

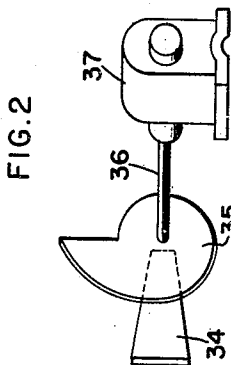
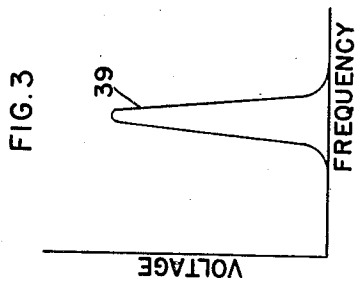
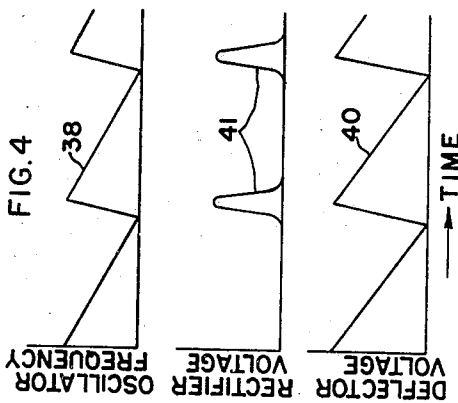
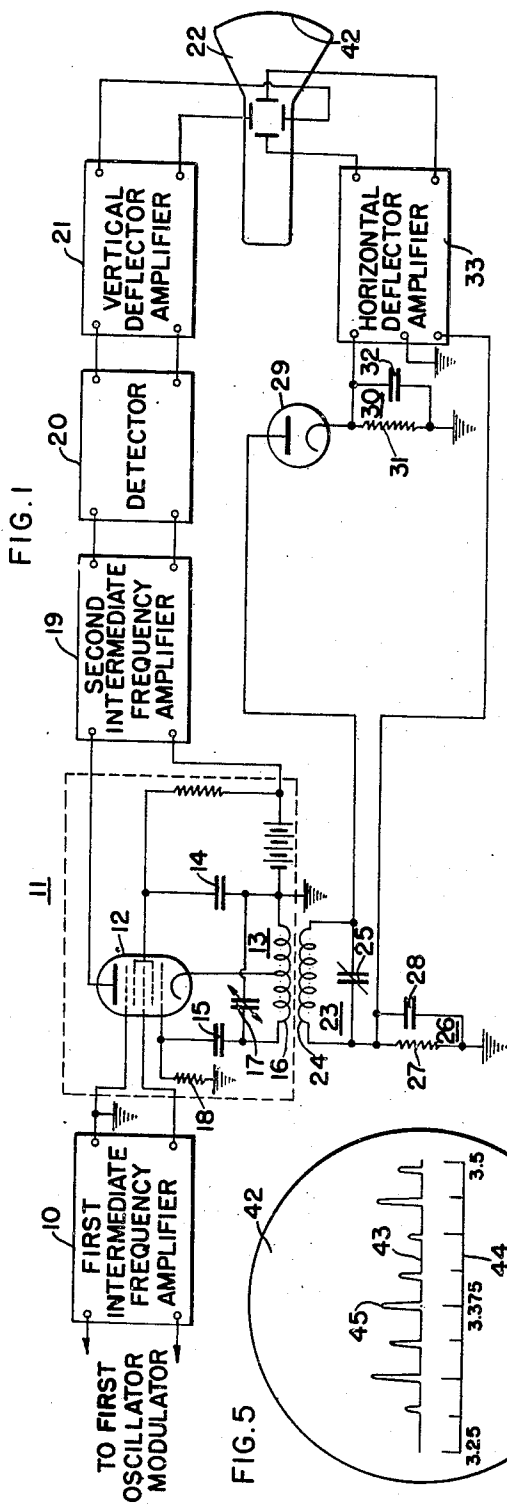
Oct. 23, 1945.

