

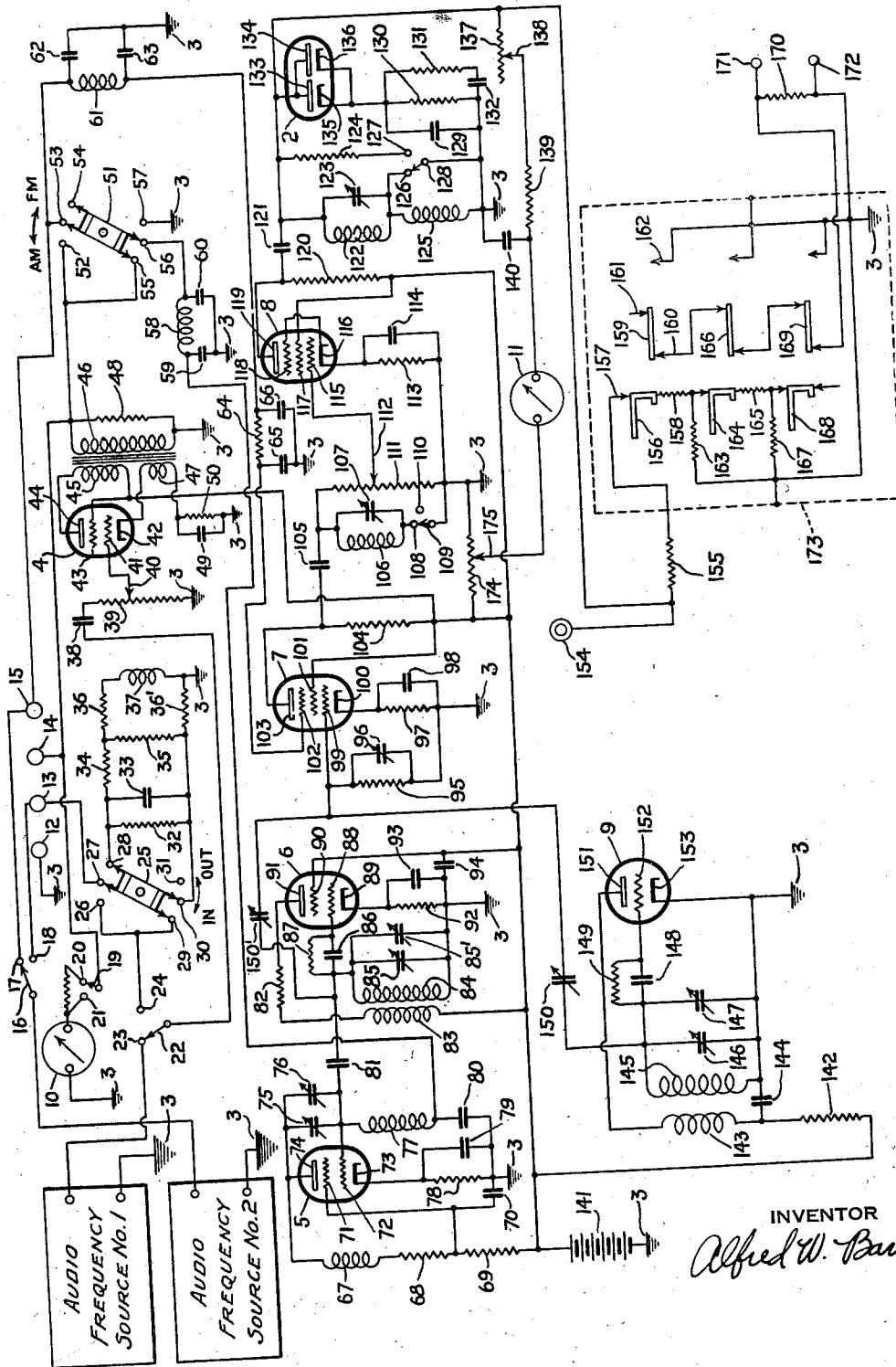
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SIGNAL GENERATOR

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SIGNAL GENERATOR

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The present invention concerns signal generators and in particular frequency modulated signal generators employing beating oscillators.

One object of the present invention is to provide an improved frequency modulated signal generator.

Another object is to provide improved modulation characteristics in a variable carrier frequency modulated signal generator.

