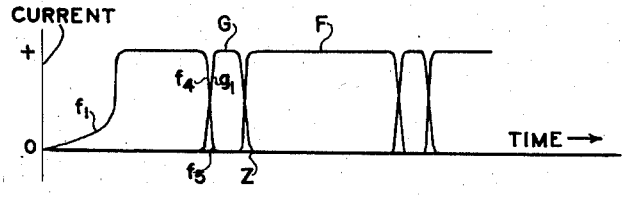


FIG. 4.



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PERIODIC WAVE GENERATOR

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11 Claims. (Cl. 250—36)

This invention relates to the generation of periodic waves having complex forms, such as saw-tooth and related forms, and more particularly to television systems including means for generating and utilizing such waves for effecting scanning.

In certain television systems according to present practice, including both transmitters and receivers, a beam, such as the cathode ray in a cathode-ray tube system, is focused on a target and, by means of electrostatic or electromagnetic fields of saw-tooth wave form, is deflected to scan series of parallel lines on the target. The image to be transmitted is usually focused on the target of the transmitter and the transmitting apparatus including this target is such that the required signal is developed. The scanning action at the receiver is synchronized with that at the transmitter and the receiving apparatus including its target is such that the scanning is effective to reproduce the scene on the target.

Scanning wave generators are required, therefore, at both television transmitters and receivers and it is essential that these generators be capable of developing waves of the proper wave form to effect accurate linearity of trace and rapid retrace of the scanning beam. Moreover, it is highly desirable that these generators be relatively simple in construction and dependable in operation.

It is an object of the present invention, therefore, to provide an improved generator for developing a periodic wave of complex form, such as saw-tooth or related form.

It is a further object to provide a television system in which a generator of the character described is employed to provide a scanning wave.

In accordance with the present invention, there is provided a generator which comprises a single vacuum tube having a cathode, an anode and a plurality of grids including inner and outer grids disposed between the cathode and anode and having relatively sharp upper and lower space-current cutoff characteristics with respect to the potential on the outer grid. A load resistor is connected between the inner grid and the cathode and a resistance-reactance network is provided, coupling the inner and outer grids and having a phase shift of less than 90 degrees and preferably as nearly zero as practicable. An impedance network is also effectively connected in the cathode-anode circuit and is proportioned to have a time constant of a predetermined value greater than and functionally related to the period of the wave to be generated. Means are further provided for applying operating potentials to the electrodes of the tube and for maintaining the inner grid at a substantially higher unidirectional potential than the outer grid.

In a preferred embodiment of the invention, the resistance-reactance network between the inner and outer grids includes a condenser connected directly between these grids and a resistor connected between the outer grid and cathode. Preferably, an auxiliary or additional biasing grid is disposed adjacent the cathode and maintained at a negative potential with respect thereto to maintain the total space current substantially constant and to ensure that the operation of the tube is non-critical with respect to the potentials of the other electrodes. There may be provided also means for applying a synchronizing signal to the last-mentioned grid to maintain the generator in synchronism with any desired control wave. The output impedance network may comprise a resistor and condenser in parallel having a time constant related to the period of the wave to be generated.

For a better understanding of the present 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, Fig. 1 is a circuit diagram, partially schematic, of a complete television receiving system including a scanning wave generator embodying the present invention; Fig. 2 is a graph representing certain static characteristics of the single tube included in generator of Fig. 1; while Figs. 3 and 4 are curves representing voltage and current waves developed at various points in the generator of Fig. 1 during operation, to aid in the understanding of the invention.