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2,387,685

VOLTAGE GENERATOR

Filed Feb. 15, 1943



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## UNITED STATES PATENT OFFICE

2,387,685

## VOLTAGE GENERATOR

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Application February 15, 1943, Serial No. 475,861

7 Claims. (Cl. 250—36)

This invention relates to the generation of periodic voltages and particularly to voltages of complex wave form such as saw-tooth and related forms.

According to conventional practice in the operation of cathode ray tubes, there is customarily provided a voltage of saw-tooth wave form for deflection purposes. When a saw-tooth voltage is applied to one set of cathode ray tube deflection elements, an electron beam is deflected across the screen of the tube alternately in two opposite directions. Usually the electron beam is started at one side of the fluorescent screen of the tube and is moved in a linear manner at a uniform relatively low velocity across the screen to the opposite side. The beam is then returned to its starting point at a uniform relatively high velocity. These two deflections of the electron beam are effected under the control of a voltage applied to one set of deflecting elements. In order to secure the two uniform deflection velocities, this voltage has a saw-tooth wave form. Voltages applied to the other set of deflecting elements cause deflections of the electron beam in a direction normal to that of the deflection effected by the first set of deflecting elements. For many uses of cathode ray tubes, it is necessary to secure a highly accurate and constant time relation between the two deflection voltages.

Certain arrangements heretofore have been devised to produce the desired time relation between the deflection voltages. For example, one expedient for this purpose is the use of two self-oscillating voltage generators which are periodically controlled by a means common to both. However, between the control periods, each generator operates independently of the other and, consequently, departures from the desired time relation are possible. For uses of cathode ray tubes, such as oscilloscopes, where an effect to be observed occurs repeatedly at the same point in a time cycle, it is necessary to secure a high degree of precision in the time relation between the deflection voltages. Otherwise, the trace or other indication on the cathode ray screen will shift in position on the screen.

The object of the present invention, therefore, is to provide an improved deflection voltage generator for cathode ray tubes by means of which it is possible to secure a precise, positive synchronization between the horizontal and vertical deflection systems.

Another object of the invention is to provide an improved method of generating a saw-tooth wave

which comprises the forming into unidirectional energy of saw-tooth wave form of a series of energy pulses derived from a periodically modulated alternating current.

In accordance with the present invention, there is provided a generator of periodic waves of a predetermined form comprising a means for periodically modulating an alternating current to produce a voltage of predetermined frequency and predetermined amplitude. The modulated alternating current is impressed upon an oscillatory circuit which is designed to respond only to a voltage of the predetermined frequency and the predetermined amplitude. Thus, a series of sharp pulses of energy is developed by the oscillatory circuit, the pulses recurring at a periodicity equal to that of the modulating frequency. The energy pulses are applied to a wave-forming circuit to produce a wave of the predetermined form which has a periodicity equal to that of the modulating frequency.

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:

Fig. 1 is a partly schematic circuit diagram of a portion of a superheterodyne receiver embodying the invention;

Fig. 2 is a detail of a frequency-changing element;

Fig. 3 is a graph of the resonance characteristics of the oscillatory circuit;

Fig. 4 illustrates graphically, the frequency time variation of the frequency-modulated alternating current, the voltage time relation of the generated saw-tooth wave, and the impulse energy time relation of the oscillatory circuit; and

Fig. 5 is a view of the cathode ray tube screen.

Referring now more particularly to Fig. 1 of the drawing, there is shown schematically the first and second intermediate frequency amplifier and the signal frequency amplifier portions of the superheterodyne receiver embodying the present invention in a preferred form. A receiver of this character is frequently used for the panoramic reception of all radio signals in a predetermined frequency band. After amplifying the received radio frequency signals and converting them to a first intermediate frequency in the present receiver, the converted signals are impressed upon a first intermediate frequency am-

plifier 10. This amplifier is tuned to amplify all frequencies within a relatively wide band of frequencies whereby a number of different signals are simultaneously amplified.