Still another object is to provide means for changing the frequency range of the signal generator without affecting its modulation characteristics.

A further object is to provide either amplitude modulation or frequency modulation or both simultaneously in a signal generator.

These and other objects will be evident from the detailed description of the invention given in connection with the drawing.

In order to design and test frequency modulation radio receivers and systems a variable frequency modulated signal generator is very useful. A frequency modulated signal is one in which the frequency is varied above and below the mean frequency at the modulation rate and in which the instantaneous frequency deviation from the mean is a linear function of the instantaneous value of the modulating voltage. A number of methods have been employed in the past for frequency modulating a signal. One method has been to vary the apparent capacity across an oscillatory circuit by means of a thermionic vacuum tube. If a thermionic vacuum repeater tube is operated with a resistive plate load and a plate to grid capacity the grid to cathode impedance of the tube is a capacity which varies with the gain of the tube. The gain may be varied by control of the grid voltage by means of a modulating voltage. The amount and quality of the modulation which may be obtained by this method depends on the mutual conductance of the tube, the plate to grid capacity and the plate load resistor among other factors. In order to obtain large amounts of frequency deviation and which remains constant as the mean frequency is varied has presented a considerable problem in the past. The problem is further complicated if amplitude modulation is also required.

According to the present invention the frequency modulation is accomplished at a fixed frequency and hence under fixed conditions. In order to provide a variable mean frequency the modulated signal beats with a variable frequency

unmodulated signal and the sum and difference frequencies are utilized. The frequencies are chosen so that the difference frequencies are chosen to provide a low frequency range as, for instance, 1 to 10 megacycles and the sum frequencies are chosen to provide a high frequency range as, for instance, 41 to 50 megacycles. Selection of the desired range is accomplished after detection so that no switching is required in the oscillator circuits. Amplitude modulation is accomplished in the detector which permits operation with frequency or amplitude modulation separately or both together.

In the drawing is shown a circuit diagram of one form of the invention.

The circuit diagram shows fixed modulated oscillator 6, variable frequency oscillator 9, modulator 5, audio frequency driver 4, detector 7, amplifier 8 and voltmeter tube 2. Various ground points 3 are common to the system. Fixed oscillator tube 6 may be any suitable thermionic vacuum tube as for instance the beam tetrode shown having cathode 89 heated by conventional means not shown, control grid 88, screen grid 99, and plate 91. Grid 88 is connected to oscillator tank coil 84 through grid leak 87 by-passed by grid condenser 86. Oscillation is produced by means of feed-back coil 83 connected to plate 91 through parasitic oscillation suppressor resistor 82 and plate bias source 141. Cathode 89 receives a proper bias by means of the cathode current flowing in resistor 92. Cathode bias resistor 92 is connected between cathode 89 and ground 3 and is by-passed by condenser 93. Screen 90 receives a bias from source 141 and is by-passed by condenser 94. The frequency of oscillation of tube 6 is partially determined by trimmer condensers 85 and 85¹. The frequency of oscillation of tube 6 is finally determined by an effective grid to cathode capacity of modulator tube 5.

Modulator tube 5 may be any suitable tube as for instance the tetrode shown including cathode 73, control grid 72, screen grid 71 and plate 74. The effective grid to cathode capacity of tube 5 is placed across tank coil 84 by means of coupling condenser 81. Cathode 73 receives its bias by means of cathode current flowing in cathode resistor 78 connected between cathode 73 and ground 3 and by-passed by condenser 79. Screen 71 receives its bias from source 141 and is by-passed by means of condenser 70. The effective grid to cathode capacity of tube 5 is partly controlled by the parallel condensers 75 and 76 connected between grid 72 and plate 74 and by means of plate load consisting of resistor 68 and phasing

coil 67 connected between plate 74 and bias source 141 through decoupling resistor 69. The effective grid to cathode capacity of tube 5 is also partly determined by the mutual conductance of tube 5 as determined by the net bias between control grid 72 and cathode 73. This effective capacity is varied by means of a modulating voltage applied to grid 72 through choke coil 77 and across radio frequency filter condenser 80.