Referring now more particularly to Fig. 1 of the drawing, the system there illustrated comprises a television receiver, which may be of either the tuned radio-frequency or superheterodyne type, including, in cascade, an antenna and ground system 10—11, a carrier-frequency amplifier 12, a detector 13, a video-frequency amplifier 14, and a cathode-ray tube 15. Where the receiver is of the superheterodyne type, the conventional oscillator-modulator and intermediate-frequency amplifier will be included as a part of the carrier-frequency amplifier 12. A frame-frequency generator 16 and a line-frequency generator, indicated generally at 17, are coupled to the video-frequency amplifier by way of a con-

ventional synchronizing signal separator 34 for synchronization and connected to scanning elements or coils of the cathode-ray tube 15 in a conventional manner. The generators 16 and 17 are similar and are constructed in accordance with the present invention, only the generator 17 being shown in detail and hereinafter further described. The apparatus shown in schematic form, excepting the generator 16, is preferably conventional in construction and operation.

Since the system of Fig. 1, as thus far described, is, in general, well understood in the art, a detailed explanation of its operation is deemed unnecessary. Briefly, however, vision-modulated carrier waves are intercepted by the antenna 10—11 and selectively amplified in the carrier amplifier 12. Where the receiver is of the superheterodyne type the signals are impressed upon an oscillator-modulator in the amplifier 12, where they are converted to an intermediate-frequency signal and further selectively amplified. The amplified signal from the amplifier 12 is delivered to the detector 13 in which are derived the video frequencies of modulation including the synchronizing components, which are supplied to the video-frequency amplifier 14 wherein they are amplified and supplied in the usual manner to the control grid of the cathode-ray tube 15 and to the synchronizing signal separator 34, wherein the synchronizing signals are separated from the video signals and the frame and line impulses are also separated, the latter being thereupon delivered to the control elements of the generators 16 and 17, respectively. The intensity of the electron beam or ray of the cathode-ray tube 15 is thus modulated or controlled in accordance with the video-frequency voltages impressed on a control grid of the tube, in the usual manner. The saw-tooth current scanning waves developed by the generators 16 and 17 are controlled by the synchronizing voltage impulses supplied from the video-frequency amplifier 14 and are utilized in a conventional manner to produce magnetic fields of saw-tooth wave form to deflect the ray of the cathode-ray tube 15 vertically and horizontally, so as to trace successive fields or frames of parallel lines on the target of the tube, thereby to reproduce the transmitted image.

Referring now more particularly to the portion of the system of Fig. 1 which embodies the present invention, the generator 17 comprises a vacuum tube 18, preferably of the pentode type and having a cathode, an anode, and a plurality of grids including inner and outer grids disposed between the cathode and anode and having relatively sharp upper and lower space-current cutoff characteristics with respect to the outer grid. The tube 18 comprises first, second, and third grids disposed between the cathode and anode in the order named. The second and third grids may be screen and suppressor grids, respectively, and hereinafter are referred to for convenience as the inner and outer grids, respectively, and the first or control grid as an auxiliary or biasing grid adjacent the cathode. The first or auxiliary grid is connected to the cathode by way of a resistor 19 and battery 20 and serves to maintain substantially constant the total space-current of the tube and render its operation non-critical with respect to voltage on the third grid. The second or inner grid is connected to the cathode by way of a load resistor 21 and a suitable source of positive operating potential, for example a battery 22. The inner and outer, or second and third, grids are coupled by means of a resistance-reactance network which may comprise a condenser 24 connected directly between these two grids, a resistor 23 and suitable source of negative biasing potential, for example battery 31, connected between the third grid and cathode, as shown, and the resistor 21. The values of these elements are such that this resistance-reactance network has a time constant of the desired predetermined value, related to the period of the saw-tooth wave to be generated, and has a phase shift which is less than 90°, preferably approaching zero. The inner or second grid is maintained at a higher unidirectional potential than the outer or third grid, by the battery 22.

An impedance network, for example a saw-tooth wave-forming circuit, is included in the anode circuit of the tube and preferably comprises a load resistor 25 and condenser 26, effectively connected in parallel between the anode and cathode, as shown, and having a time consant related to, that is, of the same order of magnitude as, the period of the wave to be generated. Operating potential may be supplied to the anode by way of the resistor 25 from a suitable source, for example a point on the battery 22. The potential of this point controls the peak output of the generator. A resistance 32, of suitable value, is preferably inserted in the cathode circuit for the purpose of stabilizing the operation of the relaxation oscillator and making the circuit constants and biases less critical. The first grid is coupled to the separator 34 by way of condenser 33 to receive the line-synchronizing impulses therefrom.