The output of the first intermediate frequency amplifier 10 is connected to an oscillator-modulator 11 wherein the intermediate frequency signals are mixed with a frequency generated by a local oscillator for the purpose of converting them to a second intermediate frequency. There is provided in the local oscillator a vacuum tube 12 which serves the dual function of aiding in the generation of the local oscillations and of mixing these oscillations with the first intermediate frequencies. The frequency of the locally produced oscillations is governed by a frequency-determining circuit 13 which is coupled between the input and output circuits of the oscillator portion of the tube 12 by condensers 14 and 15 and which includes an inductor 16 and a variable condenser 17. A leak from the oscillator grid is provided to ground through a resistor 18. The capacity of the condenser 17 is continuously varied by means to be described, whereby the frequency of the locally generated oscillations is varied between two limit frequencies as determined by the constants of the frequency-determining circuit 13.

The intermediate frequency signals thus produced then are amplified by a second intermediate frequency amplifier 19. This amplifier is tuned to pass a narrow band of frequencies, preferably including only a single second intermediate frequency. The amplified second intermediate frequency signals are rectified or demodulated by a detector 20 and the resulting signals are subsequently amplified by a vertical deflector amplifier 21. This amplifier is designed to function at signal frequencies. The amplified signals then are applied as deflection voltages to the vertical deflection elements of a cathode ray tube 22.

The varying frequency potential generated by the local oscillator is coupled inductively to an oscillatory circuit 23 comprising an inductor 24 and a condenser 25. The coupling is secured by properly disposing the inductors 16 and 24 with respect to each other. There is connected to the oscillatory circuit 23 a forming circuit 26 comprising a parallel arrangement of a resistance 27 and a condenser 28.

The energy pulses developed by the oscillatory circuit 23 are impressed upon a rectifier circuit including a diode rectifier tube 29 and a forming circuit 30 comprising a parallel arrangement of a resistance 31 and a condenser 32. The opposite polarity varying magnitude unidirectional potentials which are derived respectively from the wave forming circuits 26 and 30, have saw-tooth forms and are amplified by a horizontal deflector amplifier 33. The amplified saw-tooth voltage wave is connected to the horizontal deflection elements of the cathode ray tube 22 to control the horizontal deflection of the electron beam.

The variable condenser 17, forming a part of the frequency-determining circuit of the local oscillator, may be provided with plates having generally the shapes illustrated in Fig. 2. A stator plate 34 has a wedge-like shape. A rotor plate 35 has a periphery which is substantially spiral-shaped with a radially extending portion joining the two ends of the spiral. The rotor plates are connected to a shaft 36 which is rotated by a motor 37. With the motor 37 operating at a substantially constant rate of 1800 R. P. M., for example, the capacity of the condenser is varied from one extreme value to the other extreme val-

ue in, say  $9/300$  of a second. This result may be secured by properly shaping the condenser plates in the manner described. Having attained said other extreme value of condenser capacity, resulting in the generation of one of the limit frequencies, further rotation of the rotor plates changes the capacity to said first extreme value in, say  $1/300$  of a second. The cycle is repeated continuously, whereby the frequency of the local oscillator is varied in a substantially linear manner with respect to time at the rate of 30 cycles per second.

Thus, it is seen that it is possible to achieve a linear change in frequency with respect to time from one limit frequency to a second limit frequency at a relatively low rate of change. Also, by reason of the apparatus described, it is possible to obtain a linear change of frequencies with respect to time from the second limit frequency to the first at a relatively high rate of change. The graphic plot of such a frequency change may be represented by the curve 38 of Fig. 4. Those portions of the curve having the lesser slopes represent the frequency change of the local oscillator at the relatively low rate, while the portion of the curve having the greater slopes represent the frequency change of the oscillator at the relatively high rate.

