

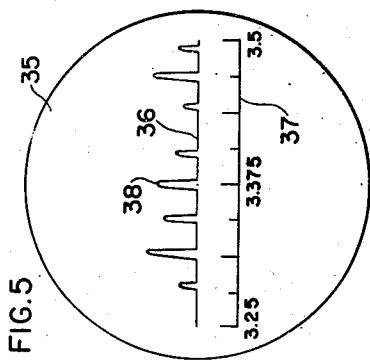
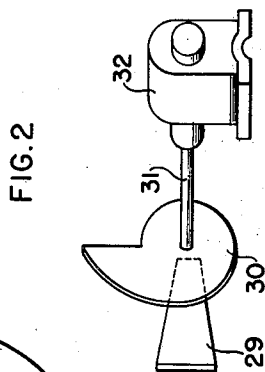
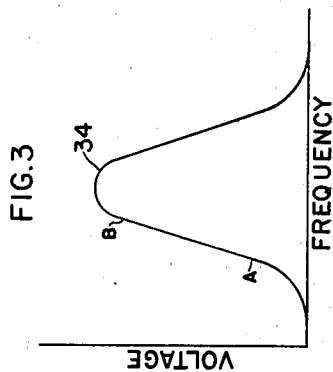
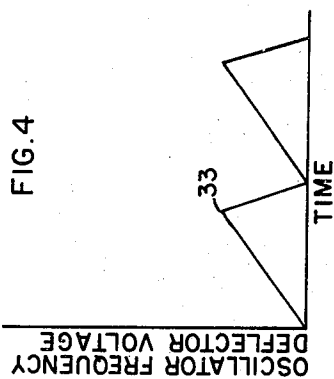
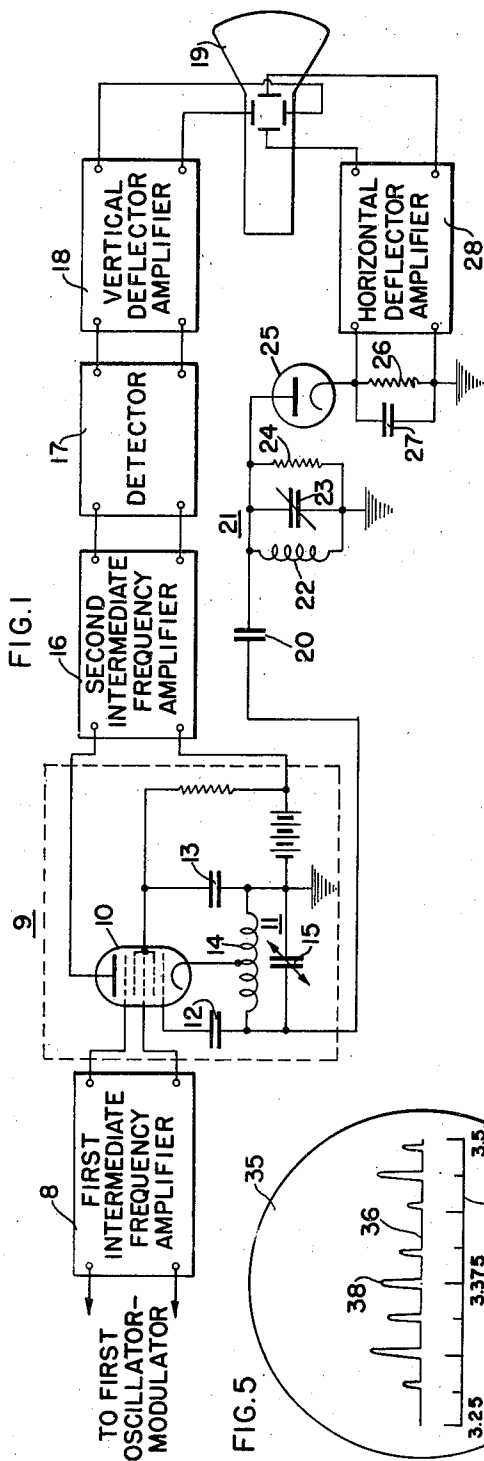
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ELECTRONIC SAW-TOOTH VOLTAGE GENERATOR

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ELECTRONIC SAW-TOOTH VOLTAGE GENERATOR

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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 close time relation between the two deflection voltages.