An output tube 27 is preferably provided for the generator 17 comprising a pentode having its input circuit coupled to the output circuit of the tube 18, by way of a coupling condenser 28, and its anode circuit coupled to the line-scanning coils of the cathode-ray tube 15, by way of a coupling condenser 29. Operating potentials may be supplied to the screen and anode of the tube 27 from suitable sources indicated at +Sc and +B, respectively, the latter being supplied by way of a suitable blocking resistor 30.

The operation of the generator may best be explained with reference to Figs. 2–4, inclusive. In Fig. 2 the curves A and B represent the inner grid and anode currents, respectively, with respect to the third grid voltage with a relatively high value of anode voltage, while the curves A_1 and B_1 represent the inner grid and anode currents, respectively, with a relatively low value of anode voltage. It will be apparent that, due to its geometry and the operating voltages applied to its electrodes, the tube has relatively sharp upper and lower space-current cutoff characteristics with respect to the outer or third grid voltage, as stated above. Moreover, this characteristic is stable for all operating conditions and is not critically affected by variations in heater current or changes in the bias voltage of the auxiliary or first grid. It is to be noted that these characteristics are not present in tubes of other types which have heretofore been proposed for use in complex wave form generators, such as tetrodes including only two grids.

Due to the coupling between the inner and outer grids, the cathode and inner and outer grids form a type of oscillator which is well known in the art, the inner grid acting as an anode. Such a circuit tends to oscillate at a relatively high natural frequency, determined primarily by its distributed inductance and capacitance, so that the potentials of the inner and outer

grids change rapidly. Due to the time constant of the circuit associated with the anode, however, this natural oscillation is blocked after a fraction of a cycle by the drop of potential of the anode and it cannot resume until the anode has charged up again sufficiently, which process requires a relatively long period of time, determined by the time constant associated with the anode impedance. When the anode has reached a critical potential, as determined by the circuit constants and operating potentials of the various electrodes, another fractional cycle of the natural oscillation ensues and the anode blocks again, this process continuing periodically.

From another standpoint, the operation of the generator may be explained by reference to Figs. 3 and 4. The curves of Figs. 3 and 4 represent the forms of the voltage or current waves developed at different points in the generator, the abscissae representing time. Curves C, D and E of Fig. 3 represent the voltages on the inner grid, the anode, and the outer grid, respectively, while curves F and G of Fig. 4 represent current to the inner grid and the anode, respectively.

The operation may be considered as starting at a point where the heater current has just been switched on, proper operating potentials having previously been applied to the electrodes of the generator tube. Under these conditions, electron space-current flows from the cathode toward the anode. Part of this current flows to the inner grid, increasing as shown at f_1 of curve F and causing a voltage drop across resistor **21**, so that the inner grid voltage gradually decreases, as shown by the portion c_1 of the curve C. This voltage being impressed on the outer grid by way of condenser **24**, the voltage of this grid follows that of the inner grid; that is, it decreases as indicated by the portion e_1 of the curve E.

The drop in voltage on the outer grid serves to decrease the current flow to the anode resulting in an increased current flow to the inner grid, since the total space current is maintained substantially constant. Hence, there results a further voltage drop across resistor **21** which, when the cathode current has built up to a sufficient value, in effect regenerates the operation during this part of the cycle, as indicated at c_2 and e_2. This part of the cycle may be considered as a high-frequency transient occurring at the natural resonant frequency of the circuit which is determined by the distributed inductance and capacitance and which, as indicated by the steepness of the slopes of the portions c_2 and e_2 of the curves mentioned, is very high.