The parameters of the oscillatory circuit 23 are adjusted to produce a sharp resonant response by this circuit to an impressed voltage of a predetermined frequency and a predetermined amplitude. The resonance characteristic of this circuit is represented in Fig. 3 by a curve 39. The frequency at which the response by the oscillatory circuit occurs may be any predetermined frequency in the band of frequencies determined by the two limit frequencies. It is preferable, however, to produce the resonant response by the oscillatory circuit at one of the limit frequencies. For the purpose of this description assume that the response is at the higher of the two limit frequencies.

When an energy pulse of the character represented by the curve 39 of Fig. 3 is applied to the rectifier circuit of Fig. 1, the result is the rapid charging of the condensers 28 and 32 in the respective forming circuits 26 and 30. The condenser charges then are dissipated at a lower rate through the associated resistances 27 and 31. Consequently, the voltages derived from the forming circuits change substantially linearly with respect to time at a relatively high rate from one value to a second value by reason of the charging of the condensers. These voltages then change from the second value to the first value substantially linearly with respect to time at a relatively low rate as a result of the dissipation of the condenser charges through the resistances. These voltages are of opposite polarity and, when simultaneously amplified by the amplifier 33, produce a saw-tooth form voltage having a value which is substantially double that of either.

The wave form of the amplified voltage is represented by the curve 40 of Fig. 4. Those portions of the curve having the greater slopes represent the charging of the condensers 28 and 32 and the portions of the curve having the lesser slopes represent the dissipation of the condenser charges through the resistances 27 and 31. Also in Fig. 4 is a graphic representation of the time-spaced energy pulses developed by the oscillatory circuit 23. These pulses are represented by the curves 41 and the time relation between successive energy pulses and the peaks of the saw-tooth voltage de-

rived from the wave-forming circuits may be seen. The energy impulses represented by the curves 41 occur coincidentally with the peaks of the saw-tooth voltage wave 40. Thus, it is seen that the periodicity of the saw-tooth deflection voltage wave is equal to the periodicity of the energy pulses developed by the oscillatory circuit.

Referring now to the operation of the system, assume that it is desired to receive panoramically all radio signals in a band of frequencies between the limit frequencies of 3.25 megacycles and 3.5 megacycles. The radio frequency amplifier stage of the receiver is tuned to pass all frequencies within this band. If it is also assumed that the first oscillator by means of which the first intermediate frequency signals are produced, generates a wave having a frequency of 5.42 megacycles, there will be impressed upon the first intermediate frequency amplifier 10, intermediate frequencies between the limit frequencies of 1.92 megacycles and 2.17 megacycles. It is seen that the band width of the radio frequency signals and also of the first intermediate frequency signals is 250 kilocycles. All signals within the frequency band between 1.92 megacycles and 2.17 megacycles are amplified by the first intermediate frequency amplifier 10. They then are applied to the oscillator modulator 11 by which they are converted successively to the second intermediate frequency. If it is assumed that the second intermediate frequency is to be 295 kilocycles, the local oscillator including the tube 12 must vary between the limit frequencies of 1.625 megacycles and 1.875 megacycles. This variation is also seen to be within a frequency band of 250 kilocycles and is periodically effected at the assumed rate of 30 cycles per second.

In order to clearly understand the following portion of the description, reference will be made to Fig. 5. There is shown in this figure of the drawing the fluorescent screen 42 of the cathode ray tube 22. The trace made by the electron beam upon this screen is represented by the line 43. For convenience in interpreting the trace made upon the screen there may be provided a scale 44 which is graduated in units representing the radio frequencies of the received signals. In the assumed case the limit frequencies are 3.25 megacycles and 3.5 megacycles which are indicated respectively on the screen by numerals corresponding to these frequencies.