Certain arrangements have heretofore 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.

An 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 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 demodulation of a saw-toothed amplitude-modulated alternating current wave which is derived from a substantially saw-toothed frequency-modulated alternating current wave.

In accordance with the present invention,

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there is provided a generator of periodic waves of a predetermined form comprising a means for periodically frequency-modulating an alternating current wave in a band of frequencies between predetermined limit frequencies. The frequency modulation is effected as a predetermined function of time. The frequency-modulated wave is impressed upon an oscillatory circuit having a resonance characteristic such that between the predetermined limit frequencies there is developed periodically in the oscillatory circuit, an alternating voltage varying linearly in amplitude with respect to time. The varying amplitude frequency-modulated alternating voltage wave is demodulated and the resultant wave has a saw-tooth form of a periodicity equal to the periodicity of the frequency modulations.

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 characteristic of the oscillatory circuit;

Fig. 4 is a graph representing the frequency-time variation of the frequency-modulated alternating current wave and also the voltage-time variation of the generated saw-tooth wave; 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 may be used for the panoramic reception of all radial 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 amplifier 8. 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 8 is connected to an oscillator-modulator 9 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 10 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 11 which is coupled between the input and output circuits of the oscillator portion of the tube 10 by condensers 12 and 13 and which includes an inductor 14 and a variable condenser 15. The capacity of the condenser 15 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 11.

The intermediate frequency signals thus produced are then amplified by a second intermediate frequency amplifier 16. 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 17 and the resulting signals are subsequently amplified by a vertical deflector amplifier 18. This amplifier is designed to function at signal frequencies. The amplified signals are then applied as deflection voltages to the vertical deflection elements of a cathode ray tube 19.

The varying frequency potential generated by the local oscillator is capacitatively coupled by means of a condenser 20 to an oscillatory circuit 21. This circuit comprises a parallel arrangement of an inductor 22 and a condenser 23, and preferably a damping resistance 24 connected in shunt therewith. There is provided for the oscillatory circuit a connection to ground. The alternating voltage of varying amplitude and frequency, which is developed by the oscillatory circuit 21 is demodulated by a rectifier circuit including a diode rectifier tube 25 and a load resistance 26. There is provided in shunt with the load resistance a small condenser 27 for the purpose of by-passing the high frequency component of the voltage developed by the oscillatory circuit 21. The varying amplitude unidirectional potential which is derived from the load resistance 26 has a saw-tooth form and is amplified by a horizontal deflector amplifier 28. The amplified saw-tooth voltage wave is connected to the horizontal deflection elements of the cathode ray tube 19 to control the horizontal deflection of the electron beam.

The variable condenser 15, 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 29 has a wedge-like shape. A rotor plate 30 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 31 which is rotated by a motor 32.

With the motor 32 operating at a substantially constant rate of 1800 R. P. M., for example, the capacity of the condenser is varied from its minimum value to its maximum value in $\frac{1}{30}$ of a second, 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. This result may be secured by properly shaping the condenser plates in the manner described. Having attained the maximum value of condenser capacity, resulting in the generation of one of the limit frequencies, further rotation of the rotor

plates substantially instantaneously reduces the capacity to its minimum value, after which the cycle is repeated. The change from maximum to minimum capacity of the variable condenser 15 does not effect the same instantaneous change in the oscillator frequency. However, this frequency does change from one limit frequency to the other in a much shorter time than that required for the frequency change in the opposite sense.