When the outer grid voltage has decreased to a point where the anode current is entirely cut off, the voltage across condenser **24**, which previously was charged, as represented by the difference between the inner and outer grid voltages, curves C and E, begins to discharge gradually through resistors **23** and **21**, in series, as indicated by the portion e_3 of the curve E. That is, the outer grid voltage rises exponentially during this part of the cycle as the potential difference across the condenser **24** falls. During this part of the cycle, the anode voltage gradually rises as indicated by the portion d_1 of the curve D. During this portion of the cycle, the anode voltage becomes relatively high and, when the outer grid and anode voltages reach the relative values indicated at point X of curves A and B of Fig. 2, and similarly indicated at point X, Fig. 3, the anode current again starts to flow, the current flow to the inner grid is reduced, as indicated at f_4, resulting in an increase of voltage on the inner and outer grids, as indicated at c_4 and e_4, with a regenerating effect similar to that described with respect to the first part of the cycle, but in the opposite sense. At the same time, the anode voltage is rapidly decreasing and, during this portion of the cycle, the operation of the tube **18** has a rapid transition from the characteristics A, B to the characteristics A_1, B_1, the regenerating action continuing rapidly until the voltage on the anode reaches the condition where the curve B represents the plate current, and that on the outer grid reaches the values indicated by the point Y of the curves A_1, B_1 of Fig. 2 and Fig. 3. At this point, the anode current, as indicated at g_1, and the inner and outer grid voltages reach their maximum values, and the inner grid current, indicated at f_5, is reduced to a minimum. The condenser **26** then discharges in approximately exponential fashion through the anode-cathode circuit of the tube with the result that the anode voltage falls rapidly, as indicated at d_5, to a low value. This decrease in anode voltage causes a decrease in anode current, thus releasing a portion of the total space current to the second grid and thereby causing its potential to fall, as indicated at c_6. This initial fall in potential is effective to lower the potential of the third grid by virtue of the condenser **24**, with a consequent regenerated decrease in the second and third grid voltages, at the resonant frequency of the circuit, as indicated at e_6 and c_6. The anode current decreases along the characteristic B_1, due to the relatively low anode voltage and, when the anode current has been reduced to zero, as indicated at the point Z, Figs. 2 and 4, the cycle begins de novo. The negative peaks of the voltage on the outer grid, curve E, are sufficient to carry the tube well below the cutoff point X on the characteristic B.

Synchronizing impulses are applied negatively from the separator **34** to the first grid of the tube **18**, preferably at a point in the cycle just prior to the point X, Fig. 3, thereby to synchronize the operation of the generator with the corresponding apparatus of the transmitter. The synchronizing impulses serve to initiate the rapid decrease in the current to the inner grid and hence the corresponding increase in the voltages on the inner and outer grids. The saw-tooth anode voltage shown by the curve D is impressed by way of the condenser **28** upon the control grid of the tube **27**, thereby producing a saw-tooth current wave in its output circuit which is passed, by way of coupling condenser **29**, through the scanning coils of the cathode-ray tube to deflect the cathode ray in the manner described above.

While the present invention is, of course, not restricted to any particular design, highly satisfactory results are obtainable by using substantially the same arrangement as described in detail hereinabove, and illustrated in the drawing. In this embodiment, the generator may be designed as follows:

Tube **18**	Type 6D6 pentode amplifier
Condenser **24**	2,000 micro-microfarads
Resistor **21**	25,000 ohms
Resistor **23**	0.1 megohm
Condenser **26**	500 micro-microfarads
Resistor **25**	0.5 megohm
Resistor **19**	0.1 megohm
Resistor **32**	10,000 ohms (adjustable)
Generated frequency	13,230 cycles

While there has been hereinbefore described

what is at present considered to be the preferred embodiment of the invention, it will be apparent to those skilled in the art that various changes and modifications may be made without departing from the invention and it is, therefore, 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 periodic wave generator comprising a vacuum tube having a cathode, an anode and a plurality of grids including inner and outer grids disposed between said cathode and anode and having relatively sharp upper and lower space-current cutoff characteristics with respect to said outer grid, a load resistor coupled between said inner grid and said cathode, means coupling said grids comprising an impedance network having a phase shift of less than 90°, an impedance network effectively connected between said cathode and anode and having a time constant of a predetermined value greater than and functionally related to the period of the wave to be generated, and means for applying operating potentials to the electrodes of said tube and for maintaining said inner grid at a higher unidirectional potential than said outer grid.