Frequency modulation of fixed oscillator 6 is accomplished by means of driver tube 4 varying the grid bias of modulator tube 5. Driver tube 4 may be any suitable tube as, for instance, the tetrode having cathode 42, control grid 41, screen grid 43 and plate 44. Driver tube 4 is essentially an amplifier and receives its input voltage from tap 40 on potentiometer 39 and feeds output transformer primary 45. Cathode 42 receives its bias from cathode current flowing in resistor 50 which is by-passed by condenser 49. The feed-back coil 47 is connected in series with cathode 42 and resistor 50 in order to decrease distortion by means of degenerative feed-back. The voltage across secondary 46 is applied to grid 72 in order to frequency modulate oscillator 6 through contacts 55 and 56 of switch 51 and radio frequency filter 58, 59, 60 when switch is turned to "FM" position as shown. The deviation or amount of frequency modulation is indicated on voltmeter 10 connected across secondary 46 through switch 19, 20, 21. Switch 19, 20, 21 may switch a resistor in or out of the circuit to multiply the scale of meter 10. Resistor 48 is connected across secondary 46 in order to improve the regulation of the driving system and this may be necessary on large deviations since on large swings of voltage the power required to drive grid 72 may vary over the voltage cycle.

Audio frequency input voltage for driver 4 may be derived from any suitable internal or external source as for instance the "Audio frequency source No. 1" through coupling condenser 38 and switch 22, 23, 24. With switch arm 22 closed to contact 23 the input to driver 4 is essentially constant with audio frequency and may be controlled by potentiometer 39. Since the frequency deviation of oscillator 6 depends on the driving audio voltage as long as the other circuit elements as, for instance, condensers 85, 85', 75, 76 and resistor 68 are held constant meter 10 may be calibrated directly in kilocycles frequency deviation. Condensers 85, 85', 75, 76 and resistor 68 may be varied or changed initially in order to set the deviation sensitivity, and mean frequency of the system to match the calibration of meter 10 and to provide the desired output frequency.

Frequency modulated transmitters for broadcast service are modulated with a rising audio frequency characteristic equivalent to the curve of a circuit having a time constant of 100 microseconds. This rising characteristic may be provided by any suitable means as for instance the substantially equivalent circuit consisting of resistors 32, 34, 35, 36 and 36', condenser 33 and coil 37 all connected to selector switch 25. This circuit equivalent to a simple 100 microsecond RL circuit is constructed by connecting resistor 32 in parallel with condenser 33 and in parallel with this, resistor 34 in series with resistor 35 in parallel with resistor 36 in series with inductance 37 and resistor 36' grounded at the connection between resistor 36' and inductance 37. Modulation following this rising characteristic may be provided by turning switch 25 to "in" thereby switching the above circuit in series with a suitable

audio source as, for instance, "Audio frequency source No. 2" and switch 22 which should be placed on contact 24 and switch 16 which should be placed on contact 18. When switch 25 is in the "out" position this circuit for producing a rising characteristic is removed and audio source No. 2 produces a linear deviation of oscillator 6.

Up to this point the fixed oscillator and frequency modulation system has been described in detail. In order to produce a variable output frequency this modulated fixed frequency signal is caused to beat with a variable frequency signal. The variable heating frequency is supplied by tube 9 which includes cathode 153 heated by conventional means not shown, control grid 152, and plate 151. Grid 152 is connected to tank coil 145 through grid leak 149 by-passed by grid condenser 148. Oscillation is produced by means of feed-back coil 143 connected to plate 151 and through filter resistor 142 to bias source 141. Filter resistor 142 is by-passed by condenser 144. The frequency of oscillation is varied by means of turning condenser 146 and the range is set by trimmer condenser 147.

The beat between oscillators 6 and 9 is detected by detector 7 and is amplified by amplifier 8. Detector 7 includes cathode 100 which receives a bias due to cathode current in resistor 97 by-passed by condenser 98, control grid 99, screen grid 101, suppressor grid 102 and plate 103. Control grid 99 is returned to ground through resistor 95. Signal voltage from fixed oscillator 6 is placed on grid 99 by means of adjustable coupling condenser 150' and signal voltage from variable oscillator 9 is placed on grid 99 by means of adjustable coupling condenser 150. The attenuation of these signals at grid 99 may be varied by means of condensers 150, 150' and 96. Plate 103 is loaded by means of resistor 104 and receives its bias from source 141. Detector 7 rectifies the signals from oscillators 6 and 9 producing the sum and difference frequencies across resistor 104.