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 means of the apparatus described, it is possible to obtain a linear change in frequency 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 33 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 portions 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 21 are adjusted to produce a resonance characteristic of this circuit which embraces a wide band of frequencies. Such a characteristic is represented in Fig. 3 by a curve 34. In the case where the variable condenser 15 of Fig. 1 is of a character to produce a linear frequency change with respect to time, it is desired to operate the apparatus between limit frequencies producing a substantially linear resonance characteristic of the oscillatory circuit 21. For example, the lower frequency limit would be that which corresponds to the point A on the curve 34. The upper frequency limit would be the one represented by the point B on this curve. Thus, it is seen that, as the frequency of the local oscillator is varied between the two limit frequencies designated by the points A and B, the voltage which is developed by the oscillatory circuit varies between maximum and minimum values as seen by referring the points A and B to the vertical coordinates of the curve. If the frequency variation at the relatively low rate of change is made from the frequency corresponding to point A to the frequency corresponding to point B, and in the reverse sense at the relatively high rate of change, the voltage developed by the oscillatory circuit increases from the low value designated by the point A at a relatively low rate to the value designated by the point B and decreases to the point A at a relatively high rate of change. Since the developed voltage change is linear with respect to the frequency producing the change, a graphic plot of this voltage with respect to time would also have a saw-tooth wave form.

When the varying-voltage alternating current developed by the oscillatory circuit 21 is rectified, the resulting unidirectional voltage will also have a saw-tooth wave form. This unidirectional voltage may be represented also by the curve 33 of Fig. 4. It is seen that, since the same curve represents the oscillator frequency change with respect to time and also the rectified unidirectional voltage with respect to time, the latter has the same periodicity as the periodicity of the frequency variation of the local oscillator.

Referring now to the operation of the system, assume that it is desired to receive panoramically radio signals in a band of frequencies between

the limit radio 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 8, 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 8. They are then applied to the oscillator-modulator 9 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 10 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 clearly to 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 35 of the cathode ray tube 19. The trace made by the electron beam upon this screen is represented by the line 36. For convenience in interpreting the trace made upon the screen, there may be provided a scale 37 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 15 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 applied to the vertical deflecting elements of the cathode ray tube 19. Each of these voltages effects a vertical deflection of the electron beam and thereby produces a vertical trace such as 38 upon the screen 35 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, 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 35 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 rep-

resents 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 18. Also, each trace is constantly varying in amplitude as a result of the signaling modulations of the radio frequency carrier wave of which the trace is representative. Consequently, it is seen that, for every signal in the band of frequencies under observation, there is produced on the screen 35 of the tube 19, 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 38 at the center of the screen for the reason that such a frequency lies midway 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 including a substantially linear portion is one in which the inductor 22 has an approximate value of $2\frac{1}{2}$ millihenries and the condenser 23 has an approximate value of 100 micromicrofarads. The damping resistance 24 has a value suitable to provide the linear portion of the curve 34 with the desired slope.

It will be obvious to those skilled in the art that it is within the scope of the instant invention to permit some deviation from linearity in the variation of the oscillator frequency by means of the variable condenser 15. In such a case, this may be compensated for by a corresponding deviation from linearity in the opposite sense in the resonance characteristic of the oscillatory circuit 21. By properly adjusting these two circuit elements, a horizontal deflector voltage having a saw-tooth wave form may also be produced in this case.

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 degree 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 oscillation generator having a frequency determining circuit including a variable condenser, a driving motor connected to rotate said condenser and thereby continuously vary the constants of said frequency determining circuit in a manner to effect the periodic generation by said oscillation generator of a potential having frequencies varying relatively slowly in one sense and relatively rapidly in the opposite sense in a linear manner with respect to time and periodically through a predetermined band of frequencies, an oscillatory circuit having maximum and minimum cutoff frequencies and also having a substantially linear resonance characteristic throughout said predetermined band of frequencies, means coupling said oscillation generator to said oscillatory circuit to impress said variable frequency potential upon said oscillatory circuit, whereby to effect the development by said oscillatory circuit of an alternating voltage having a linearly varying amplitude with respect to time, and means coupled to said oscillatory circuit for rectifying said variable amplitude alternating voltage to produce a saw-tooth wave having a periodicity equal to the periodicity of the frequency variation of said oscillation generator.