2. A periodic wave generator comprising a vacuum tube having a cathode, an anode and a plurality of grids including inner, outer and auxiliary grids disposed between said cathode and anode and having relatively sharp upper and lower space-current cutoff characteristics with respect to said outer grid, a load resistor coupled between said inner grid and said cathode, means coupling said inner and outer grids comprising an impedance network having a phase shift of less than 90°, an impedance network effectively connected between said cathode and anode and having a time constant of a predetermined value greater than and functionally related to the period of the wave to be generated, and means for applying operating potentials to the electrodes of said tube and for maintaining said auxiliary grid at a fixed unidirectional potential with respect to said cathode and said inner grid at a higher unidirectional potential than said outer grid.

3. A periodic wave generator comprising a vaccum tube having a cathode, an anode and a plurality of grids including inner, outer and auxiliary grids disposed between said cathode and anode and having relatively sharp upper and lower space-current cut-off characteristics with respect to said outer grid, a load resistor coupled between said inner grid and said cathode, means coupling said inner and outer grids comprising an impedance network having a phase shift of less than 90°, an impedance network effectively connected between said cathode and anode and having a time constant of a predetermined value greater than and functionally related to the period of the wave to be generated, and means for applying operating potentials to the electrodes of said tube and for maintaining said auxiliary grid at a fixed unidirectional potential with respect to said cathode and said inner grid at a higher unidirectional potential than said outer grid, and means for applying a synchronizing signal to said auxiliary grid.

4. A periodic wave generator comprising a vacuum tube having a cathode, an anode and a plurality of grids including inner and outer grids disposed between said cathode and anode and having relatively sharp upper and lower space-current cutoff characteristics with respect to said outer grid, a load resistor coupled between said inner grid and said cathode, means coupling said grids comprising an impedance network having a phase shift of less than 90°, means for applying operating potentials to the electrodes of said tube and for maintaining said inner grid at a higher unidirectional potential than said outer grid, and a resistance-reactance network effectively connected between said anode and cathode and having a time constant of a predetermined value greater than and functionally related to the frequency of the wave to be generated.

5. A periodic wave generator comprising a vacuum tube having a cathode, an anode and a plurality of grids including inner and outer grids disposed between said cathode and anode and having relatively sharp upper and lower space-current cutoff characteristics with respect to said outer grid, a load resistor coupled between said inner grid and said cathode, means coupling said grids comprising an impedance network having a phase shift of less than 90°, means for applying operating potentials to the electrodes of said tube and for maintaining said inner grid at a higher unidirectional potential than said outer grid, and a resistor and condenser having a time constant of a predetermined value greater than and functionally related to the period of the wave to be generated effectively connected between said anode and cathode to integrate the anode current of said tube, thereby to develop an output voltage wave thereacross of saw-tooth form.

6. A periodic wave generator comprising a vacuum tube having a cathode, an anode and a plurality of grids including inner and outer grids disposed between said cathode and anode and having relatively sharp upper and lower space-current cutoff characteristics with respect to said outer grid, a load resistor coupled between said inner grid and said cathode, a condenser and resistance means effectively in parallel therewith for generated periodic waves, said condenser and resistance means coupling said grids and having a phase shift of less than 90°, an impedance network effectively connected between said cathode and anode and having a time constant of a predetermined value greater than and functionally related to the period of the wave to be generated, and means for applying operating potentials to the electrodes of said tube and for maintaining said inner grid at a higher unidirectional potential than said outer grid.