The sum and difference frequencies thus produced are amplified by means of amplifier 8. Amplifier 8 may be any suitable thermionic vacuum tube as, for instance, the pentode shown having cathode 116 receiving its bias from the cathode current flowing in resistor 113 by-passed by condenser 114, control grid 115, screen grid 117, suppressor grid 118, and plate 119. A portion of the sum and difference signals appears across resistor 104 through coupling condenser 105. The amplified sum and difference signals appear across plate load resistor 120 connected between plate 119 and bias source 141.

The amplified sum and difference signals across resistor 120 are coupled to an output attenuator 173 and output voltmeter 2 by means of coupling condenser 121. The output attenuator 173 includes an initial dropping resistor 155, attenuator resistors 158, 163, 165 and 167, output terminating resistor 170 and push-button switches 156—157—159—160—161—162, 164—165 and 168—169.

The low end of resistor 158 is shunted to ground by resistor 163 and the low end of resistor 165 is shunted to ground by resistor 167. Switch 156—157—159—160—161—162 connects the low end of resistor 155 to the high end of resistor 158 when in its neutral position as shown and connects the low end of resistor 155 to output terminal 171 when in its operative position. Similarly switch 164—166 connects resistor 158 to resistor 165 or to output terminal 171 and switch

162—169 connects resistor 165 to terminal 171 in its operative position. The attenuated output appears across terminals 171 and 172 and the full output is available at terminal 154 connected to the high end of resistor 155. The voltage across attenuator 173 is measured by diode voltmeter 2. Diode 2 includes cathodes 135 and 136 and corresponding anodes 133 and 134. Anodes 133—134 are connected together and to the high side of resistor 155. The diode circuit includes the cathode load comprising resistor 129 and condenser 130 in shunt and paralleled by resistor 131 in series with condenser 132 and the combination is connected between paralleled cathodes 135—136 and ground 3. Meter 11 by-passed to ground by condenser 140 is connected in series with resistors 139 and a portion of resistor 137 to plates 133—134 and to a point on resistor 174. Thus the rectified current generated by diode 2 flows thru meter 11. The sensitivity of the voltmeter is adjusted by means of adjustable contact 133 on resistor 137 connected in series with meter 11 and the zero signal current from diode 2 is bucked out by adjusting contact 175 on resistor 174 connected between battery 141 and ground 3. Meter 11 reads the voltage across the attenuator including the initial dropping resistor 155. The actual output voltage at point 154 is thus read by meter 11 and the output voltage across points 171 and 172 is the reading on meter 11 times the attenuation factor introduced in attenuator 173.

Amplitude modulation of the output signal is produced by applying a modulating signal to suppressor grid 102 of detector tube 7. This is accomplished through contacts 52 and 53 of switch 51 by throwing it to "AM." This connects the output of driver tube 4 to grid 102 through filter 61—62—63 and 64—65—66. The amount of amplitude modulation thus produced is indicated on meter 10.

With switch 51 at "FM," switch 22 closed to 23 and switch 16 closed to 17 frequency and amplitude modulation are produced at the same time. Frequency modulation is produced by "Audio frequency source No. 2." In this way independent frequency and amplitude modulation of the output signal is produced. The modulating frequencies may be anything from the same frequency to widely different frequencies. Evidently a single source of audio frequency may also be used in which case the two modulations are equal in frequency and phase.

Thus far a generator has been described for generating a variable frequency either modulated in frequency or amplitude or both. Both sum and difference frequencies are produced in the output of detector 7. In order to provide either sum or difference frequencies in the output of the generator at will selection is made in the amplifier as, for instance, by means of selective circuits 106—107 and 122—123 switched in or out by means of switches 109 and 128. In one form of the invention fixed oscillator 6 is operated at 20 megacycles and the variable oscillator 9 is operated over a range from 21 to 30 megacycles. The plate loads of tubes 7 and 8 and other circuit constants are chosen so that with switch 109 on contact 110 and switch 128 on contact 127 the detector and amplifier circuits pass the difference frequency of 1 to 10 megacycles. This provides operation for one frequency range. The 1 to 10 megacycle range is thus selected and higher frequencies are eliminated by the cut-off characteristics of the amplifier. With switch 109 on contact 108 circuit 106 is tuned by condenser 107

to one end of the sum frequency range of 41 to 50 megacycles and with switch 128 on contact 126 circuit 122 is tuned by condenser 123 near the other end of the 41 to 50 megacycle range.