As the variable condenser 17 of Fig. 1 varies from the capacity producing an oscillator frequency of 1.625 megacycles to the capacity producing an oscillator frequency of 1.875 megacycles, all first intermediate frequency signals are converted successively in point of time to the assumed second intermediate frequency of 250 kilocycles. Each time that the second intermediate frequency is produced there is a voltage resulting therefrom which is detected, amplified and then applied to the vertical deflector elements of the cathode ray tube 22. Each of these voltages effects a vertical deflection of the electron beam and thereby produces a vertical trace such as 45 upon the screen 42 of the tube. Since the oscillator frequency is varying continuously with respect to time through the assumed frequency spectrum and is effective, not only to produce the second intermediate frequency, but also to control the generation of the voltage applied to the horizontal deflector elements of the cathode ray tube, the vertical traces produced by the generation of the second intermediate frequency appear upon the screen in spaced relation to one another. Also, 75

by reason of the linear manner with respect to time that the oscillator frequency change is effected, the spacing on the cathode ray tube screen 42 of any vertical trace from the starting point of the horizontal deflection of the electron beam is a measure of the frequency deviation of the signal producing the vertical trace from the frequency represented by the starting point of the horizontal deflection. Since such a point represents the lower limit frequency of the band of frequencies under observation, the horizontal position of the vertical trace is an indication of the radio frequency of the signal producing the trace. The wave form of the vertical trace corresponds to the tuning of the vertical deflector amplifier 21. Consequently, it is seen that, for every signal in the band of frequencies under observation, there is produced on the screen 42 of the tube 22 a vertical trace displaced horizontally from the side of the screen by an amount corresponding to the difference of the radio frequency upon which the signal is modulated from one of the limit radio frequencies. For example, in the case assumed, a signal having a radio frequency of 3.375 megacycles will appear as the trace 45 at the center of the screen for the reason that such a frequency lies mid-way between the two assumed limit radio frequencies of 3.25 megacycles and 3.5 megacycles.

It has been found that, when working within the range of frequencies specified in the assumed example used for illustrative purposes, an oscillatory circuit which has a resonance characteristic capable of effecting the development of short energy impulses at a predetermined frequency is one in which the inductor 24 has a value of 287 microhenrys and the condenser 25 has a value of 25 micromicrofarads.

It will be obvious to those skilled in the art that it is within the scope of the instant invention to permit a substantial deviation from linearity in the variation of the oscillator frequency by means of variable condenser 17. Insofar as the derivation of a saw-tooth voltage wave from a frequency-modulated alternating current in accordance with the instant invention is concerned, it is immaterial what the shape of the curve representing the frequency time relation of the oscillator variation is, so long as there is generated periodically the predetermined frequency at which the oscillatory circuit 23 develops an energy pulse. Of course, in cases where the oscillator frequency is varied for a purpose such as that described, it is desirable that the variation be substantially linear with respect to time. However, since the apparatus utilizing the linear frequency variation for the production of the second intermediate frequency forms no part of the present invention, it is not contemplated that the saw-tooth wave generator be limited to the control by a linearly varying oscillator frequency. Also, it is obviously within the scope of the invention to develop the time-spaced energy pulses by the periodic amplitude-modulation of an alternating current wave of the predetermined frequency.

It is seen that, by reason of the arrangement provided by the instant invention, it is possible to secure positive synchronization between the vertical and horizontal deflection voltages for a cathode ray tube which is of a high order of precision throughout the entire ranges of such voltages. Such synchronization is necessary when using a cathode ray tube for a purpose such as that described, namely, as the indicating element in a panoramic radio receiver. In order for the

trace produced upon the screen of the tube by a signal of a given frequency to be repeated on successive horizontal deflections of the electron beam, and upon each repetition to appear at the same point on the screen, positive synchronization between the two deflecting systems must be of a high order of precision. It will be obvious that these requirements are satisfactorily met by the instant invention.