7. A periodic wave generator comprising a vacuum tube having a cathode, an anode and a plurality of grids including inner, outer and auxiliary grids disposed between said cathode and anode and having relatively sharp upper and lower space-current cutoff characteristics with respect to said outer grid, a load resistor connected between said inner grid and said cathode, a condenser and resistance means effectively in parallel therewith for generated periodic waves, said condenser and resistance means coupling said inner and outer grids and having a phase shift of less than 90°, an impedance network effectively connected between said cathode and anode and having a time constant of a predetermined value greater than and functionally related to the period of the wave to be generated, and means for applying operating potentials to the electrodes of said tube and for maintaining said auxiliary grid at a fixed unidirectional potential relative to said cathode and said inner grid at a higher unidirectional potential than said outer grid.

8. A periodic wave generator comprising a vacuum tube having a cathode, an anode and a plurality of grids including inner, outer and auxiliary grids disposed between said cathode and anode and having relatively sharp upper and lower space-current cutoff characteristics with respect to said outer grid, a load resistor connected between said inner grid and said cathode, means coupling said inner and outer grids comprising an impedance network having a phase shift of less than 90°, a resistance-reactance network effectively connected between said anode and cathode and having a time constant of a predetermined value greater than and functionally related to the period of the wave to be generated, and means for applying operating potentials to the electrodes of said tube and for maintaining said auxiliary grid at a fixed unidirectional potential relative to said cathode and said inner grid at a higher unidirectional potential than said outer grid.

9. A periodic wave generator comprising a vacuum tube having a cathode, an anode and a plurality of grids including inner, outer and auxiliary grids disposed between said cathode and anode and having relatively sharp upper and lower space-current cutoff characteristics with respect to said outer grid, a load resistor connected between said inner grid and said cathode, a condenser and resistor coupling said inner and outer grids and having a phase shift of less than 90°, and means for applying operating potentials to the electrodes of said tube and for maintaining said auxiliary grid at a fixed unidirectional potential relative to said cathode and said inner grid at a higher unidirectional potential than said outer grid, and a resistance-reactance network effectively connected between said anode and cathode and having a time constant of a predetermined value greater than and functionally related to the period of the wave to be generated.

10. A periodic wave generator comprising a vacuum tube having a cathode, an anode and a plurality of grids including inner, outer and auxiliary grids disposed between said cathode and anode and having relatively sharp upper and lower space-current cutoff characteristics with respect to said outer grid, a load resistor connected between said inner grid and said cathode, a condenser and resistance means effectively in parallel therewith for generated periodic waves, said condenser and resistance means coupling said inner and outer grids and having a phase shift of less than 90°, and means for applying operating potentials to the electrodes of said tube and for maintaining said auxiliary grid at a fixed unidirectional potential relative to said cathode and said inner grid at a higher unidirectional potential than said outer grid, means for applying a synchronizing signal to said auxiliary grid, and a parallel-connected resistor and condenser effectively connected between said anode and cathode and having a time constant of a predetermined value greater than and functionally related to the period of the wave to be generated, thereby to develop an output voltage wave thereacross of saw-tooth form.

11. A relaxation oscillator comprising a vacuum tube having a cathode, a control grid, a screen grid, a suppressor grid and an anode, a circuit between said cathode and said anode consisting of a resistor and a source of voltage in series, said source being so poled as to apply a positive voltage to said anode, a circuit between said cathode and said screen grid consisting of a resistor and a source of potential in series, said second source being so poled as to apply a positive voltage to said screen grid, a circuit between said cathode and said suppressor grid consisting of a resistor and a third source of potential, said third source being so poled as to apply a negative potential to said suppressor grid, a condenser connected between said screen grid and said suppressor grid, and a grid resistor connected between said control grid and said cathode, the voltage applied to said screen grid being substantially greater than the voltage applied to said anode.

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