2. In a saw-tooth wave generator, an oscillation generator having a frequency determining circuit including a variable condenser, a driving motor connected to rotate said condenser and thereby continuously vary the constants of said frequency determining circuit in a manner to effect the periodic generation by said oscillation generator of a potential having frequencies varying relatively slowly in one sense and relatively rapidly in the opposite sense in a linear manner with respect to time and periodically through a predetermined band of frequencies, a parallel resonant oscillatory circuit having maximum and minimum cutoff frequencies and also having a substantially linear resonance characteristic throughout said predetermined band of frequencies, capacitive coupling means between said oscillation generator and said oscillatory circuit to impress said variable frequency potential upon said oscillatory circuit, whereby to effect the development by said oscillatory circuit of an alternating voltage having a linearly varying amplitude with respect to time, and means coupled to said oscillatory circuit for rectifying said variable amplitude alternating voltage to produce a saw-tooth wave having a periodicity equal to the periodicity of the frequency variation of said oscillation generator.

3. In a saw-tooth wave generator, an oscillation generator having a frequency determining circuit including a variable condenser comprising a set of stator plates and a set of rotor plates, one of said sets of plates being spiral-shaped and mounted with all plates in alignment, the other of said sets of plates being wedge-shaped and mounted with all plates in alignment, a driving motor connected to rotate the set of rotor plates of said condenser and thereby continuously vary the constants of said frequency determining circuit in a manner to effect the periodic generation by said oscillation generator of a potential having frequencies varying relatively slowly in one sense and relatively rapidly in the opposite sense in a linear manner with respect to time and periodically through a predetermined band of

frequencies, an oscillatory circuit comprising a parallel arrangement of inductance and capacitance devices and having maximum and minimum cutoff frequencies and also having a substantially linear resonance characteristic throughout said predetermined band frequencies, means coupling said oscillation generator to said oscillatory circuit to impress said variable frequency potential upon said oscillatory circuit, whereby to effect the development by said oscillatory circuit of an alternating voltage having a linearly varying amplitude with respect to time, and means including a diode coupled to said oscillatory circuit for rectifying said variable amplitude alternating voltage to produce a saw-tooth wave having a periodicity equal to the periodicity of the frequency variation of said oscillation generator.

4. In a saw-tooth wave generator, an oscillation generator having a frequency determining circuit including a variable condenser comprising a plurality of wedge-shaped stator plates and a plurality of spiral-shaped rotor plates, all of said stator plates and all of said rotor plates being respectively mounted in alignment, a driving motor connected to rotate the set of rotor plates of said condenser and thereby continuously vary the constants of said frequency determining circuit in a manner to effect the periodic generation by said oscillation generator of a potential having frequencies varying relatively slowly in one sense and relatively rapidly in the opposite sense in a linear manner with respect to time and periodically through a predetermined band of frequencies, an oscillatory circuit comprising a parallel arrangement of inductance, capacitance and damping resistance devices and having maximum and minimum cutoff frequencies and also having a substantially linear resonance characteristic throughout said predetermined band of frequencies, means including a condenser coupling between said oscillation generator to said oscillatory circuit to impress said variable frequency potential upon said oscillatory circuit, whereby to effect the development by said oscillatory circuit of an alternating voltage having a linearly varying amplitude with respect to time, and means including a diode coupled to said oscillatory circuit and having a load circuit for rectifying said variable amplitude alternating voltage to produce in said load circuit a saw-tooth wave having a periodicity equal to the periodicity of the frequency variation of said oscillation generator.

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