While there has been described what is at present 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 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. In a saw-tooth wave generator, an oscillator for generating a wave having normal amplitude and frequency characteristics and having coupled thereto a resonant network to determine the free oscillation frequency, means coupled to said oscillator for repeatedly varying one of said characteristics of said wave through a given range of values, whereby once during each cycle of variation to produce a voltage of predetermined frequency and predetermined amplitude, an oscillatory circuit coupled to said resonant network and adjusted for response substantially only at said predetermined frequency and said predetermined amplitude, whereby to develop a series of energy pulses of a periodicity equal to the production periodicity of said voltage of predetermined frequency and amplitude, and means including a wave-forming integrating circuit coupled to said oscillatory circuit for converting said energy pulses to a unidirectional wave of saw-tooth form.

2. In a saw-tooth wave generator, an oscillator, means including said oscillator for periodically frequency-modulating an alternating current wave in a predetermined band of frequencies, an oscillatory circuit sharply tuned for resonance at one of said frequencies in said band, means for impressing said frequency-modulated wave upon said oscillatory circuit to develop a series of energy pulses of a periodicity equal to the periodicity of said frequency modulation, and means including an integrating circuit for converting said energy pulses to a periodic unidirectional wave of saw-tooth form.

3. In a saw-tooth wave generator, an oscillator, means for controlling said oscillator to generate periodically an alternating current wave modulated in frequency in a band of frequencies determined by two limit frequencies, an oscillatory circuit sharply tuned for resonance at one of said limit frequencies, means including said oscillatory circuit for deriving from said frequency-modulated wave a series of energy pulses of a periodicity equal to the periodicity of said frequency modulation, and a rectifier including an integrating circuit for converting said energy pulses to a periodic unidirectional wave of saw-tooth form.

4. In a saw-tooth wave generator, an electronic oscillator having a frequency-determining circuit, means including said oscillator and controlled by said frequency-determining circuit for generating periodically an alternating current wave modulated in frequency in a band of frequencies determined by two limit frequencies, an oscillatory circuit sharply tuned for resonance at one of said limit frequencies, means including said oscillatory circuit for deriving from said frequency-modulated wave a series of energy pulses of a periodicity equal to the periodicity of said frequency modulation, and a rectifier including a saw-tooth wave-forming circuit for converting said energy pulses to a unidirectional wave of saw-tooth form.

5. In a saw-tooth wave generator, a circuit sharply tuned for resonance at a predetermined frequency, an oscillation generator including a frequency-determining circuit, motor-driven means for continuously varying the constants of said frequency-determining circuit to effect the periodic generation by said oscillator of a predetermined band of frequencies including said predetermined frequency, means for coupling said generator to said tuned circuit to effect the development of a series of periodic energy pulses by said tuned circuit by the resonance thereof at said predetermined frequency, means for demodulating said energy pulses, and means including a saw-tooth wave-forming circuit connected to said demodulating means to effect the generation from said energy pulses of a wave having a saw-tooth form and a frequency equal to the frequency of said pulses.

6. In a saw-tooth wave generator, a circuit sharply tuned for resonance at a predetermined frequency, an oscillator tube having input and output circuits, a frequency-determining circuit connected between said input and output circuits and having a variable condenser, a driving motor for continuously varying the capacity of said condenser to effect the periodic generation by said oscillator of a predetermined band of frequencies including said predetermined frequency, means for impressing said band of frequencies upon said tuned circuit to effect the development of a series of periodic energy pulses by said tuned circuit by the resonance thereof at said predetermined frequency, a rectifier connected to said tuned circuit, means including said rectifier for demodulating said energy pulses, and means including a parallel arrangement of resistance and capacitance connected to said rectifier to effect the generation from said demodulated pulses of a unidirectional wave having a saw-tooth form and a frequency equal to the frequency of said pulses.

7. The method of generating a saw-tooth wave which includes the steps of, effecting a periodic frequency modulation of an alternating current wave, deriving periodically from said frequency-modulated alternating wave a series of energy pulses, and converting said energy pulses to unidirectional energy of a saw-tooth wave form.

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