This provides substantially constant amplification over the sum frequency range from 41 to 50 megacycles and since circuits 106—107 and 122—123 have low impedances in the 1 to 10 megacycle range the difference frequencies are eliminated. This provides a high frequency range output. It will be noted that for convenience of calibration of the generator 1 megacycle corresponds to 41 megacycles, 2 to 42 etc. The range of operation is changed merely by shifting switches 109 and 128 in the amplifier without any connection or change in the oscillator circuits. This provides constant oscillator and modulation conditions on both ranges of output frequency.

Thus frequency modulation is accomplished at a fixed frequency at a point mid-way between the output frequency ranges. Conditions for frequency modulation are not changed by changing the range or value of the output frequency. The harmonics of the fixed oscillator fall outside both output frequency ranges. Amplitude modulation is carried out in the detector without effect on the frequency modulation. Both frequency and amplitude modulation may be produced at the same time at the same or different modulating frequencies and by independent amounts. The output frequency ranges may be changed without affecting either modulation or frequency stability since no changes are made in the oscillating circuits. These and many other advantages of the system shown and described will be apparent to those skilled in the art.

While only a single embodiment of the present invention has been shown and described many modifications will be apparent to those skilled in the art and within the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. In a signal generator, the combination of, an oscillator having a fixed mean frequency, means including a second oscillator for frequency modulating said oscillator about said mean frequency, a variable frequency oscillator, a detector for rectifying signals from the first mentioned oscillator and from said variable frequency oscillator to produce sum and difference frequencies, means including said second oscillator for amplitude modulating said sum and difference frequencies after they have been produced, means for selecting said sum frequencies and eliminating said difference frequencies to produce a first useful output signal, means for selecting said difference frequencies and eliminating said sum frequencies to produce a second useful output, and means for selecting said selecting means.

2. In a signal generator, the combination of, a high frequency electronic oscillation generator, a low frequency electronic oscillation generator, means for frequency modulating said high frequency oscillation in accordance with a signal derived from said low frequency generator, a variable frequency second high frequency electronic oscillation generator, means for mixing signals from said two high frequency generators to produce a frequency modulated variable frequency beat note signal, and means for amplitude modulating said beat note signal in accordance with a second signal derived from said low frequency generator to provide a frequency and amplitude modulated test signal.

3. In a signal generator, the combination of,

an oscillator having a fixed mean frequency, means including a second oscillator for frequency modulating said oscillator about said mean frequency, a variable frequency oscillator, a detector for rectifying signals from the first mentioned oscillator and said variable frequency oscillator to produce sum and difference frequencies, means including said second oscillator for amplitude modulating said sum and difference frequencies after they have been produced, means for selecting said sum frequencies and eliminating said difference frequencies to produce a useful output signal, the fixed mean frequency of the first means oscillator being greater than the range of the variable frequency oscillator.

4. In a signal generator, the combination of, an oscillator having a fixed mean frequency, means including a second oscillator for frequency modulating the first mentioned oscillator about said mean frequency, a variable frequency oscillator having a range less than the mean frequency of the first mentioned oscillator, a detector for rectifying signals from the first mentioned oscillator and the variable frequency oscillator

to produce sum and difference frequencies, means including said second oscillator for amplitude modulating said sum and difference frequencies after they have been produced, and means for selecting said difference frequencies and eliminating said sum frequency to produce a useful output signal.

5. In a signal generator, the combination of, an oscillator having a fixed mean frequency, means including a second oscillator for frequency modulating the first mentioned oscillator about said mean frequency, a variable frequency oscillator having a range less than the mean frequency of the first mentioned oscillator, a detector for rectifying signals from the first mentioned oscillator and the variable frequency oscillator to produce sum and difference frequencies, means including said second oscillator for amplitude modulating said sum and difference frequencies after they have been produced, and means for selecting a said sum frequency and eliminating a said difference frequency to produce a useful output signal.

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